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# Prioritizing Use Cases for Water Smart Technology Development: Similarities and Differences from Portugal and UK Case Studies

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**Abstract**

This paper describes the process of use cases prioritizing by ranking their usefulness to improve water losses, control and water-energy efficiency in networks, to provide new services to the consumer, to improve billing systems and pricing schemes, to improve leak detection and water-energy efficiency and to develop better services to consumers. Results showed that priority use cases were to obtain water consumption data, understand water consumption and assist consumers to increase water use efficiency (consumer domain) and to obtain water and related energy consumption data, understand water consumption and get support to increase operational efficiency (water utility domain).

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## 1. Introduction

One of the most important barriers to efficient water-energy use in water distribution systems is the lack of sufficient data about water and related energy consumption in the network and at the consumer level, which poses a challenge in identifying appropriate measures to promote efficiency and water consumption behaviors. Smart meter technologies allow for the identification of when and how much water is being consumed, as well as opportunities for efficiency improvements, namely efficient water use in the household and utility-level control of water losses and cost-benefit water planning. Developed within a wider research and innovation project (iWIDGET - Improved Water efficiency

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through ICT technologies for integrated supply-Demand side ManaGEmenT), the present paper identifies and describes the range of relevant use cases to be addressed by the system in improving efficient water and related energy consumption for water utilities and water consumers.

The concept of use cases is used by different science communities, sometimes without a clear definition. In the scope of the present paper, a formal definition as used in the information systems and system modeling domains was preferred, referring to use cases as one of the modeling techniques used to model the behavior of systems in the Unified Modeling Language (UML). UML is a general-purpose modeling language that includes a set of graphic notation techniques to create models of information systems. UML diagrams are split into structure diagrams (things that must be present in the system) and behavior diagrams (modeling the functionalities of systems). Use cases are part of the behavior diagrams and are "means for specifying required usages of a system" [1]. In general, use cases are used as a basis to capture the requirements of a system (i.e., what a system is supposed to do). Use cases are usually based on three main concepts: i) Actor (specifies a role played by a user or any other system that interacts with the system); ii) Use Case (specification of a set of actions performed by a system, which yields an observable result of value for the actors/stakeholders of the system); iii) Subject (the subject is the system to which use cases apply to). The scope of the considered use cases comprises urban water distribution systems and residential systems and was conceived by attending to two different targets: consumers and water utilities [2,3,4].

For the consumer domain, the goals of the use cases were to:

1) Promote easier, faster and more flexible access to detailed water consumption data and related energy consumption in the household;
2) Promote an effective control of water uses and appliances at the household level;
3) Enable consumers to understand their water consumption patterns and related energy consumption patterns;
4) Assist consumers in changing wasteful behaviors and appliances.

For the water utility domain, the goals of the use cases were to:

5) Improve understanding of metered water consumption and related energy consumption and water losses;
6) Improve domestic demand management;
7) Improve operational planning and long term asset management;
8) Promote easier, faster and more flexible access to accurate data;
9) Enable the water utilities to improve the quality of service provided to the consumers;
10) Optimize real-time operation in terms of water-energy efficiency.

## 2. Methods

In order to obtain a harmonized list of use cases, a two-step methodology was used. First, a list of high-level use cases was compiled and described and harmonized. High-level use cases were used to describe the main processes in the iWIDGET system and were aligned with the project objectives. Harmonization aimed to balance the level of detail between use cases, finding equivalent or overlapping use cases, identifying conflicting objectives or use cases. For each high-level use case, a list of detailed-level use cases was subsequently compiled, described, and harmonized.

At a second stage, the proposed high-level use cases were validated and ranked, based on the contributions of two different target audiences: (1) the project partners and (2) national stakeholders who attended a dedicated workshop held in Lisbon (February 2013) and in London (June 2013) (see Table 1). Both workshops were conducted with the main objective to discuss and validate the list of the use cases previously identified within iWIDGET and to provide new use cases (see Tables 2 and 3) and included two brainstorming exercises. The first brainstorming exercise was composed of two tasks. First, each participant was asked to generate relevant use cases for smart meters in urban water services, from the perspective of a water utility and a consumer. Second, the stakeholders engaged in group discussion to reach a consensus as to the three most relevant use cases for the consumer and the water utility perspectives. One delegate of each group presented the selected use cases to the audience. The second brainstorming exercise was an individual one and consisted of the prioritization of iWIDGET high-level use cases previously presented to the stakeholders using a 3-point Likert scale (3 = UC is highly relevant; 2 = UC is relevant; 1 = UC is not relevant). Prior

to that evaluation, stakeholders were informed about the prioritization criteria for the water utility and consumer domains and made their prioritization based on the criteria presented in Table 1.

Table 1. Criteria for the use cases prioritization.

| 1) Does the use case help a water utility to: | 2) Does the use case help the consumer to |
|---|---|
| a) Improve water losses control; | a) Improve leak detection; |
| b) Improve water-energy efficiency in networks; | b) Increase water-energy use efficiency; |
| c) Enhance data management and integration among information systems; | c) Benefit from a better service or from new services; |
| d) Provide new services to the consumer; | d) Decrease the water-energy bill. |
| e) Improve billing systems and pricing schemes; | |
| f) Make more sustainable planning. | |

With these criteria in mind, each stakeholder individually evaluated the relevance of each high-level use case. An overall rating was obtained for each UC corresponding to the average evaluation assigned by project partners and by the stakeholders (Portugal; [PT] & UK).

## 3. Results

The 36 participants in both workshops represented various organizations, including water utilities, consumer organizations, technology providers, government organizations, companies with experience in the energy domain and research organizations and consultants (Table 2).

Table 2. Stakeholders' organizational membership.

| Organizational membership | PT | UK |
|---|---|---|
| Water utilities | 9 | 7 |
| Consumer organisations | 3 | 1 |
| Technology providers | 3 | 0 |
| Government organisations | 6 | 1 |
| Companies with experience in energy domains | 4 | 0 |
| Research organisation/consultancy | 0 | 2 |
| Total | 25 | 11 |

Table 3. Use cases identified by the stakeholders (consumer domain)

| Domain: Consumer | | PT | UK |
|---|---|---|---|
| Information | Data about profile and historical consumption data | √ | √ |
| | Data to support increasing water efficiency | √ | √ |
| | Data for billing (e.g., flexibility, increased reliability) | √ | √ |
| | High usage alerts (e.g., via an app) | | √ |
| | Increased understanding of billing through linking utility bills (i.e., water and energy) | | √ |
| | Comparison data/benchmarking with neighbours and other consumers | | √ |
| Control | Alerts to leaks at the domestic side | √ | √ |
| | Access to different pricing schemes | √ | √ |
| | Alerts to consumption above pre-set amount | √ | |
| | Ability to have flexibility in billing/tariffs to manage consumption costs | | √ |

The production of new iWIDGET use cases in the first brainstorming exercise for both domains (consumer and water utility) was categorized through content analysis process into two different themes – information and control – since the content of the use cases is related to general information on the use and control of water consumption [5].

As presented in Table 3, both PT and UK stakeholders agree that data about profile and historical consumption data, data to support increasing water efficiency, and data for billing are relevant use cases (information theme). In addition, UK stakeholders identify that high usage alerts, increased understanding of billing through linking utility bills (i.e., water and energy), and comparing data/benchmarking with neighbours and other consumers are also relevant use cases in the consumer domain. In the control theme, both PT and UK stakeholders identify as relevant the use cases related with alerts to leaks at the domestic side and access to different pricing schemes. The PT stakeholders also identify the alerts to consumption above pre-set amount, whereas the UK stakeholders recognize the ability to have flexibility in billing/tariffs to manage consumption costs as a relevant iWIDGET use case.

Table 4. Use cases identified by the stakeholders (water utility domain)

| Domain: Water Utility | | PT | UK |
|---|---|---|---|
| Information | Data for real time water balance | √ | √ |
| | Data to support communication with consumers | √ | √ |
| | Data for consumption profiling | √ | √ |
| | Increase water use awareness through social comparison campaigns | √ | √ |
| | Data for system simulation | √ | |
| | Data for better network management | | √ |
| | Inform tariffs and billing information offered to consumers | | √ |
| Control | Warnings about leaks in the distribution system | √ | √ |
| | Distribution system management/operation | √ | √ |
| | Warnings for client management (e.g., detection of abnormal flows, meter malfunction) | √ | √ |
| | Warnings to client (e.g., atypical consumption) | √ | √ |
| | Support for billing | √ | √ |
| | Control of consumption in emergency/drought | √ | |
| | Better and more efficient demand management | | √ |
| | Improved financial management for utility | | √ |

Regarding the water utility domain (Table 4), both PT and UK stakeholders agree that data for real time water balance, data to support communication with consumers, data for consumption profiling, and increasing water use awareness through social comparison campaigns could be considered as relevant iWIDGET use cases (information theme). In addition, PT stakeholders also consider that data for system simulation might be a relevant use case, whereas UK stakeholders include data for better network management and the information about tariffs and billing to consumers as relevant use cases. Finally, within the control theme, all the stakeholders agree that warnings about leaks in the distribution system, warnings for client management, warnings to client, support for billing and distribution system management/operation are important water utility use cases. PT stakeholders also refer the control of consumption in emergency/drought to the list of significant use cases, while UK stakeholders find that better and more efficient demand management and improved financial management for utility should be also considered as pertinent use cases (water utility domain).

As noted earlier, the second brainstorming exercise evaluated all the consensual use cases (project partners and national stakeholders) regarding their relevance for iWIDGET system development. Tables 4 and 5 present the results obtained.

For the consumer domain, the overall evaluation considers the use cases related to obtaining water consumption data (UC01) and getting assistance to increase water use efficiency (UC05) as the most useful (2.6), followed by the use case “understand water consumption” (UC03). Lowest priorities were given to energy related use cases (UC02 & UC04) and control water use (UC06). As can be seen, the most relevant use cases correspond to more consensual evaluations among audiences. The use cases that divide the opinions are the ones linked with energy associated with

water consumption and control water use, where UK stakeholders evaluate energy related use cases as more relevant and PT stakeholders consider control water use as more pertinent (Table 5).

Table 5. Use Cases ranking for the consumer domain

| Domain: Consumer | Partners | PT | UK | Overall |
|---|---|---|---|---|
| Use Case C01: Obtain water consumption data | 2.7 | 2.6 | 2.5 | 2.6 |
| Use Case C02: Obtain energy data associated with water consumption | 1.9 | 1.9 | 2.3 | 2.0 |
| Use Case C03: Understand water consumption | 2.6 | 2.2 | 2.6 | 2.5 |
| Use Case C04: Understand energy associated with water consumption | 2.0 | 1.5 | 2.5 | 2.0 |
| Use Case C05: Get assistance to increase water use efficiency | 2.8 | 2.4 | 2.5 | 2.6 |
| Use Case C06: Control water use | 2.1 | 2.3 | 1.5 | 2.0 |

For the water utility domain (Table 6), the use cases regarding the access and understanding of water consumption data and getting support to increase operational efficiency (UC01, UC02, UC04) were assigned with higher priorities (2.6-2.8). The overall evaluation considered the use case intended to understand energy associated with water consumption (UC04) as having the lowest priority (2.0).

Table 6. Use Cases ranking for the water utility domain

| Domain: Water Utility | Partners | PT | UK | Overall |
|---|---|---|---|---|
| Use Case WU01: Obtain water and related energy consumption data | 2.8 | 2.7 | 2.6 | 2.7 |
| Use Case WU02: Understand water consumption | 2.8 | 2.9 | 2.1 | 2.6 |
| Use Case WU03: Understand energy associated with water consumption | 2.0 | 2.3 | 1.7 | 2.0 |
| Use Case WU04: Get support to increase operational efficiency | 2.8 | 2.9 | 2.6 | 2.8 |
| Use Case WU05: Get support to increase quality of service | 2.3 | 2.2 | 2.7 | 2.4 |
| Use Case WU06: Get support to improve consumers' efficient water use | 2.4 | 1.8 | 2.4 | 2.2 |
| Use Case WU07: Get support for system planning and design | 2.3 | 2.6 | 2.0 | 2.3 |

The use cases related with understanding water consumption, energy associated with water consumption and getting several types of support (to increase quality of service, to improve consumers' efficient water use and for system planning and design) are the most non-consensual among stakeholders. PT stakeholders consider understanding water consumption and energy associated with water consumption as more relevant use cases than UK stakeholders. UK stakeholders considerer that getting support to increase quality of service and to improve consumers' efficient water use as more relevant use cases than support for system planning and design (Table 6).

## 4. Conclusions

The general results identify and characterize a range of relevant use cases to improve efficient water and related energy consumption in water utilities and water consumers using smart metering technologies. A comprehensive list of high-level use cases was compiled for two domains: consumer and water utility. For the consumer domain, six high-level use cases were ranked and for the water utility domain seven high-level were ranked with higher priority to be implemented in the iWIDGET system.

The list of use cases covers a comprehensive range of possible usages that can be built upon the exploitation of data related to water and energy use in water distribution systems and in households. The list of the most relevant use cases should drive the subsequent tasks of the project, at least on a first approach. The methodology used in iWIDGET for use case description proved to be adequate to identify functionalities useful for efficient water and energy use in water distribution systems and in the households, using smart metering systems.

Regarding the similarities and differences between PT and UK stakeholders use cases ranking the results support a general consensus on priorities for the utility and consumer domains in the most relevant use cases. The less consensual evaluations refer to less priority use cases. For the consumer domain, the use case related with energy-water consumption was more relevant to UK stakeholders and PT stakeholders consider control water use as more

significant. For the water utility, understanding water consumption and energy associated with water consumption are more relevant use cases for PT stakeholders, whereas UK stakeholders considerer that getting support to increase quality of service and to improve efficient water use as more relevant use cases.

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