# Contextualise! Personalise! Persuade! A Mobile HCI Framework for Behaviour Change Support Systems

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## Abstract
This paper presents a context-aware, personalised, persuasive (CPP) system design framework applicable to the sustainable transport field and other behaviour change support system domains. It operates on a situational, a user, and a target behaviour layer. Emphasis is placed on interlinking each layer's behaviour change factors for greater effectiveness. A prototype CPP system for more sustainable travel behaviour is introduced to demonstrate how the framework can be applied in practice.

## Author Keywords
Context-awareness; personalisation; persuasion

## ACM Classification Keywords
H.1.2. Models and Principles: User/Machine Systems – Human Factors

## General Terms
Design, Human Factors, Theory

## Introduction
Motivating people to use more ecologically friendly modes of transport is one step towards a sustainable future. In HCI, a comprehensive framework for

contextualised, personalised, persuasive (CPP) systems to increase motivational effects is currently not available. This paper introduces our approach of such a framework. It consists of three layers: On a *situation* layer, context-aware mobile computing has recently taken large leaps forward thanks to sensor-rich smart phones that allow systems to adapt to various situational variables [14]. On a *user* layer, personalisation has been identified as a key factor for travel mode choice [1, 11] and behaviour change [3]. On a *target behaviour* layer, different persuasive strategies and system designs [7, 10] have been suggested to support more sustainable behaviours. The objective of this paper is to demonstrate that interlinking these three layers allows designers of Behaviour Change Support Systems (BCSS) [15] to support a targeted behaviour change more effectively. As an example of how this framework can be applied in practice, we present PEACOX[1], a mobile prototype currently under development that aims at motivating travellers to switch from cars to public transport, cycling or walking.

## Related Work

The work presented in this paper builds upon research in the fields of context-aware mobile computing, transport research, and persuasive technology.

*Context-Aware Mobile Computing*

For the purpose of this paper, we will follow Dey's [6] definition of context as "any information that can be used to characterize the situation of an entity". Zimmerman et al. [21] extend this definition: Multiple entities can share contexts through relations. In our instance the entity "user" "carries" (relation) the entity "device". Ever since the introduction of context-aware computing by Shilit [17], the challenge here is to allow the device to exploit this relation and build an internal model of the user's context. A common, but still challenging, approach is to try to derive so-called high-level context factors such as the user's activities from sensing low-level context data such as time, location, system status, touch, light, sound, and movement [4].

*Transport Research*

Looking at transport research, two high-level factors are important to identify: current mode of transport (e.g. car, public transport, bicycle, walking) and trip purpose (e.g. going to work or back home, daily errands, leisure, and business trips). Furthermore, in transport research, studies have identified several purposive-rational, socio-emotional and socio-demographic variables contributing to an individual's travel behaviour [1, 2, 11, 13]. Influencing variables include travel time, travel costs, comfort, availability, accessibility, trip purpose, autonomy, status, experience, privacy, stress-free travelling, safety, ecological awareness, ecological values, social and moral norms, habits, and a number of demographic variables. These factors serve as an important basis for our CPP system design framework.

*Persuasive Technology*

For over a decade now, persuasive technology [9, 18] has been applied in sustainable HCI to motivate persons to change their attitude and behaviour [7, 10]. Context-awareness has always been recognised as key for mobile persuasive technology [8, 9]. The Persuasive System Design (PSD) model [15] recognises, among others, "use" (meaning usage domain) and "user"

1 http://www.project-peacox.eu.

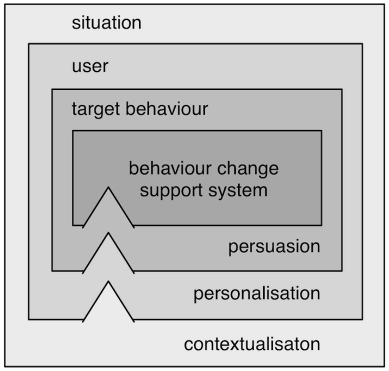


**Figure 1:** The CPP system design framework. Target behaviour is motivated by persuasive strategies, which are adjusted to the user (personalisation), and in turn to the situation the user is in (contextualisation)

(meaning user group) contexts. Applications using the PSD model [18, 20], understand these contexts as primarily static. However, context-aware technology needs to sense and respond to personal and situational factors to adapt a system to factors identified in transport research. Recently, research in persuasive technology has turned towards personalisation [12, 16]. The concept of persuadability [12] describes an individual's susceptibility to a specific persuasive strategy and methods to measure persuadability have been developed [4, 5]. Thus, looking again at transport research, a BCSS should focus on an individual's persuadability for greater efficiency and impact.

## A System Design Framework for Context-aware, Personalised, and Persuasive BCSS

Our proposed CPP framework supports system designers to apply and interlink context, personal, and persuasive factors to achieve the targeted behaviour change towards more ecologically friendly travelling.

*The CPP framework: A Layered Approach*

The suggested framework operates on and between three layers (see Figure 1 for a graphical representation). First, on the target behaviour layer, a BCSS implements a number of persuasive strategies. Next, on the user layer, it personalises its services. Finally, on the situation layer, it adjusts to a specific context. The selection of strategies, personal, and context variables needs to be based on the system's application domain.

*Interlinked Layers*

As represented in Figure 1, the individual layers are not isolated but interlinked. Designers of BCCS should therefore consider the following connections between layers:

- Personalisation should adjust to specific contexts.
- Persuasion should adapt to specific users and situations.
- The BCSS should respond to specific target behaviours, users, and situations.

*Behaviour Change Support Factors*

For each layer, several behaviour change support factors (BCSFs) may be identified, depending on the specific BCSS application. It is those factors that interlink the different layers. They describe which factors on one layer influence which factors on another layer. For example, a certain situational factor (such as location or weather) can alter the system's personalisation and persuasion mechanisms.

## Putting the CPP Framework into Practice

In this section we present PEACOX, a system that represents our attempt to put the framework into practice. The system is a trip-planning application for smartphones that motivates users to switch to more sustainable modes of transport. It applies the CPP framework through multiple BCSFs. As an example of how layers can be interlinked, we can look at route recommendations. The presentation of route options and $CO_2$ data can be varied by inclusion of different persuasive strategies. These in turn can be adapted to the user's personality, e.g. the attitude towards different modes of transport and a user's persuadability. Finally, routing data can be altered by context, e.g. the weather or the trip purpose. Table 1 lists all the factors to be implemented in PEACOX.

| BCSF | PEACOX Prototype Example |
|---|---|
| **Contextualisation:** Adjust to … | |
| Time | … time of day, week, season; real-time updates on arrival times of public transport |
| Location | … proximity to public transport stops, distance to destination; proactive suggestions of nearby eco-friendly alternatives |
| Physical Environment | … weather and traffic conditions |
| Social Environment | … travelling alone or in a group (as a trip-specific setting) |
| Current Activity | … trip mode (car, tram, bus, metro, train, cycling, walking) (automatic detection) |
| Current Goals | … trip purpose (work, home, business, leisure, daily errands) (automatic detection) |
| **Personalisation** | |
| Persuadability | Adjust persuasive strategies to user's persuadability (profile questions, machine-learning) |
| Mobility Type | Adjust to mobility type of user (e.g. die-hard driver vs. car-less crusaders [1]) (profile questions, machine learning) |
| Rational Variables | Give trip-relevant information, such as time, costs, comfort, availability, accessibility, reliability |
| Social-Emotional Variables | Focus on appealing to environmental values (highlighting $CO_2$ emissions), experience factor (playful and competitive or collaborative challenges), and social norms (behaviour comparison with others) |
| History | Learn travel patterns (route recommendations, $CO_2$ feedback, persuasive strategies) |
| Demographics | Adjust to disabilities, life situation (e.g. travelling alone or with kids), possession of car, bicycle, or driver's licence (e.g. for car sharing options) (user profile setting) |
| **Persuasive Strategies** | |
| Mobile Loyalty | The application primarily serves the user by providing directions instead of trying to change behaviour |
| Feedback & Self-Monitoring | Information on past trips (including modes of transport and personal $CO_2$ emissions); daily $CO_2$ feedback |
| Expertise, Tunnelling & Suggestion | Eco-friendly and personalised trip recommendations |
| Kairos & Information Quality | Eco-friendly & trip-relevant information while travelling, travel mode specific POIs; accurate $CO_2$ emission feedback, automatic trip mode & trip purpose detection |
| Surveillance & Social Facilitation | Visualisation of tracking status, possibility to share trips on social networking websites |
| Commitment, Competition & Rewards | Voluntary, public commitments to $CO_2$ -saving challenges (e.g. "I ride my bike to work three times a week"), virtual rewards for completed challenges |
| Social Comparison & Social Learning | Sharing of $CO_2$ performance on social-networking sites, comparison with others |

**Table 1:** The CPP system design framework put into practice in the PEACOX prototype smartphone application providing eco-friendly, context-aware, personalised, persuasive trip recommendations and $CO_2$ emission feedback. The right column lists how the app implements different BCSFs (on the left side) and how they are interlinked.

Figure 2 shows a selection of user interface design concepts for implementing the BCSFs listed in Table 1. Figure 2a shows an early design sketch. Challenges have been integrated into a slide-in side bar. Travel mode and trip purpose detection, as well as live $CO_2$ feedback have been integrated below the map. Figure 2b shows a design mock-up for a tree-based $CO_2$ feedback and reward system. The tree grows new leaves when the user takes sustainable transport, but looses leaves when $CO_2$ is emitted. Figure 2c shows an example of a personalised pre-trip $CO_2$ feedback. The type of message is adjusted to the persuadability of the user (for example a message designed to contain a self-monitoring or social comparison strategy). Figure 2d shows a design for travel-mode specific $CO_2$ emission statistics.

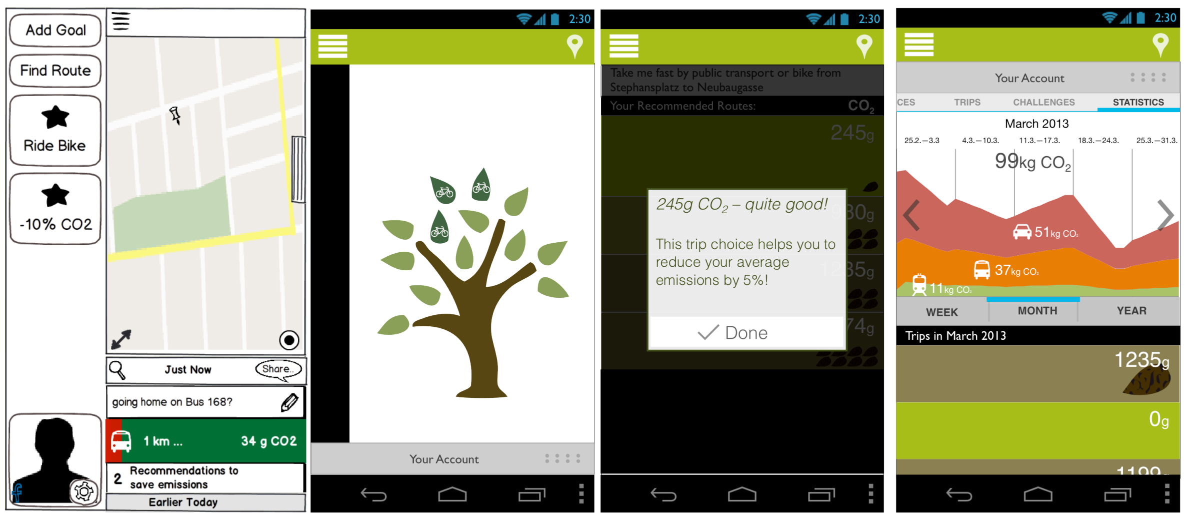


**Figure 2.** User interface design concepts of the PEACOX app: $CO_2$-reducing challenges (a), daily $CO_2$ feedback and rewards (b), personalised pre-trip $CO_2$ feedback (c), and trip-mode specific $CO_2$ statistics (d).

## Conclusions & Future Research

We presented a system design framework for context-aware, personalised, and persuasive BCSS. It aims at supporting designers in effectively changing user behaviour. Furthermore, the paper demonstrated how the framework can be put into practice with a mobile smart phone application for behaviour change towards more sustainable transport modes. A first running prototype of the system will be evaluated in the field in summer 2013. We expect to get valuable insights on how effectively the system can motivate users to increase use of public transport, cycling or walking and to further improve the system. For future work, we believe that the framework has a high application potential and can be transferred from the context of sustainable transport to other areas of BCSS.

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