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A GAMIFICATION FRAMEWORK FOR CUSTOMER ENGAGEMENT AND SUSTAINABLE WATER USAGE PROMOTION

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ABSTRACT

The recent advent of smart meters to increase the effectiveness of urban Water Demand Management Strategies (WDM) has allowed water utilities to gather quasi real-time consumption data to monitor the network status and load and useful to develop models of consumers' behavior. At the same time, the consumption information can warn users about their habits in a fine-grained way.
In principle, the feedback alone could stimulate increased awareness on water usage, but the motivations and individual attitudes of consumers are mostly hidden. Moreover, the same sustainable behavior should be incentivized also for households in which smart metering solutions are not present, but for which data gathering becomes a challenge.
Modifying users' behavior by means of software is a tough task, due to the difficulty in designing an effective application able to maintain the behavioral changes in the long term.
Gamification, the use of game design techniques and game mechanics to enhance traditional applications and drive behaviors of its users, has been proven successful in tackling with the problem.
In this work, we propose a gamified application to enhance users' participation and data gathering in a real WDM scenario, by describing the designing principles and the architecture of the envisioned solution.
An integrated approach exploiting both board and digital games to incentivize users to submit meaningful data for water utilities and change their long-term behavior is also detailed.
The work is part of the SmartH2O project, which aims at creating an ICT platform to raise customers' awareness about their consumption and pursue water savings in the residential sector.

Keywords: *ICT for water management, Gamification, Smart meters for water consumption, Serious games for sustainability awareness*

1. INTRODUCTION

The traditional approach for solving issues related to an increasing demand of water involved a change in supply-side policies, with actions targeted at extending the existing infrastructure or increasing the water availability by applying desalinization and recycling strategies. Such strategies are unfeasible in the long term, since they inevitably lead to increasing environmental and financial costs, as reported by Dharmaratnaa et al.(2010).
For these reasons, as described in the work of Stewart et al.(2010), in recent years the problem is faced with water demand management actions, ranging from (1) engineering actions**,** i.e. by introducing efficient water consuming devices; (2) economic strategies, i.e. by defining suitable water pricing policies; (3) enforcement, i.e. by defining water restrictions rules; (4) encouragement, i.e. by promoting and incentivizing sustainable behaviors; (5) education, i.e. by informing the citizens about water saving actions. In particular, actions 2 to 5 result effective without the need of modifying the underlying water infrastructure. This helps utilities and governments at bringing improvements in shorter time cycles, with less costs and with the possibility of modifying the strategies on the go if a monitoring phase highlights inefficiencies.
The introduction of smart metering devices and applications, which allow water managers to understand the effectiveness of water management strategies and household water consumption patterns, has made this possible, even among different socio-demographic groups, as defined in Stewart (2010) and Willis (2013).
Nonetheless, the water sector has a number of issues that cannot be resolved by conventional engineering interventions without incurring in massive costs: supply-demand imbalance, sewer blockages, peak demand are just few examples. These challenges usually require the contribution of the water utilities' customers. The issues faced by water companies are critical for their business but irrelevant to normal customers as long as those ones are not affected directly.
Influencing the behavior of users regarding water consumption has been proven a complex and multi-faceted task that cannot be accomplished with the use of technology alone (Stewart, Willis 2013); right incentives should be provided to the citizens in order not only to adopt a particular habit but also in maintaining it. The European Commission (2012) highlights that pricing is a powerful awareness-raising tool for consumers that combines environmental and economic benefits while stimulating innovation. However, behavioral change could be achieved with techniques that has been proven effective also in other domains, such as Gamification, the use of design elements characteristic for games in non-game contexts (Deterding et al., 2011).

The SmartH2O Project fits and meets the challenges and objectives described before with the use of an Information Communications Technology (ICT) platform (see Fig. 1) that aids water utilities in determining optimal water pricing and driving consumers in changing their water consumption habits. This is obtained by integrating smart metering, social computation, dynamic water pricing, and advanced consumer behavioral models. In particular, the focus of the SmartH2O project involves the characterization of water utilities' customers in terms of water usage habits, knowledge and psychographic attributes to adopt preemptive, informative and corrective strategies in real time, based on consumers' and water utilities' needs. This feedback can be used to revise demand management policies to address water and energy saving goals. The novelty of the project resides in the capability of facing water consumption problems from different angles, including dynamic water pricing policies, physical rewards, incentives for the virtuous citizens and engaging activities able to involve the whole family. Figure 1 The flow of information and control in the SmartH20 system (Source: Rizzoli et al. 2014). describes the flow of information and control in SmartH2O.
Goal of this work is to present the general architecture of the SmartH2O platform with a focus on the technological and design choices adopted to introduce an effective gamification strategy to the problem, considering even hybrid approaches involving physical games to engage and drive the behavior of the users.
Section 2 reviews the works in literature with respect to water consumption modeling and existing gamification platforms used in water and energy saving domains.
Section 3 details the SmartH2O requirements and architecture, by describing at high level how its components are able to fulfill the desired goals.
Section 4 describes the design choices of the SmartH2O Gamified platform and its ability to be adapted to several preexisting water utilities infrastructures.
Section 5 describes the hybrid engagement strategy adopted to collect additional data from the users and drive them in using the gamified platform described before.

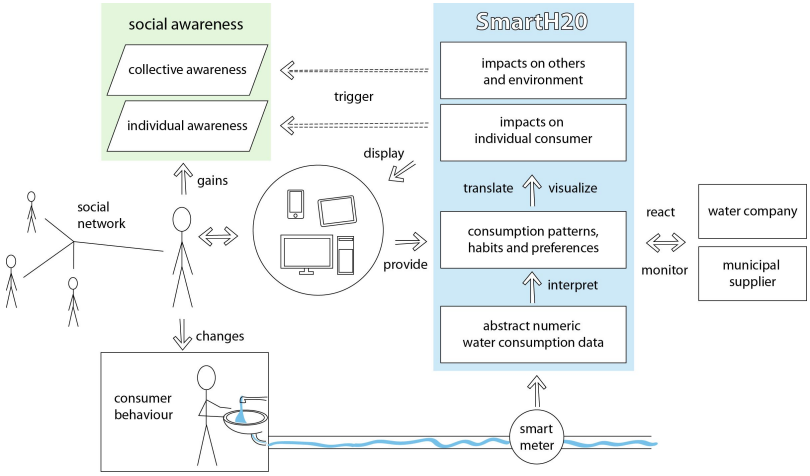


Figure 1 The flow of information and control in the SmartH20 system (Source: Rizzoli et al. 2014).

2. RELATED WORK

Accurate measurements of end-user water consumption are essential to evaluate alternative water management policies (Khoi Anh et al., 2013). However, water consumption has been studied for many years using top-down approaches based on pattern analysis at city or district level; these approaches relied mostly on periodic billing data (Lee et al., 2011; Bakker et al., 2003) to infer climate, season (Olmstead et al., 2007) and calendar dependencies (Wong et al., 2010). More recently, the development of smart metering systems allowed increasing temporal and spatial resolution and disaggregation of water consumption into sub-daily events at the household level (Beal et al., 2013; Gato-Trinidad et al., 2011; Blokker et al., 2010). High resolution smart metered data enabled much deeper understanding of water consumptions, including economic and socio-demographic factors (Grafton et al., 2011; Willis et al., 2013) such as income, family composition, lifestyle (Syme et al., 2004), property characteristics (Fox et al., 2009), environmental and water conservation attitude (Randolph and Troy, 2008; Corral-Verdugo et al., 2002). Many pilot projects have been undertaken to identify the correlations between demographical subsets within a population and water consumptions, in order to build user profiles and behavioral predictive models for demand management. For example, Blokker et al. (2010) developed a stochastic end-use model to predict water demand patterns at the residential scale, to explain large part of the variance for the observed consumption data based on statistical information on users. More recently, Bennett et al. (2013) proposed another forecasting model built upon smart metered data gathered during a two-year study in South East Queensland (Australia). Outcomes from these studies are very encouraging, as continuous progress improves the understanding of the factors driving water consumers' behavior (Makki et al., 2013) and several trials show how management approaches based on users' awareness can lead to significant water savings (Fielding et al., 2013) and changes in users' behavior (Anda et al., 2013).
Yet, in scientific literature, there are no cases of voluntary testing of water saving strategies on the long run and at a scale; therefore this gap must be filled, as Fielding et al. (2013) suggest.

Data related to users' or household features such as dwelling size, device efficiency and perceptions about demand management measures are currently only inferred through surveys on the current or predicted users' behavior (Willis et al., 2013), but are usually not repeated. Such approach is limiting the possibilities offered by demand forecast models, that would require continuously and adaptively updated information on users' behavior to assess the improvements induced by the application of new management policies. Further efforts should be devoted to understand how data obtained by smart meters influence users' responses (Giurco et al., 2010) and the impact of social norm and social influence in the modeling process, dimensions considered only in few studies based on agent modeling (e.g., Rixon et al., 2007). Similar problems are present in other domains, such as Marketing, E-Learning or Energy Saving and have been successfully tackled with the use of Gamification, a persuasive technology that attempts to influence user behavior by activating individual motives via game-design elements (Petkov et al.,2011).
Beside the encouraging results in other fields, the use of gamification strategies in the water sector has been so far limited and hardly documented in the academic literature; this is due to the current, highly centralized structure of water companies and their reluctance to engage with customers in a more active way.
The *IBM study* conducted in 2011 in Dubuque, Iowa, with the use of IBM analytics and cloud computing technologies is an example of successful application of gamification that helped to reduce water utilization by 6.6 percent and increased leak detection and response eightfold. Just providing citizens and city officials with an integrated view of their water consumption and comparing them to a similar control group that was able to use just smart meters without having access to the analytical platform allowed IBM to assess the effectiveness that increased engagement of citizens brings to water saving problems.
Mpaani is a company that implements a loyalty program where, by purchasing mobile credits from sponsoring companies, individuals earn redeemable points to acquire sanitization products or water-related infrastructure for villages in third world countries.
Student Programs Like Aquatic Science Sampling Headquarters (Adams et al., 2013) is a social network for investigating, sharing, and visualizing data involving water. The project plans to engage users by prompting them to share how they are using water, for instance by posting short status updates regarding their interaction with water, whether they are boating, swimming, fishing, or exploring. General users, students, and citizens are encouraged to produce, consume, and visualize data while being recognized for their participation through gamification. The various forms of data postings are then used to disseminate findings, network interested parties, and track trends in water use and information.
Successful examples of gamification applied towards environmental sustainability outside of the water sector are *Practically Green* and *One Milion Acts of Green*, in which green actions performed by the user can be tracked and automatically estimated showing one's own impact and savings accompanied by a score. *My Energy*, *OPower* and *Simple Energy* are platforms that help customers to understand the power bill, compare it with similar homes, friends and neighbors and take actions towards a reduction of energy consumptions.
SmartH2O is one of the first attempts at integrating both digital and physical gamification strategies to collect accurate and human validated consumption data in the water domain. In the following sections, we describe the benefits of the SmartH2O platform and how it helps the implementation of gamified elements in existing water utilities' infrastructures.

3. THE SMARTH2O PLATFORM

The SmartH2O platform aims at supporting the cooperation of water utilities, municipalities and citizens to implement better water management practices and policies, thus reducing water consumption without compromising the quality of life. To accomplish these results, the first step involves the modeling of existing consumers that are interacting with the water utility infrastructure, based on historical and real-time water usage data. This allows predictions on how the consumers' behavior is influenced by different water demand management policies while, at the same time, raising their awareness on their current water usage habits and lifestyle with the use of ad-hoc interfaces. The water utility ICT infrastructure is, typically, already in place within public or commercial companies and such entities usually have their own web portal or data gathering platforms. For this reason, SmartH2O offers a modular framework to ease the design implementation and integration of sustainable water management platforms able to profile the utilities' clients, understand how the consumers have adapted to new situations and provide feedbacks to water management companies to revise water management policies and maximizing water and energy saving goals.
Users' behaviors models are generated by collecting data on their water consumption with smart meters and, at the same time, by exploiting a gamified portal (the social game) where qualitative information about the users' preferences and attitudes are collected. The social participation applications are also used to deploy policies in the real world, by providing signals to the users, such as incentives to save water in specific environmental conditions or as dynamic price information. Once the policies have been deployed, the platform will allow continuous monitoring of the users' aggregate behavior to react and suggest other actions if the original policy loses effectiveness.
In **Figure 2**: Overview of the main components of the SmartH2O architecture. we illustrate the main components that constitute the SmartH2O platform.
The **SmartH2O Database** is the central repository of information shared among all the SmartH2O components and supports the coordination and exchange of messages among them. Due to integration requirements, not all the data of SmartH2O will reside in the SmartH2O database; for example, we allow commercial data about the water consumers to be maintained by the water utility and stored in their proprietary systems.
The **Enterprise Service Bus** (from now on, ESB) is a middleware layer that supports the loose coupling of the SmartH2O components; it allows them to expose their interfaces (Application Programming Interfaces, APIs) and synchronous and asynchronous communication among components. The goal of the ESB is to decouple the heterogeneous components of the SmartH2O platform as much as possible, by supporting future extensions of the platform with new services and functions able to guarantee its modularity.

The **Smart Meter Data Manager** deals with the acquisition of data streams from smart meters and their consolidation within the SmartH2O database. It guarantees the respect of data privacy and security policies of the utility company and ensures that only admissible (e.g., aggregated, anonymized) data is stored within the platform database.
The **Water Utility Consumer Portal** is a component, typically embedded within the proprietary portal services of the utility company, which supports the interaction between the utility customers and the SmartH2O awareness functionality. The integration is lightweight: the consumer will navigate from the standard GUI of the utility company to what she sees as a special section of the portal, where she can access the awareness tools and interfaces developed by SmartH2O.
The **Water Utility Admin Portal** is a component, integrated within the proprietary portal services of the utility company, which supports the work of the supervisor in the analysis of water consumption data. It allows the administration of the content (e.g., tips, articles, news, etc.) to be published to the customers and offers interfaces to the water utility operators to run simulations, based on models retrieved by the User Behavior component and on the algorithms implemented in the Pricing Engine and in the Agent Based Modelling component.

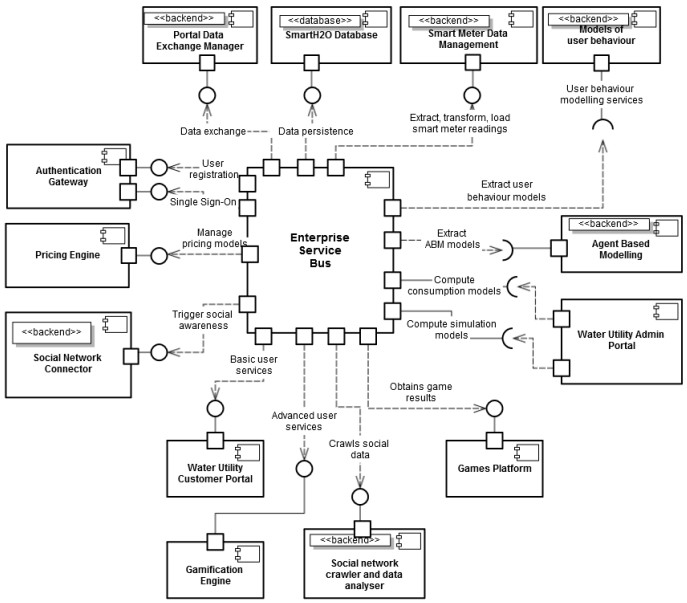


Figure 2: Overview of the main components of the SmartH2O architecture.

The **Portal Data Exchange Manager** manages the data exchange occurring among the SmartH2O platform and third party applications such as the "standard" customers' portal of the utility company or a B2E application for the utility company's supervisors.
The **Gamification Engine** is a back-end component that embodies rules to drive users' actions within the platform and turn them into points and achievements. The end-user can understand both in a qualitative and quantitative way the effects of her water consumption actions. An administrative interface for the utilities' managers and operators allows the supervision of the outcome of the gamification campaigns and the definition of rules to reward virtuous actions.
The **Games Platform** supports the execution of digital games used to increase the engagement of casual players and all the members of a househol; it has an independent users' registration procedure, as well as a procedure for enrolling users already registered in the Utility Portal. The Games Platform exposes two kinds of interfaces: one or more digital games directed to the end users and an administrative interface to allow content editing. The GUIs are served by a local database (the Games DB), which stores information that is pertinent only to the game play (e.g., the gaming history of players not registered in the Utility Portal).
The **Pricing Engine** allows water utility companies to assess the impact of various dynamic pricing algorithms on their customer behavior. The pricing engine uses consumption data, user profile data, external input like meteorological data, water supply forecast. The Pricing Engine models the user elasticity to different pricing schemes and it will be able to report how pricing stimuli can affect aggregate customer behavior.
The **Models of User Behavior** component contains models and algorithms for profiling the behavior of water consumers. It contains a classification algorithm that creates user segments (classes of users with similar behavior) based on their features. It also contains a disaggregation algorithm that can attribute the end uses of the total amount of water used by a household during one day, with a certain degree of approximation. It orchestrates also other components, such as the Gamification Engine or the Pricing Engine to obtain additional features such as the sensibility of social awareness or the sensibility to price changes.
The **Agent Based Modelling** component allows the simulation of whole districts of users, thus extrapolating user models provided by the Models of User Behavior component at a larger scale and the impact of network effects due to users' interactions, both in the physical and in the virtual world. The agent based model includes influence/mimicking mechanisms and social interaction among the consumers, and thus will be employed by the water utility to understand how some user types (leaders/influencers) can stimulate a behavioral change on other users.

The **Authentication Gateway** component centralizes user registration into the SmartH2O platform database for the users registered in the components having their own databases; the credentials can then be used in every component belonging into the platform.
The **Social Network Crawler and Data Analyzer** is a component that can be used to launch social data analysis campaigns to identify relevant users and content in the area of sustainable water consumption on platforms like Twitter or Facebook.
The **Social Network Connector** allows the users to share the accomplishments they have earned within the SmartH2O Water Utility Portal or Games Platform to the social network of their preference. This creates the opportunity for the water utility company to engage people from their social circle, suggesting water saving actions and possibly attracting them toward the use of their consumer or gamified portal.
To validate the effectiveness of the adopted solution to tackle with water management tasks, key performance indicators are used to describe the results over two summarized goals: a) the capability of the platform of saving water by introducing dynamic water pricing policies and b) the ability of the platform to improve efficiency of business operation for water companies.
With regard to the first objective, the key performance indicators account for amount of water saved per capita per period. As water saving could be the consequence of increased awareness, we will also evaluate the combined effect of dynamic water pricing and user awareness, to verify if the interactions of these two signals can be cooperative or competitive.
With respect to the second objective the key performance indicators have to take into account: a) the peak ratio reduction of water consumption, measured by comparing the historical data of peak water consumption with the data monitored after the introduction of SmartH2O; b) the energy required for pumping water; c) the peak ratio reduction in CO2 emissions; d) the investments avoided, that is the total amount of money that has not been spent over a given period thanks to reduction in water consumption. This last indicator helps to assess how reduced water consumptions prevented the creation of new infrastructures (e.g. new wastewater treatment plants).
The customizable Gamification Engine and the Games Platform are the main components that distinguish the SmartH2O approach over the traditional water saving approaches and are described in more detail in Section 4 and 5 respectively.

4. THE GAMIFIED WATER UTILITY PORTAL

The main problem that the project has to face is, as we have described in Section 3, the collection of customers' related data based on their water consumption, habits and psychographic information, to create models used to drive future intervention of the water utilities and foster sustainable behaviors.
The data collection cannot rely just on hardware able to submit contributions on its own. If it is true that smart meters are an effective mean to collect water usage data with sufficient resolution, at a scale and without requiring the intervention of the users, water consumption figures are not sufficient for the purpose of the project and the number of smart meters installed in households is still limited.
In the case in which a user that we want to monitor does not own a Smart Metering device, she should provide the data manually. Information regarding the members of the household, specific reasons describing why water has been used at a specific time of the day (e.g. the user was taking a shower and not gardening), the number and kind of appliances installed and details about the architecture of the household (e.g. size and number of rooms) are all meaningful data that can improve the effectiveness of the predictive models in identifying behaviors and cluster the users in classes.
Unfortunately, due to the importance and need of collecting this data at a scale, we cannot rely just on voluntary contributions from the users.
The users may fulfill such tasks for several different reasons, including the appeal of the activity, altruism, reputation, monetary incentives or the need to feel challenged and entertained, as described in Organisciak (2010). Self Determination Theory, described in Deci et al. (1994), groups these motivations under two different categories: *intrinsic motivation*, defined as doing an activity for its inherent satisfactions rather than for some separable consequence, and *extrinsic motivation*, the desire of doing an activity in order to attain some separable outcome. Some of the users of the water utilities that will make use of the SmartH2O platform may be interested in performing such activities to reduce water waste, to save money and monitor their own behavior. On the other hand, we expect that most of the users will consider these activities as dull and boring tasks that provide no real benefits to them; the platform needs to incentivize these contributions with the use of extrinsic motivators.
One of the approaches to follow for obtaining such results is the use of Gamification to drive the users' behavior with the introduction of game like mechanics, ad-hoc challenges to maintain active the interest of the participants and real world rewards for the most prominent contributors.
The SmartH2O project fosters social participation with a gamified platform that allows consumers to monitor their water usage and display the data provided by smart meters, or (in absence of smart meters) estimated from consumer profiles and from water bills. The Gamified Water Utility Portal (GWUP) translates bare consumption data into more engaging formats, fostering individual and collective awareness. Individual awareness includes e.g., how current and future water usage affects the water bill; collective awareness includes how consumption impacts the likelihood of water shortages, price setting mechanisms, groundwater levels, plants and wildlife. For water managers such as water utilities, architects, planners and public authorities, the GWUP will provide insights into customers' consumption behavior. They will be able to test different WDM strategies and identify which of these strategies are potentially the most effective. It will allow companies to test new incentives, such as translating virtual game results into redeemable points or water bill discounts, and offer smart products, such as personalized water tariffs based on customers' real-time consumption data or devices to improve efficient water usage.

Mechanics typical of the gaming domain and described in Galli et al. (2014) are used to create an active community in which users compete against their neighbors for a rationale use of resources. This means that the platform does not reward the users that were able to consume less water but the households in which water consumption has been efficient based on family composition, available devices and needs, according to the trained behavioral models. The gamified platform is thus able to accomplish two different goals: collect meaningful data regarding the users, used to generate suitable models and profiling them, and use this data to drive the future behavior of its players, by warning users when they are using too much water, calculate future scenarios based on the current consumption, and suggest countermeasures. Impact will be assessed by checking the average water consumption per user before and after the adoption of SmartH2O, the number of users playing the game, their willingness to change behavior, and the level of awareness attained. In the following, the chosen game mechanics and their feasibility with respect to the objectives of the project are described, along with a description for two different views of the portal used to gather information from the users: a standard customer portal and the gamified water utility portal.

4.1 Gamification Design

The Gamified Water Portal is in charge of promoting the submission of meaningful contributions from the players while driving them towards water sustainable behaviors. Users consulting the gamified water portal will also have the possibility to monitor their consumptions, activities and choices during a span of several months in an immediate and synthetic way, comprehensible even for non-technical users thanks to the introduction of strategies borrowed from the gaming field.
The platform should allow each water utility to define its own objectives and defining which data to collect by detailing custom actions for the users to perform in the platform.
To gamify the contributions of the players, we opted for a Point, Badges, Leaderboard system (PBL), augmented with the introduction of physical rewards and filters to enhance competition among new players. Filters are useful to avoid discouraging new players, because they can hide the presence of experienced users that were able to amass considerable amounts of contributions in the platform.
In the following, we describe the reasons beyond the need of the PBL mechanics in the SmartH2O platform.

- **Points** are numerical values that represent a measure of the skill of a player. When a player submits an action within the system, she is rewarded with an amount of points that depend on the difficulty and importance of the task performed. The player score is the sum of all the points a player has received since the creation of its account within the platform. Points are used in the platform for several reasons: (a) by keeping the players' score, they inform them on how well they are performing; (b) when it is necessary to define a comprehensible target goal, points can be an easy mean to achieve the result; (c) they can be used to connect the progression of the player within the system with real world rewards to be redeemed; (d) they provide quantifiable data over qualitative and descriptive actions, allowing the designer to define and analyze metrics about the system, such as progression rates of the users, the frequency of their contributions and so on.
- **Leaderboards** are ordered lists of players based on the points they have accumulated within the platform. They give context to progression by making the performance of a player public within the system. Leaderboards also give to a player the possibility to understand if she is really working towards the needs of the platform, by comparing her own results with the ones of her peers. They foster competition among neighbors by providing the challenge of being the most efficient household with respect to water consumption in a particular area.
- An **Achievement** describes a set of tasks for the player to fulfill to complete a goal in the platform; a **Badge** is the artifact associated to its completion and awarded to the player once the required actions have been performed. In literature this distinction is often blurred, so from now on just the term "Badge" will be used. Badges represent a milestone that shows that certain amounts of points have been collected, but they are mostly used to show to a player the actions that are expected from him to be completed. For instance, a Badge could be awarded when a player provides personal information and details regarding the member of her family; by seeing a badge that has not been obtained yet, the player can set her own goals in order to obtain it and fulfill her role within the platform.
- A **Level** is a numerical status that is used to represent, in a synthetic way, the ability of the user within a system; it typically defines a particular milestone to reach through a combination of points and badges.

Actions represent the meaningful tasks that a water utility would like its user to perform.
Based on our analysis, we have defined six possible thematic areas that could group the activities performed by the users in the platform:

- Consumption: actions that the users performs to submit their water consumption measures in the platforms.
- Habits: actions with which the users can refine their water usage data by specifying the particular activities they have performed (e.g. today at 17:30 I took a shower).
- Learning: watching an educational video or informative material provided by the platform.

- Profiling: submitting information related to the household such as the number of family members.
- Devices: associating an appliance to the household or specifying its characteristic.
- Playing: playing a round of one of the mobile games created for the project.

An area, a name and a description of the activity that has to be performed characterize each action, along with a numerical value representing the points obtained by performing it. When defining an action is also necessary to choose if the action could be repeated or not and the amount of time that has to elapse before being able to perform a repeatable action again. Participation and Reputation are two different areas to which the platform can assign points for a specific action. Users acquire participation points, used as an intrinsic motivator, by playing "an active role" within the community, for example by filling their personal information on their profile, reading a tip, logging into the platform and other similar activities. Reputation points express, through a numerical value, the ability of a user to perform water saving activities and is used as an extrinsic motivator.
These mechanics are introduced in the portals of the platform to provide gamification features used to engage and drive the behavior of the customers as described in the following sections.

4.2 Customer portal

The smartH2O customer portal provides to customers access to their water consumption information. It is available as a basic version that focuses on basic water meter access, and an advanced version (see Figure 3). The latter will be a gamified platform, which enables interactive water saving and raises customers' individual awareness of their consumption. Gamification mechanics like the collection of points, badges and rewards and the ability to compare one's own consumption to others via e.g. leaderboards accomplish these goals.

Figure 3. Customer portal home page, which links to both the basic and the advanced, gamified version.

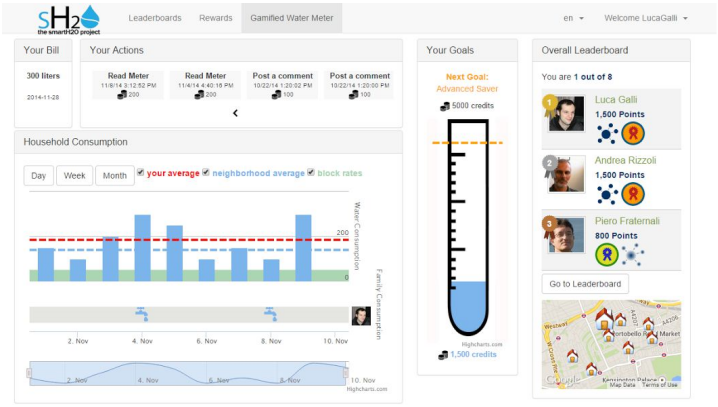
4.2.1 Basic customer portal: Visual water meter

The visual water meter provides customers with the most basic access to their consumption information. It connects to the meter data either collected automatically via smart meters or provided manually by customers owning only standard meters but that would like to use the application as well.
A visual widget displays the consumption over time and calculates the average consumption of the user's household (see Figure 4). It can also calculate other important metrics like peak hours. These averages can also be compared to other aggregated consumption information, e.g. to the neighborhood's or town's consumption average. Based on the consumption information, the application can calculate a "virtual bill" that shows how much a household would have to pay approximately, if it was billed based on the smart meter information.
The basic application can also provide alerts, e.g. warning the user about possible leaks or bad water quality; additionally, the application can also display water saving tips and info material like videos providing information about topics related to water saving, thus promoting sustainable behaviors.
The Basic customer portal is provided for those users which are not interested in competing with the other water utilities' customers or being profiled in order to obtain personalized suggestions, but would rather stick with a traditional interface similar to the one that may be provided by the water utility itself. Such an interface would still allow the platform to collect anonymized data regarding the basic users to improve the predictive models.

Figure 4. The Visual Water meter interface.

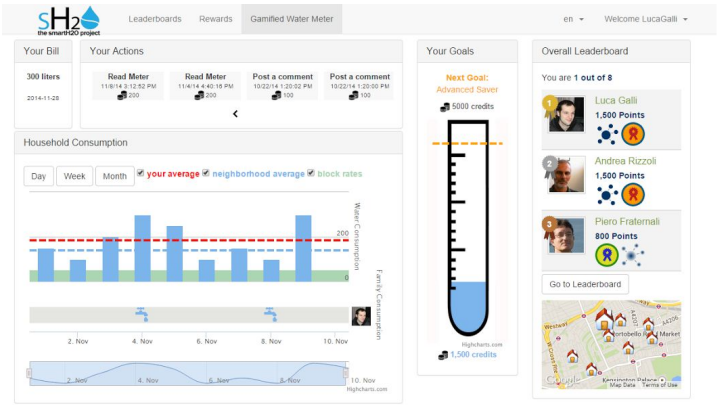
4.2.2 Advanced customer portal: Gamified water meter

Besides the functionalities that are available in the basic customer portal, the gamified water meter provides entertainment means for customers and benefits derived from additional information (see Figure 5 for an overview of the interface).



The platform leverages the experience acquired by the group in a previous project, the CUbRIK FP7 project[1], in which a business application for the model driven development of web applications, called Webratio[2], was extended to allow the creation of gamified communities. Both the gamified and basic version of the portal have been implemented with the use of the Webratio tool by defining IFML[3] models; this guarantees robustness, scalability and ease of update of the platform in case of new or refined business objectives. The tool also permits to use different themes for the layout of the pages, allowing the customization of the platform to different water utilities without the need of adapting the underlying infrastructure.

The application will also be available as an optimized mobile application providing the same functionalities of the main portal (see Figure 6 for mobile application mockups) as soon as Webratio will consolidate the generation of mobile applications from the IFML models.



[1] www.cubrikproject.eu/
[2] http://www.webratio.com/
[3] http://www.ifml.org/

Figure 5 Interface of the Gamified Water Meter Web application.

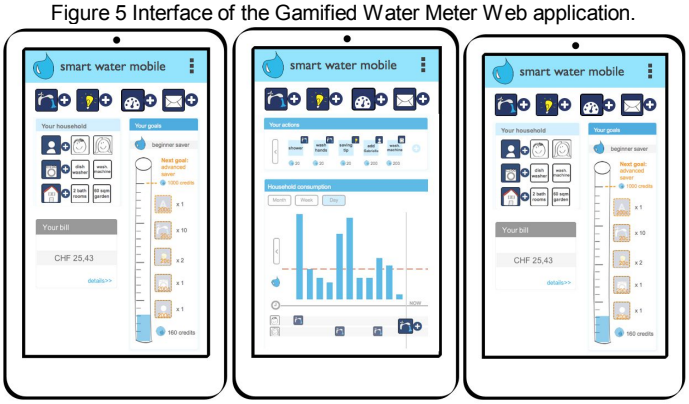


Figure 6. Mockups of gamified water meter mobile application.

By using the gamified version of the customer portal, users are able to take advantage of the full features that SmartH2O provides. They will be able to receive personalized suggestions on how to improve water usage (once the Behavioral Models are trained), the possibility to compare their actions with their neighbors and to redeem physical rewards to improve the water management in the household.
Besides learning about their consumption, customers can earn "credit points" for each action they perform in the application. With these points, they can reach different levels and earn badges, and based on their status, they can eventually redeem the points for different kinds of rewards, e.g. water saving gadgets like tank less water heaters. The collected points are displayed in a way that also suggests users a series of action that would lead to reaching the next level (see Figure 5 **Interface of the Gamified Water Meter Web application.**).

Badges, like actions, are dynamically defined under one of the thematic areas described in the gamification design section by a member of the water utility company. In this way, the strategies to motivate the users can be defined even at runtime, when the portal is put in place, empowering the mechanics proven successful and removing the useless or the counter effective ones. This feature is available via a special administrative panel that allows the definition of new actions, the management of rewards, users and tips notification to share in the platform, as shown in Figure 7: **Administrative panel with action management**

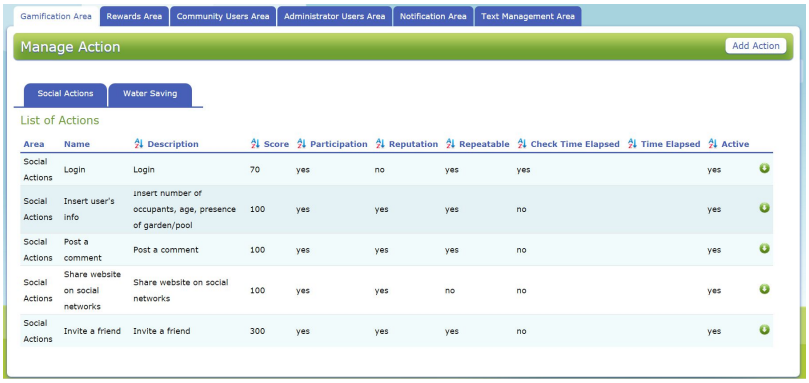


Figure 7: Administrative panel with action management

In the following, we describe possible general user actions for the gamified water meter application suitable to most water utility companies; water utility experts can then refine and expand this list by inserting customized actions prior or after the deployment of the platform.
User action: Providing household information like number and demographics of household members (see Figure 8), number and kinds of appliances (see Figure 9) or general information like number of rooms, size of garden.

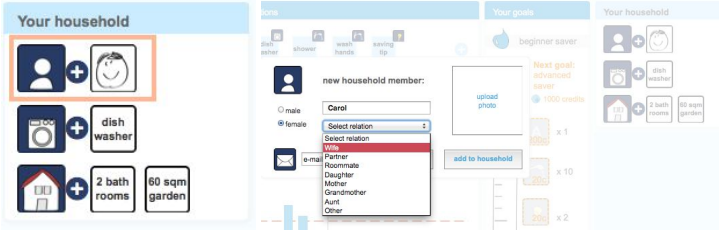


Figure 8. User action: providing household information – adding a household member.

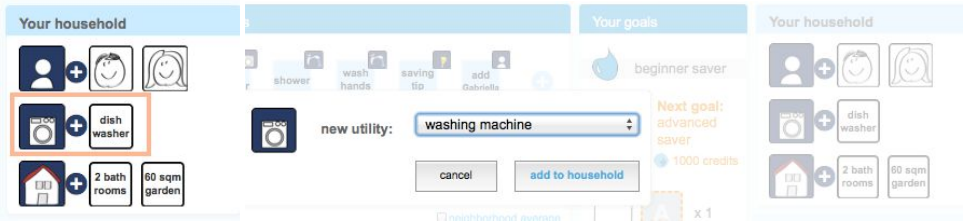


Figure 9. User action: providing household information – type of appliances.

User action: Providing consumption information of specific end use events like "10 min. shower at 7am" or "14 min. watering the garden". (see **Figure 10. User action: providing consumption information – specific end use events.**)

Figure 10. User action: providing consumption information – specific end use events.

User action: Fulfilling consumption goals that were set either by the utility or by the customers themselves (see Figure 11).

Figure 11. User action: fulfilling consumption goals based on consumption average.

User action: Reading / watching / listening to water saving tips in separate section that provides info material like videos or slide shows on water saving and sustainable consumption (see Figure 12).

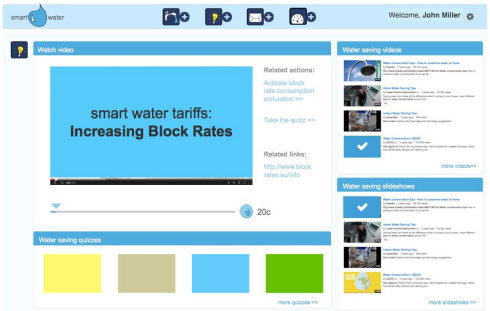


Figure 12. User action: consuming information material like videos, slide shows, and other water saving tips.

User action: Learning about innovative pricing models by simulating tariff blocks rates in the visual widget. Thus, customers can understand the potential impact of innovative pricing models if they were to be applied to their current consumption (see Figure 13).

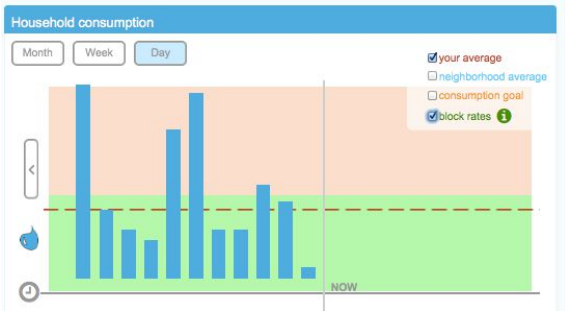


Figure 13. Innovative pricing simulated in gamified water meter (here: block rates).

In addition to considering one's own actions, users can compare themselves directly with family, friends and neighbors by allowing the application to show them in the leaderboard. There, each user is listed with her level and total of points. Top ranking users can be identified and rewarded in addition to their individual rewards.
Users can also team up with others to benefit from each other's points, and work towards achieving common goals as a larger group of users, e.g. a circle of friends or all inhabitants of a participating town.

5. ENGAGEMENT THROUGH THE USE OF HYBRID GAMES

The Gamified Portal may prove to be insufficient in keeping the interest of the users high and reaching a meaningful amount of contributions. It has been proven that interests for a particular platform fade off quite quickly: even if the users interact with the platform for the first days and may be interested in it due to novelty, keeping them engaged in performing the same actions and submitting contributions depends on their intrinsic motivations. In this section, we describe a novel approach for maintaining the interest of the users: a standalone boardgame used to raise awareness of players towards the project and the gamified utility portal. The boardgame will also aid in increasing the number of submitted actions and the gathering of information related to a particular household thanks to a particular digital extension used to collect information of the users' habits through a series of quiz.

5.1 The Games Platform

The games platform is a mobile application that encloses several digital games used as educational means and as bridges towards the use of the gamified application. One of the digital games connects a physical card game called "Drop!" with the games platform. Points earned in the mobile game can be stored and added as points in the gamified water meter applications by connecting the gamer's account to the water utility account.
The games platform leverages a physical card game and augment it with a digital mobile app in order to:

- Raise awareness of water saving practices and prevent wasteful water consumption practices among children.
- Engage all the members of a family household.
- Gather useful data for the specific utility on which to base marketing and commercial decisions.

The setting of the game describes to the story of a kid and his monster. The two are always together playing and messing around. When playing, they encounter many different water-related activities and while the kid, remembering her parents' teachings, adopts water saving behaviors, the monster is always so clumsy that he wastes a lot of water. Therefore, the kid tries to teach the monster to avoid wasting water and the player will be in charge of this teaching as well.
With the playful graphics, we want to leverage the juvenile adventure nostalgia on the grown-ups while engaging directly the young players, teaching them good or bad habits thanks to the actions represented on the cards.

5.2 The Drop Boardgame

The card game "Drop!" is based on a mechanic known as "push your luck": in this genre of games, you acquire points only if you stop at the right time, before hitting a penalty that makes you lose everything. The mechanic has been adapted to the type of audience by introducing the possibility for a player to win thanks to her own luck or due to unlucky draws of the others. The game consists of regular playing cards, which have different numeric values, and "bad" cards showing the water wasting monster and a unique QR code (see **Figure 14: Initial prototype of the boardgame**).
The rules of the card game are the following:

1. Shuffle the deck and choose who starts (usually the younger one)
2. The current player takes the deck and declares how many good cards she will be able to flip without finding the monster.
3. The player on her left has two choices: taking the deck and declaring a higher number of cards to flip or challenge the current player to flip the cards
4. If the current player is challenged and is able to flip the declared number of cards, he scores points based on the value of the cards flipped, but only counting each number once (e.g. two cards showing "7" count just as 7 points).
5. If a monster card is flipped, the current turn stops. The current player keeps the monster card in front of him, while the player that has challenged him distributes a card among the flipped ones to each player.
6. It is possible to keep scores with coins put in front of the players.
7. The good cards are ALWAYS shuffled back into the deck that is then shuffled again to start a new round.

8. The monster cards on the other hands are always kept in front of the player that has drawn them and count as -10 points at the end of the match. The negative score can be turned in positive points by using a digital extension of the game and scanning the QR code on the card; trivia questions will be given to the players as a challenge in order to convert the points. This strategy allows us to link a pleasant and repeatable activity done by children with the goals of the project of collecting information about a household, as described in the next section.
9. The match ends when eight monsters out of the fifteen present in the deck are flipped.

Figure 14: Initial prototype of the boardgame

5.3 Drop! Digital Extension

The mobile app, developed with the Unity3D[4] game engine, expands the possibility of engaging the users through:

- Onboarding of the users: by playing with the digital extension of the boardgame to turn "bad" cards into "positive" ones, children and parents alike are introduced to the SmartH2O project.
- The integration of the digital games with the Gamified Portal allows the acquisition of information about users' behaviours and habits in the form of trivia questions during the games.
- Single player games developed to maintain the engagement of the children high even when they are alone and used as an educational mean.

As soon as a boardgame round ends, all players that kept monster cards can try to convert them into points. The player scans the card she wants to convert with the smartphone camera. The app reads the QR code and launches a Trivia mini-game, asking the user to reply to a question by choosing among 3-4 answers (see Figure 15, center screen). Providing the correct answer will grant the user 10 additional points for the result of the boardgame session and in the Gamified Portal, if she is registered. The questions may be picked from a database created by a professional biologist or may be dynamically generated to refine the information that have been submitted in the gamified portal, effectively eliciting submissions in a task hidden within the game.

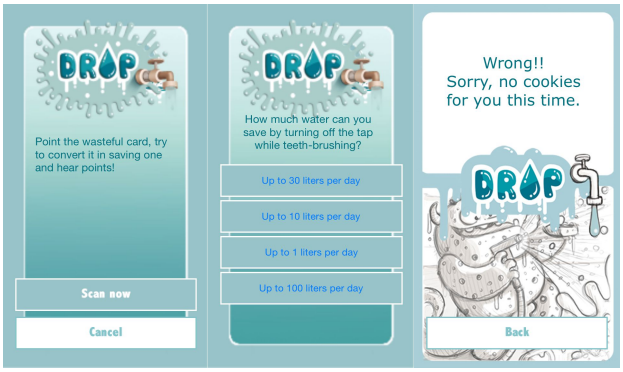


Figure 15. Mobile app mini-game connected to the boardgame. The user scans the water monster card (left) and answers trivia questions to earn extra points (center). Wrong answers result in no points (right).

6. CONCLUSIONS

In this paper, we report the general architecture of a digital infrastructure that aids water utilities in the collection of data related to end user water consumption and psychographics. Voluntary submission of data by the users is encouraged through the use of hybrid gamified applications integrated in the platform, that make use of both digital and physical games to elicit contributions and refinement of data useful for the definition of behavioral models used in dynamic pricing policies and personalized suggestions on water usage. The platform is currently under internal testing and, as we will progress through the project lifetime, we expect to be able to provide the research community with data collected from our experimental set-ups and proving the effectiveness of applying gamification in the water management field with statistically relevant considerations.

[4] http://unity3d.com/

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