A Service Science and Engineering Approach to Public Information Services in Exceptional Situations - Examples from Transport

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Abstract. ITC based information services are widely used for providing or accessing information on a daily basis. In exceptional or emergency situations relevant information could be sent to citizens in order to elicit improved responses. There are examples of using mobile devices to reach users, e.g., in some countries, citizens have received text messages with relevant information about H1N1, such as a list of the main symptoms and a telephone number to call in case of emergency.

This paper proposes the *Contemplate* initial extension to the engineering CDIO process (conceive, design, implement and operate) and stresses out its iterative nature as a framework suitable for new service design, in our case for emergency or exceptional information services. Although the proposal is applicable in general, this paper uses examples from public transport in urban areas. Road works, congestion, and accidents are examples of undesirable influences on public transportation. Technologies such as GPS, mobile communication devices, databases, data mining and other approaches for profiling user activities with careful individual and social considerations could be used to improve the quality of service and quality of life in cities.

Keywords: Service science, service development framework, transportation, exceptional information services.

1 Introduction

Service Science, Management, and Engineering (SSME) has been proposed as a new study field required to face the challenges of the increased predominance

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of services in the world economy. According to [7] "there is a need for a new science of service systems, which aims to increase service innovation by applying scientific understanding, engineering discipline, and management practices to designing, improving, and scaling service systems".

There has been a wide range of research in SSME, in particular changing the focus of existing work from *product* to *service.* This shift is particularly visible in the marketing area, where the work of Lusch and Vargo (see for instance [6]) has been contributing to establish a service-dominant logic with concepts at the core of service science.

This paper acknowledges these efforts and proposes to apply the well known engineering process, based on CDIO (conceive, design, implement and operate, www.cdio.org), to the development of services. Given the experience of one of the authors in several projects in the public transport area, this work relies on examples of information services under exceptional situations related to transport. This seemed to us to be an area where new technologies that are being deployed could enable innovative services to be defined under demanding requirements. This paper can therefore be seen as a contribution towards bringing an engineering framework into the SSME field of study.

1.1 Context

Urban life is characterized by movements of people that follow daily, weekly and yearly patterns. When something goes wrong or when the situation does not follow the usual patterns it is usually difficult for people to know what is happening. Current technologies could help to overcome both the information gap and to provide useful alternatives in case they exist.

For instance, suppose you are in a train, metro or a bus and it stops for a few minutes or more time. Or suppose you are waiting for a bus, but there was an accident that will make it arrive over half an hour late at your bus stop. But other exceptional occurrences may involve special gatherings of people, say for a large concert, sport event, or political gathering.

Existing information and communication technologies can be used to identify relevant users in need of information and provide them with useful information. In some cases guidance can also be provided. For instance, in the case when a train breaks down, or there is a strike, affected users could receive information on alternative transport. To be acceptable to receive unusual information, some aspects must be taken into consideration. Some people may like to receive information, but others may see that as an intrusion. Therefore some careful steps must be taken in order to assure that such emergency information services are acceptable. If we could guarantee that information provided was always 100% accurate it would be simple to make such services available. But it is usually the case that does not happen.

Exceptional or emergency situations could be defined as situations that are not planned and that no forecasting system could determine accurately the place or time when they would occur. Depending on the type of situation, more precise definitions could be provided. For instance, in transportation, there are planned timetables, and there is a known distribution of variability. But no forecasting system can predict major accidents. Therefore, it could be defined that exceptional or emergency situations involve situations where users' plans would be affected over a certain time for instance, over thirty minutes.

The examples used in this work will assume such situations.

1.2 Relevant Technologies

There are three levels of technology involved in information services for exceptional situations:

- The delivery technology (e.g., mobile devices and networks);
- The technology to identify relevant information (e.g., GPS systems in buses and transit supervision systems that detect that a particular bus will be very likely to be 30 minutes late due to congestion or accident); and
- The technology to match information to users in relevant areas (e.g., data bases/data mining to determine that a particular group of users is likely to need such information in a particular area and time).

Although we could think of many technologies to be used for supporting public information services in exceptional situations, the most likely candidates will need to be available in such exceptional situations. Mobile devices and underlying systems, such as communication networks, will be the most interesting ones to consider. Framework services could be text messaging or mobile Internet. Large visible displays available in public places, including the TV networks or cable TV, or public speaker systems, including radio networks, could also be used. A mix of such channels or interfaces would be even more effective in many situations, although in many cases only one would be available or would reach the user or customer.

When inexpensive and widespread mobile devices with GPS and permanent Internet are available, information services may offer even more support in exceptional situations. Although it is already possible to identify the position of a cellular phone using cellular triangulation, telecommunication companies do not usually let that information be available except in emergency situations.

However widespread mobile devices are, we need also to find the appropriate information for each situation and for each user. In order to achieve this goal we can start both with data that characterizes users' patterns and relevant data to help them in those exceptional situations.

For instance, transport users have usually to validate their transport card, either when entering the transport system and/or when leaving it, leaving behind a rich history of transport behavior. In case of unusual events, for instance involving heavy delays in a particular route, users that are likely to be involved could be sent relevant information for other transport options. Section 2 and 3 will provide further details on this example.

An alternative to finding patterns in users' data would be to have the user cooperation. With appropriate information and publicity, some users could provide relevant information or demand information services. It could be thought of that a user may register to get relevant information on a particular route and wishes to receive updates on changes to that route, either planned in advance, or exceptional. Users could receive such information over the Internet, trough email, social networks (e.g.: Twitter, Facebook, Hi5), or messages in the mobile phones. A possibility would involve that each user could define a set of possibilities having to do with the channels to be used, and perhaps the timing and place (if the location of the user could be determined based on the position of the registered mobile device). But such registration process may be difficult to master for the large majority of people and even more difficult for irregular users. Unsolicited exceptional information must then be relevant and accurate, and of course it would be important that users may provide feedback, to improve the services or to make sure that they are removed from the service if they so wish.

Applying sound service science principles to the study of people, technology, and systems will be essential to select the appropriate technologies, develop the relevant services, always having in mind the needs of the users, both as individuals and as a social group with habits, rules, and laws. To develop the relevant services, an engineering discipline will be required and we propose to base this on the CDIO, conceive, design, implement and operate, process.

1.3 Main Foundations for the Proposed Framework: SSME and CDIO

The framework described in this paper is based on service science foundations, in particular SSME – Service Science Engineering and Management, as proposed by [9], and Service-Dominant Logic, as proposed by [6]. Moreover, it follows the engineering process approach that is currently used in many engineering schools as a basic reference, the CDIO™initiative (www.cdio.org).

According to [9], a service system is a "value–coproduction configuration of people, technology, other internal and external service systems, and shared information (such as language, processes, metrics, prices, policies, and laws)."

According to [6] "Advancing service science requires a service-centered conceptual foundation [...]. The primary tenets of service-dominant logic are: (1) the conceptualization of service as a process, rather than a unit of output; (2) a focus on dynamic resources, such as knowledge and skills, rather than static resources, such as natural resources; and (3) an understanding of value as a collaborative process between providers and customers, rather than what producers create and subsequently deliver to customers."

The CDIO™initiative is "an innovative educational framework for producing the next generation of engineers. It provides students with an education stressing engineering fundamentals set in the context of Conceiving – Designing – Implementing – Operating real–world systems and products. The CDIO™Initiative was developed with input from academics, industry, engineers and students. It is universally adaptable for all engineering schools." (www.cdio.org).

Although the original CDIO is targeted at "real-world systems and products", our work shows that it can also be adapted or applied to service systems, offering therefore a suitable process for the engineering and management of services, taking into consideration the service-centered conceptual foundation: service as a process, focus on dynamic resources, and value as a collaborative process.

CDIO is a simple, abstract, and multidisciplinary overview of the well known engineering approach. It related well with specific engineering process models and frameworks, such as the software process. The conceive stage includes requirements elicitation and systems specification, design includes architecture definition, implementation includes testing and deployment, and operation includes maintenance.

This paper proposes an improvement on CDIO, adding a *Contemplate* stage. Such stage is also considered under a service-dominant logic, keeping in mind that one is interested in *contemplating* the *service system.*

1.4 Relevant Aspects of Information Services on Exceptional Situations

Information services that may be used by a large number of people in exceptional situations must therefore be providing relevant value for the users in such exceptional situations. Such services have to rely on:

- knowledge from users' habits;
- use normal users' language;
- obey to regulations and local law;
- focus on very dynamic situations; and
- involve an ever improving collaborative process between providers and customers.

This is required to make sure that the service will adapt to the evolution of users' needs.

Moreover, a very sound business model must be underlying the services, from the beginning of the process.

As usual, testing ideas and concrete proposals, in all steps of the CDIO process, will be fundamental for developing relevant information services on exceptional situations. If exceptional situations are also critical, a good understanding of the risks involved in providing inaccurate information is also very important. For this purpose, users associations, relevant social groups and legal experts may need to be involved in the process. As will be seen in the next section the Contemplate extension to the CDIO process attempts to improve and focus on one of the stages. The stress on the iterative nature of the process is denoted by a loop, which is followed continuously and possibly many times during the whole service design process.

1.5 Organization of the Paper

In section 2 we present the proposed framework for public information service development, as an extension to CDIO, and in section 3 we introduce some examples of information services that may be used under exceptional situations involving public transport. Section 4 highlights some relevant conclusions that we have learned from thinking about the development process for such services, and indicates areas that will need further research in order to improve the overall framework.

2 The CCDIO Loop

In this section we propose an extension of the CDIO framework, the CCDIO loop - Contemplate–Conceive–Design–Implement–Operate (see Fig. 1). The individual stages will be discussed later in following subsections, but first we refer to various categories of new services. The CCDIO loop: it is a loop because after the 0 stage is reached, there is a new contemplate stage. In fact, contemplate can start after any CCDIO stage.

According to [1], there are several categories of new services. There are three categories dealing with already existing and stable services for a given provider. There are services so called *cost reductions,* which are basically already existing services or very similar to existing services offered at a lower price. A usage of existing services in different market segments or whole new markets is a category of *repositioning services.* Services that bring improvements in performance to current services and as such replace current services are seen as *improved services* (or *revisions to existing services*).

Another three categories focus on brand new services. A category of services which are *new to the world* represent such services which are seen by the customer as new and/or surprising. Often these services are a great challenge for the service provider. *New service lines* represent a category of services which are new for the provider, but customers/users can have a chance to experience them thanks to the offering of a different provider, often in the same space (e.g. locality or cyberspace). And there are of course *additions to existing service lines.*

One of the advantages of the CCDIO loop is that it covers all these categories and supports the overall process of new service development. It is possible to enter the loop at two stages, either in the contemplate–conceive sub-loop or within the operate loop. Depending on the entrance point, following the CCDIO loop is then more suitable for a brand new services or for improvements of already existing ones respectively. The objective of the framework is to make sure that all steps are followed when contemplating, conceiving, designing, implementing and operating information service systems. User validation and system testing are essential parts of this framework. Social validation is also required.

The CCDIO loop describes the process of a new public information service development with a five step iterative framework. The main steps are as follows: Contemplate–Conceive–Design–Implement–Operate.

Before we will describe every step in more detail in the following subsections, we would like to comment the framework as a whole. First, we would like to talk about the loop. It is important that the new service development follows a spiral loop, which leads to an improvement or even a complete new offering. The contemplating and conceiving phase are followed by designing a service leading

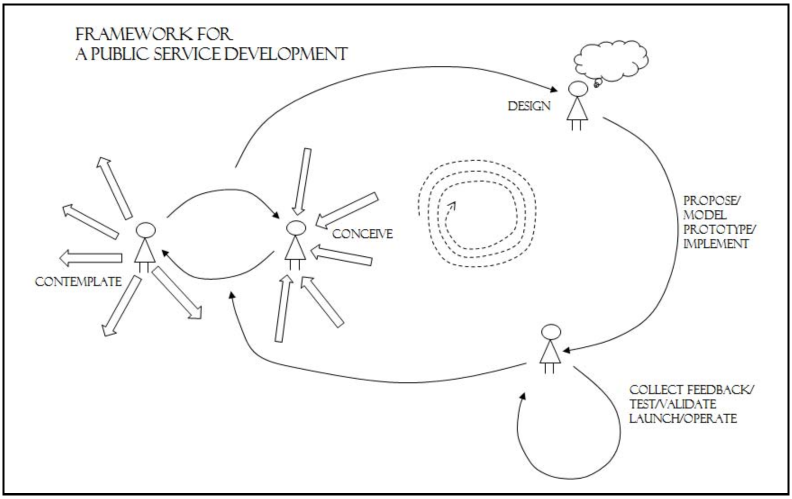

Fig. 1. CCDIO Framework for new public information service development

to a sound proposal. Collection of the feedback in some form is necessary for us to be able to contemplate and conceive again. Following the CCDIO loop again, we would go through redefining the initial ideas and possibly move to a service prototype with its testing and validation. Feedback will take us again to the phase of contemplating and conceiving. At this point, dependently on the success of previous loops and phases within the loops, the provider might be ready to implement the service and launch it.

To develop a new service, we need a sequence of steps, which need to be followed in a given order. For example, it does not make much sense to validate non–existing services or to prototype services without knowing and understanding the subject matter.

While designing a new service, it is very likely that we will have to handle vague information and learn new things on the way. Customers, who have to be involved into the service creation, can agree on the fact, that "something is missing" or "something could be done better", but sometimes to realize what is the good solution can require to go through the loop more than once.

The framework contains two sub-loops. One is the loop between contemplating and conceiving. Contemplating is more a passive activity of mapping the domain, while conceiving is more about active combination of possibilities and finding out interesting perspectives, helpful to the (potential) users of the service. These two phases are continuously switching until the provider believes it is time to come up with a solid design. A second sub-loop is at the stage of operating.

The framework serves as a simple conceptual lead not to omit some important issues. The proposed steps themselves are not surprising at all, but their usage according to the rules and the focus on the user had proved the usability of this framework and an example will be discussed further on.

In the following subsections we will describe the individual steps in more detail.

2.1 Contemplate

As Fig. 1 shows, this step is about searching around and looking for new or interesting incentives. This step is also about simple mapping of a situation. It gives us the overall picture of a domain, but also we should be aware of some important details.

When we are contemplating the landscape for a new public service (or an actual service improvement), we are trying to understand what is the particular domain about and what is possibly missing there. The questions which have to be asked are:

- What is the domain about? What is important the domain for the users (public)? What can bring the service/information closer to the user? How is the public served in exceptional situations?
- What are the boarders of the search? How far/deep we intend to go?
- What channels are used? Which channels are suitable for the users to spread the information according to given situation? ([8])
- What is missing? Is everything as we would expect when using the public service? Is it understandable?

To pass this phase successfully, we recommend using common practices and techniques of ethnographic research to collect data. We mention here an Internet or library search and interviews and/or questionnaires as the simplest ways of data collection. Social networks can be used as well to ask around friends or business partners to share their views. Another way of gaining the information and insights is use of crowdsourcing as it was used by IBM online jam session of university students on April, 2009, who were discussing the matters of the Smarter Planet ([3]).

Moreover, since public transportation is meant to be for the public, to get data to better understand the end users is the objective of this phase. Examples of large sources of data for later data mining and pattern searching result from photo and video recordings (as it was used e.g. in SAS airlines by Doblin Group (http://doblin.com). These sources are a channel for direct observations in real situations.

From the side of a mental effort this is activity (conceiving phase) that can be viewed as a more passive one and serve for orientation and positioning oneself in the domain.

We started the contemplating phase thinking about the domain of public transportation in Porto, Portugal, and about how transport information services could be improved. There are many providers of transportation but the overall service and also the service information is very dispersed. According to Service Aspect Star [5], we analyzed the situation from all seven perspectives - *Who: Agent – What: Outcome – Where : Location – When: Time – How much:*

Evaluation – Why: Rule – How: Process. The focus on every individual aspect helped us to find out a space for improvements of information services in Porto. One of the identified points was to handle exceptional situations in public transportation (referring to the aspect of time). During this phase important questions were identified:

Who: Which agents are going to be involved in exceptional situations?
Where and how: How can we reach them? Which relevant channels regarding their position can be used? What kind of rules we will use to decide the relevant channel?
How much: How are we going to build a business model capturing exceptional situations?

The aspects *Why: rules* and *What: Outcome* will be handled later depending on the answers to previous questions.

2.2 Conceive

The next phase Conceive can be considered as a more active one. It focuses on active selecting and sorting out the important information. The problem nowadays is that there is an information overload in nearly every domain and to select the right information is a demanding task. There are approaches which could be used in this phase to build upon the results from the previous contemplating phase. We would divide them into two sub-phases: a differentiation of patterns and a new ideas generating [2].

While trying to differentiate patterns, we focus on following questions:

– In the observed domain, are there any behavioral patterns of the agents? Which are the ones more obvious? Why are the patterns there? Do they signal positive acceptance of a service or do they express a common failure of actual service setting?
– Can we abstract from our domain to another one? Is there a domain with similar rules or patterns (even not related to the observed one)? Did we witness similar settings in another domain? Do the relationships between individual elements remind me of another domain?
– Do we have all the information needed or do we have to contemplate a bit more?

The conceiving phase enable us to have an insight into the domain and help us to deconstruct the domain elements to understand it more fully. To define new offerings, the techniques of generating new ideas are used. Except the ones mentioned in previous section (crowdsourcing, asking around, and other ethnographic techniques), we recommend to employ for instance storyboarding, mind mapping, brainstorming, or metaphorical thinking.

The information about public transportation in Porto region is fragmentary. Our analysis fully approved the following statement, in particular from the view of foreign visitors of the city. There are "[...] services offered by many different companies, as well as across the different functional units within a single company. These service "fragments" all add up to an experience that can be disjoined and exhausting. In addition to the fragmented experience any single problem along the way tends to be associated with the "major" service provider, fairly or unfairly. This is especially so when the service experience is poorly defined, with unclear boundaries of responsibility." [2]. New services integrating information of different means of transportation are being identified [4].

2.3 Design

The design process follows the sub-loop of contemplating and conceiving in the CCDIO loop. Within the designing process we typically set up new settings of elements and make them visible for other stakeholders of the designing process. In this phase we create the first proposals and/or prototypes and/or implementations based on findings from the previous phases. At this stage, the clear picture of the proposed solution should be finished, even though it will be most likely changed during the active feedback later on. In Porto, we are in the stage of a new service proposal. Nevertheless, some important issues were already decided. The location aspect (of the Service Aspect Star), defining the boundaries of the system, were set to the Porto metropolitan area. When identifying agents involved in the exceptional situations in public transportation, we identified the following groups:

a) *vehicles (buses, trains and metro trains)* - every bus is equipped by GPS and the information about its location is obtained real time in every few seconds, trains and metro trains are connected with the stations through radio to exchange the messages about the location and situation. Also, to enter the bus or the area of the metro, every user is obligated to swipe an electronic chip card through the reading device. The same obligation holds for transfers as well. Therefore, it is possible to follow up a direction of his/her movement, but not the whole trip, as the validation does not have to be done when leaving the transportation system;
b) *users of public transportation*, which are separated into three groups:
   i) *actual/present users* - these are traveling passengers or the ones expecting the arrival of the vehicle in a near future
   ii) *expected users* - these are such passengers, who usually travel at given time through given location
   iii) *past users* passengers, who used a given means of transportation in given time in the past

The users/customers are either identified by using the personal electronic chip card with pre–paid service, or not identified in case of using individual trip tickets. The service provider here is represented by drivers and other public transportation personnel.

The most common exceptional state in the public transportation is a delay of a vehicle. Such delay can be caused by accident ahead, heavy traffic on the streets or detours because of street work. The *primary need* of the user in such situation is to be informed about *what caused the delay.* The *secondary need* is to be informed about and offered some *possible solutions.* The needs are forming the design of the service. The possible location of the user is denoting a group of information channels.

The situation is pictured on Fig. 2. Let us say, there is an accident on the road ahead of the bus. The engine/information system, which receives the regular information about the bus location through the GPS, deduces a major discrepancy between the bus location schedule and the actual location of the bus. The information system follows the scenario for every user group.

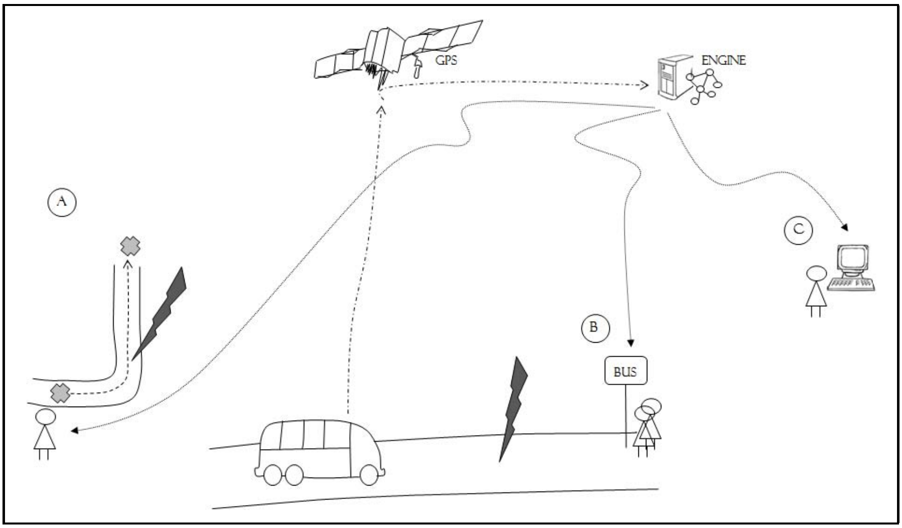

Fig. 2. Scenarios for agents of the system

i) *present users* - (case B on Fig. 2) two possible channels can be used to pass the information about the delay, its length and possible alternatives: either electronic information boards used on relevant stations, or a mobile network. A selection of subset of present users can be done based on behavioral patterns found in data of identified users;

ii) *expected users* - (case A on Fig. 2) two possible channels can be used to pass the information about the delay, its length and possible alternatives: either a mobile network or the Internet. Through a mobile network, we can reach the identified users, who are willing to receive such service, and according to their behavioral patterns are classified as expected users. An example of the pattern can be that the user, every work day validates her transport card at a certain bus stop in the critical time period and did not validate it yet.

The Internet offers also a few reasonable possibilities: the information will be shown on the home web page of the service provider, but can also be displayed through social networking platforms. For instance, a Facebook account of the public transportation company or a Twitter account for informing relations about new status. The relevance and individualization of the messages might be based on the information about identified users, but basically, this channel would be devoted more to all users (i.e., the identification does not play a role here);

iii) *past users* - (case C on Fig. 2) two possible channels in this case: a mobile network and the Internet. In the case of identified user, we would be looking for particular individuals who were traveling in a certain time through a certain location (for example in case of witness search or other case of identification of past passengers). The reasons for looking for past users may be very rare, but the way to reach both, identified and non-identified, users is analogical to the previous case. Privacy of information must be assured, and only statistical data may be collected.

The phase of design leads into the activities such is working on a proposal, modeling, prototyping or implementation of service which are under development. The crucial part of outputs of these activities has to be focused on possible business models.

2.4 Implement

Once we are clear on the design, i.e. with structure of individual elements and their relationships, with processes which need to be taken into account in given domain of proposed service, we are ready to work further on. These activities lead to proposals in the first stages of the service development and their further negotiations. In later stages (later, repeated pass through the CCDIO loop), models or prototypes are done. The last stage is devoted to the implementation and results in a working service.

The outputs (proposals, models, prototypes, implementations) have to cover the core needs identified in earlier stages of the development.

In Porto, we are now in the first or second cycle of the CCDIO loop, working on the sound proposal for the public transport companies based already on expressed needs and ideas of the (potential) users.

Exceptional situations are not happening very often and for assurance of later ease of the process, we have to start to think about modeling possibilities of these situations together with probability models to be able to test them as well later on. At the beginning, the model will not be very difficult since the agents - users - can have only very few states: not-traveling, traveling before transfer, and states referring to every transfer. The states of the vehicles can be at the beginning set to: at the bus stop, between bus stops, in a depot.

The communication channels were set in previous phases, but the communication protocol was not discussed yet. In this case, we mean the communication between the users and provider about their interest of this service. This activity is very closely linked to the business model. This service could be offered to volunteering customers/users, who would be willing to collaborate on improvements of initial versions. Later on, an improved service could perhaps be offered for a monthly payment. In Porto transportation domain, the hardware support is already available - GPS in the buses, radio in the trains and metro trains, SmsBus^{TM}- a real time service handling user requests about transport connections at particular bus stops and database of the trips of passengers. The new service could use current technologies in different ways.

2.5 Operate

The operate state covers few more actions, which precede to the final operating status - it is about the feedback and critical insights on usability and value added by the service. At this stage the main focus lays on involvement of the customers. The operation state provides a space for collaboration.

– Is the proposed output (proposal, model, prototype, and implementation) considered as useful and usable? Is the participation in this service comfortable (e.g. does it bother me that I am receiving text messages about road work once in a while?)
– Are there any new ways (new channels) to provide the service? By using them, is it possible to increase the "comfortability" of the service? Which variants were accepted as the best? Why?
– Do we still work on the satisfaction of the core needs? Do users use the service in the desired way or do they tend to use it differently? Why? Are all aspects of the Service Aspect Star covered?

3 Examples of Information Services in Exceptional Situations for Public Transport

There are many possibilities of information services that could be used when thinking about the proposed CCDIO framework.

We will describe three information services that could help people in unusual circumstances or exceptional situations and are therefore not to be used very often:

1. Information service for travelers that are likely to be affected by heavy transport delays;
2. Information service for people attending large gatherings and would benefit from public transport to go and leave;
3. Information service for travelers that are likely to be affected by strikes.

All these three services could of course be a unique overall service for exceptional situations. The range of people that would be potential recipients of the service may vary, and depending on the type of transport users different strategies may need to be followed in order to develop the services. Bringing them together would be beneficial from the point of view of public awareness.

Information services in exceptional situations could be just providing information on what is happening, but it would be more interesting if advice on alternatives is provided.

Example 2 above already seems to be indicating that alternative information on transport is provided, but perhaps just providing information on what is being offered or not offered could be valuable.

3.1 Example 1 - Information Service for Travelers That Are Likely to be Affected by Heavy Transport Delays

This was the example that has been mentioned in the paper. The service in the simple form could update targeted travelers about using routes that are suffering heavy delays due to unusual congestion or accidents.

It would be important to provide the user with advance information on the delay, but only in cases that such user is planning to use the affected transport service. Therefore the proposed information service must determine beforehand the likelihood that each customer will be using the transport service in the time frame and the area of the disruption. In general a time space boundary must be calculated and a set of people must be identified as the most likely recipients of the information service.

As mentioned in a previous section, users may have subscribed the exceptional information service, but more often automatic systems could be used to identify relevant users that would appreciate the information. In this later case, data collected from transport card validation (for instance) could be used to define user transport patterns. Such patterns could then be cross checked with the routes under heavy delay. Likely affected users would be sent messages to their mobile phones with warnings and perhaps alternative options for traveling and a number to call for help if required.

Occasional travelers, not registered, would be missing warnings as there were no patterns to be used. The information service could be improved if there were ways to identify those occasional travelers. For example, tourists that arrived recently in the area of the service would need an alternative approach. Perhaps when arriving to the city they are visiting they may be sent a message proposing a set of exceptional information services, including transport. Telecommunication companies are used to send text messages with information on tariffs for roaming customers or help line numbers. Tourists might be asked to register at the tourist information office for such services, when and if they buy a travel card. In order for the information to reach the mobile device, there is the need to associate a mobile phone with a travel card. Perhaps then recent card owners could be targeted with an initial exceptional message with details of transport information services.

This also raises the issue of language: information messages must be sent to users in their own language, or in a language that they understand.

3.2 Example 2 - Information Services for People Attending Large Gatherings

Using public transport is usually desirable from an environmental point of view. Events that attract very large numbers of people usually benefit from exceptional public transport offers that many people could use (instead of private/individual transport) if more information was available.

As with the previous example a mixture of previous registration and pattern mining could be used for spreading the service. In this case buying the ticket could be associated with registering for the service. With more advanced technologies, guidance could be provided at the event for the return transport availability, location and timetable. Cooperation from the organizers of the events and from the media that is publicizing it would also be highly desirable.

This information service could also involve in some degree example 1 as in those events traffic congestion would be likely.

3.3 Example 3 - Information Services on Strikes Affecting Large Number of Travelers

Transport related strikes are usually rare, but have a big impact on people moving through the system. Strikes in one mode of transport usually affect the other modes. For instance, a taxi strike will force a tourist arriving to the destination to use the public transport system, and vice versa.

The effectiveness of the information system would depend on how information is shared between the different players. For instance, arriving passengers to a particular airport could be warned beforehand of a strike in a particular mode of transport and receive specific information on where to find alternatives.

Strikes on public transport may be partial and then it would be important for customers to receive both update information on expected timetables or alternatives taking into consideration the available transport service.

Once again user registration and pattern mining could be used to define service targets in many situations.

3.4 Advances in Technologies and Social Perception

Advances in technologies, and changes in individual and social perception of its possibilities are critical for deploying these proposed information services. For instance it is possible with current technology to know the likely position of people using mobile devices, or making payments with electronic cards. With the expansion of mobile devices with GPS the accuracy will increase. However it is not acceptable that this information is used by the benefit of others, and therefore the access to such information is restricted to very few cases, usually having to do with emergency situations, e.g., determining the origin of calls to emergency numbers (112 in most of Europe, or 999 in the USA). Customers sometimes allow location to be used in some experimental projects.

Perhaps with high quality exceptional information services it would be possible to use such information for the benefit of the user.

4 Conclusions

The proposal presented in this paper resulted from conceptual work of applying the principles of service science, management, and engineering (SSME) when thinking about developing exceptional information services in public transport.

The focus of the proposal was in the engineering process, with the CCDIO framework: contemplate, conceive, design, implement and operate. CDIO is usually applied to product engineering, but this paper argues that it can also be applied to new service engineering.

The proposed framework needs to be validated with real service development, and we believe that the examples provided could be used for such validation. Applied research on user needs, user feedback and social acceptance seem to be important in early phases of a project involving exceptional information services.

In a concrete project, management aspects are also naturally relevant and an important issue to be considered would be business modeling for the services under study. These issues would need to be covered in all steps of the CCDIO process, and would be critically important for a sustainable service. A sound engineering service development process should also take into account those matters.

The proposed CCDIO approach is targeted at real-world service systems, instead of "real-world systems and products" as the original CDIO. Given that a service system is a "value-coproduction configuration of people, technology, other internal and external service systems, and shared information", it is a more complex system that traditional "real-world systems or products" that engineering targets. Therefore the proposed contemplate stage is addressing this "value-coproduction configuration", and therefore our CCDIO approach aligns well with SSME.

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