A Specialised Social Network Software Architecture for Efficient Household Water Use Management

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Abstract. Specialised, or vertical, social networks (SSN) are emerging as a useful tool to address practical issues such as household water use management. Despite the perceived benefits, the design of such systems is still not fully aware of the social interactions or the incentives that could be used to change user's behaviours when engaging with the network and peers. In this work, we propose and demonstrate the software architecture of a social network aimed at the efficient management of water in households, defining and connecting specialised system components. Three aspects are relevant in this work: first, the architecture explicitly defines components that support social interactions, in the context of existing water management instruments. Second, the architecture defines components addressing openness, which enable easy communication with external resources. Third, as part of a gamification ecosystem, universal and transferable rewards are proposed to incentivise the expected online and offline behaviours.

Keywords: Software architecture · Software engineering · Specialised social network · Social interaction

1 Introduction

A system architecture is usually the result of a set of decisions, taking into account multiple factors such as the input of expert knowledge, technical constraints and available resources. Before finalising a system architecture, the designing process can be problematic especially when 1) the software is specialised but needs to target audiences with different expertises and 2) its interfaces may require to be open to heterogeneous systems. SSN (Specialised social network) software is one of such kind. The recent developments of SSN software enables existing specialised software to address the practical issues of niche, specialised groups, addressing broader issues concerning the whole society. As an example, in the FP7 EU Project ISS-EWATUS[1] a SSN software is used to manage the efficient household water use. The SSN allows users to interact with the communities via a range of activities such as i) sharing water bill with friends, ii) monitoring municipal water use statistics, iii) asking and answering water use questions, and iv) entering competitions sponsored by external stakeholders by completing

[1] http://issewatus.eu

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specific water conservation tasks offline. While this SSN paradigm is becoming popular, there are also concomitant software design challenges when designing such systems.

1. Aligning User Interactions with System's Objectives: One of the features of a SSN software is that it allows users to interact with other users. The interactions need to be clearly defined, so that the social interactions between users can support the overall system objectives, such as achieving the household water-use efficiency. This task can be tricky especially when considering the SSN system objectives and user preferences or approaches in online social interactions.

2. SSN Ecosystems and Incentives: Since a SSN can be used to help users to positively change behaviours such as in a more efficient water use, the system should define a set of "incentives" to encourage positive change in user behaviours. Existing approaches to incentives for users include obtaining reputation, points, prizes etc., which can be designed and deployed to motivate users to engage more and more often in a SSN. However, planning and delivering these incentives means proposing to the users a set of instruments to support their online and offline tasks, which can be specific to a problem domain. Moreover, these incentives can be SSN specific which makes these problematic to be reused, accumulated or redeemed within other social networks.

3. Interface Openness: Addressing a global issue like the efficient water usage is a concern of the whole society, and it requires the participation of many (if not all) water stakeholders. An SSN, even if specialised, should be designed to reach as many audiences as possible, and part of these audiences can be also using other social network systems, or expertise systems. As a result, the openness of interfaces is required for transparency and integration between social networks. However, this poses an inherent difficulty, in particular when the external system interfaces are unknown or incompatible with the designed SN system interfaces (e.g., when finding a match between user names and identities in the various SNs, etc.).

In this paper, we explore the possibility of a SSN architecture to address the above three challenges, i.e. 1) to model and define the social interactions used in a SSN targeting the efficient water use management at household level; 2) to model and define the incentives that support a user's behavioural change in online and offline water usage; 3) to allow the system to be easily accessed or integrated within an heterogeneous ecosystem.

The presented system architecture is currently being used in the ISS-EWATUS project. We expect that the work presented here can serve as an additional system architecture modelling method, on top of existing software engineering processes. We also expect that our work can be extended and customised for designing and implementing a SNN in other social problem domains.

The rest of the paper is organised as follows. In section 2, related works are reviewed in terms of SSN interactions, social network's implications on user behaviour change and SSN access and openness. The proposed architecture is presented and discussed in Section 3. Section 4 concludes and outlooks the work.

2 Related Works

2.1 Specialised Social Networks and Online Social Interactions

The reasons for why social networks are becoming one of the most popular topics studied by both authorities and researchers can partly be attributed to the growing number of users and different types of features made available for interacting with users [10]. There are privacy regulations and grouping methods specially designed for social network such as in [5] and [1], and there are also implications found from using social networks. For example, users of social network sites are more likely to enact a certain behaviour if they could observe their contacts exhibiting the same behaviour before [2,3]. SSN further extends the common social network to target a niche group of users concerning certain specialised issues. Existing SSNs from related works are more often used as a platform to improve the quality of engineering tasks and to target group of expert users. For example, in [11], a SSN is used to help software developers gaining awareness of relevant software tools by enabling them to learn from their peers. In [4] and [7], the SSN was used to empower communities to discuss and extract high-level design features or design patterns. In this work, we use a newly developed SSN to target common users and specially defined online interactions as a set of instruments supporting the efficient household water use management.

2.2 SSN Incentives and Behaviour Change

Incentives are often used to encourage people to engage in the activities available on social networks. In [8] it was found that behavioural change was more likely to occur if physical (i.e. real) rewards were offered. A virtual reward system (such as scores, stars, reputations and badges), as one of the incentives, is a common practice in many social networks. Gamification is a further recent development of virtual rewards and the gamification here refers to the use of game design elements in non-game contexts [15]. Reasons for why such a reward system is successful can be explained by using the behavioural model proposed in [6], the model argued that activities requiring different difficulty levels, will also correspondingly require different motivation levels for a person to do it.

Another type of reward is the private personal rewards which are strongly dependent upon individuals and they do not have explicit forms. Individual can only expect to receive private personal rewards by participating in social network interactions [12,16] and these rewards cannot be measured objectively. Here, we propose to use universal virtual rewards to be collected, reused and redeemed in an ecosystem of SSNs, in order to encourage more quickly the expected behaviours.

2.3 SSN Access and Openness

The main challenge for SSNs thus is to share content with heterogeneous systems including other social network systems and mobile terminals software. This is difficult when there are a variety of candidate technical options for developing a SSN, e.g. technologies used to build a SSN can include Java, JavaScript, AJAX, PHP, HTML, MySQL, FOAF, SPARQL, RSS, ATOM, etc. Existing solutions are mainly relying on communication protocol specific Web services e.g. SOAP [9] is used to communicate with external systems for service discovery and invocation. In [17] and [18] Restful Service is used for external systems communications. In the proposed system architecture, Restful Web services are chosen to support data exchange between loosely coupled components including infrastructural resources such as smart water meters and external social networks.

3 Towards a SSN Software Architecture for Efficient Household Water Use

There are different ways to create a system architecture. The system architecture presented here is component-based and it supports high cohesions within the components. This allows the system to perform well-defined functions and to loose the coupling between components. A component can be any software package, Web service or module that encapsulates a related set of functions or data [13]. The advantages of using a component based architecture include: Ease of development and deployment, reduced cost (e.g. free third party components) and reusability.

The ISS-EWATUS SSN system architecture consists of a set of components, working together in a distributed configuration. The ISS-EWATUS social media platform also uses resources offered by external components that are not themselves part of the platform, e.g., smart water meters in households to monitor water consumption. Users can interact with the system through application(s) on their mobile phone, or by using a more traditional web browser. The architecture (see Fig. 1) groups the ISS-EWATUS components into three categories, i.e. the ISS-EWATUS social media service, a Web portal, and external resources. After deploying the system, we envision the SSN will be able to provide the following features:

- **Online social interactions for efficient water use:** the social interactions will be used as instruments managing efficient water use and they are defined by referring to the efficient water use theory.
- **Universal Rewards for online and offline behaviours:** the expected interactive behaviours including online interactions and offline water saving activities will be rewarded. The metrics are based upon the data retrieved from external and internal components handling the user activities.
- **Openness:** The platform will make its interfaces open for integration with other social networking applications to share content. And its reward system will also simplify the communication between different social networking applications.

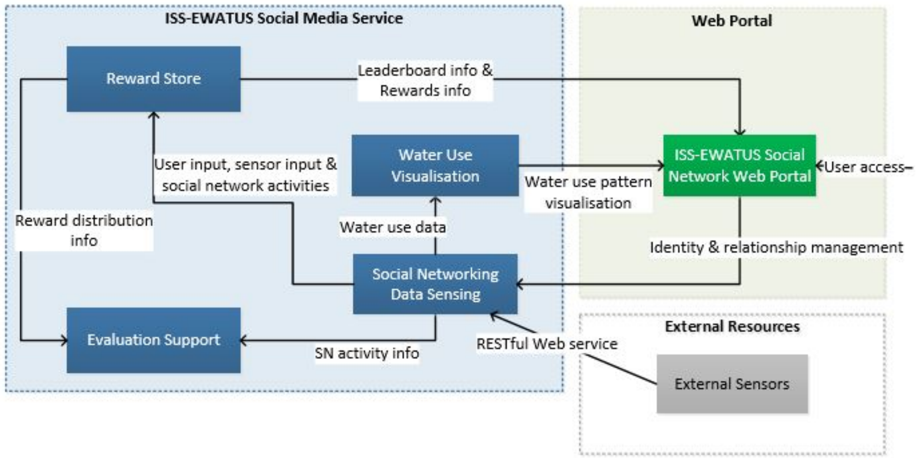

Fig. 1. ISS-EWATUS social media platform system architecture

3.1 ISS-EWATUS Social Media Service

There are four subcomponents within the ISS-EWATUS social media services: the Social Networking Data Sensing, the Reward Store, evaluation support and the Water Use Visualisation.

Social Networking Data Sensing

The Social Networking Data Sensing is primarily used to handle the data from user input and the data from external monitoring systems. These data include user identity, user online activities and those from other social networks. Apart from identifying and validating these data, the component also logs the data and dispenses the validated data to the expected components so that related components within the ISS-EWATUS social media service can always get the expected input.

ISS-EWATUS defines a set of social networking interactions in two steps. The first step is to define them based upon existing popular online social network interactions (including sharing information; getting recommendations; organising social events; playing games and keeping in touch with friends); The second step is to classified and tailored to support the efficient water use by referencing to the WCM (water conservation management) theory [14]. In the WCM, there are five categories of instruments used for efficient water use, they are: a) engineering (i.e. physical WCM equipment); b) economics (i.e. water price related information); c) enforcement (i.e. penalty measurements on water waste); d) encouragement (i.e. endorsement on water conservation behaviour); e) education (i.e. distribution on water conservation knowledge). Table 1 shows a set of social networking interactions defined in the ISS-EWATUS.

Table 1. Social networking interactions in ISS-EWATUS in terms of WCM theory

Instruments	**Social Networking Interactions**
Engineering	Completing a gamification offline task and win a physical prize
Economics	Sharing water readings with friends
Enforcement/ Encouragement	Reviewing information/recommendations with comments
Education	Sharing tips on water conservation; Take part in discussion; Reviewing information/recommendations with comments; Organising wise water use discussion; Playing water saving educational games

Reward Store

The Reward Store plays a key role in designing the social network tasks for the users. It is responsible for the user task design, rewards definitions, user task monitoring and reward calculations. The system will offer a GUI (graphical user interface) for designing task in terms of a set of task properties and the required time frame to complete the tasks and rewards for the tasks. The rewards can be defined in terms of points, badges and other virtual objects. Upon completion of tasks, the reward store will assign calculated rewards to the users.

In ISS-EWATUS, the rewards are designed to be universally recognised by leveraging the open credit systems such as credly.com[2]. The benefits of doing this are two-fold. First, this enables users to further use the rewards gained, e.g. to reuse or redeem the rewards gained from ISS-EWATUS for other services or goods elsewhere. Secondly, this, to an extent, helps promote the integration in an ecosystem consisted of systems of different domains especially if they share the same target users.

Evaluation Support

The Evaluation Support collects data from the reward store and the ISS-EWATUS Data sensing. It can produce the summative results of rewarding and other social network activities occurred within a defined time frame. The Evaluation Support is also designed to facilitate researchers to perform scientific functions such as statistical hypothesis tests. The stats indicators can be defined from inside or outside the ISS-EWATUS systems depending on the system goal. For example if the system goal is to reduce household water consumption lever by 5 %, then the indicator will be the readings of the water meter. There are different options to retrieve the information required by an indicator. Furthering the example above, other than asking a user to input the readings to the social network system, the meter readings can be automatically read by an external system, e.g. as a smart metering system used in ISS-EWATUS where fewer human interventions are required.

[2] http://credly.com/

Water Visualisation

The Water Use Visualizer defines the information required for describe water use pattern such as temporal, spatial, activity and cost. Water user visualizer will offer interfaces to receive defined data from other external components, it will also offer interface to end users to allow them to input information that cannot be obtained from external resources.

3.2 Web Portal

The Web Portal allows users with different access terminals such as smart phones, PCs to access the services offered by the platform. Apart from the authentication process provided by the ISS-EWATUS platform, users can also log in with third party social networks credentials, such as Facebook, Twitter etc.

3.3 External Resources

The *External Resources* include the smart water meters and external social networks that the platform will communicate with and they also include the household decision support systems and water companies decision support systems. The user profiles and water use related information can be shared among all these resources. The ISS-EWATUS platform is able to offer anonymous online user profiles and rewarding information to heterogeneous systems. The data exchanges are done via Restful Web services.

4 Conclusion and Further Work

We presented a software architecture with the aim of supporting the design and the implementation of a specialized social network system for managing efficient household water use. We demonstrated how the architecture addresses the related challenges by defining and orchestrating the proposed components. A special attention is given to the openness of the interfaces and the interaction of the proposed architecture with an ecosystem of related platforms, with which our platform will be able to share the results of the interactions between users as well as the points gained in the proposed activities.

The next steps are to implement and to evaluate the proposed approach in the context of the ISS-EWATUS European project. We aim to find out how effective the social interactions and incentives can influence users' behaviours. This will be done via two methods, one is via continuous collecting and analysing the quantitative data from the systems including both within the platform and associated external systems; and the other is to analyse the qualitative data periodically retrieved from questionnaires and focus groups on using the system within and outside the project consortium.

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