Peacox – Persuasive Advisor for CO2-reducing cross-modal trip planning

Project Reference: 288466

FP7-ICT 2011: 6.6 Low carbon multi-modal mobility and freight transport

Project Duration: 1 Oct 2011 – 30 Sept 2014

D5.4.2 Detailed Design Persuasive Eco-Feedback Strategies – Version 2

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Date: 27/06/2014

Dissemination level: (PU, PP, RE, CO): PU

Project Co-Funded by the European Commission within the 7th Framework Program

Abstract

This deliverable details the persuasive eco-feedback strategies that will be integrated in the second PEACOX prototype and how they are designed into client app. Their aim is to motivate users to use more environmentally-friendly modes of transport and thus reduce their CO_2 emissions. The document first gives an overview over all strategies used and then details the five areas of the app where they are translated into the user interface. The five areas are: route recommendations, route choice suggestion messages, challenges and rewards, a CO2 tree, and statistics. For each area the strategies implemented are presented in detail.

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1. Introduction

This deliverable presents the persuasive strategies chosen and implemented for the first PEACOX prototype. The aim of these persuasive strategies is to motivate users to change their mobility habits in such a way that they reduce CO_2 emission-intensive mode of transports, such as cars, and increase environmentally-friendly modes, such as public transport, cycling or walking. For this purpose, we will first discuss the work this deliverable is building on, before introducing the scope and structure of this document. The remaining chapters will describe the persuasive strategies and how they are integrated into the design of the PEACOX app at various points.

1.1 Background

The work presented in this deliverable is a continuation of the work already documented in *D5.4.1 Detailed Design of Persuasive Eco-Feedback Strategies – Version 1*. It is based on several tasks of work package 5. Within task 5.2 we developed persuasive strategies for personalised eco-feedback of a user's environmental impact. In task 5.3 we explored further strategies from different contexts, such as gaming, and how they can be meaningfully and effectively utilised in PEACOX. Finally, in task 5.4 we developed design solutions for the selected strategies and how they can be integrated in the overall PEACOX user interface.

Furthermore, the design of the persuasive strategies and eco-feedback mechanisms was influenced by the outcomes of the first PEACOX field trial. The results and recommendations of which are documented in *D7.4 Field Trial I Report.*

For the development of the PEACOX user interface design, we continued our work in the user interface design working group (UID working group), that was first formed for the design of the first PEACOX prototype. Experts from CURE, FLU, and TMX were working iteratively to develop the user interface.

The developed user interface will be implemented in the final PEACOX prototype and will be tested in the second field trial.

1.2 Scope of This Deliverable

The second version of this deliverable presents the persuasive eco-feedback strategies and personalised eco-feedback mechanisms and how they are integrated into the overall PEACOX user interface design. After the first field trials in summer 2013 the PEACOX user interface is redesigned and additional persuasive strategies will be implemented. Accordingly, this deliverable is an update of D5.4.1 to reflect these changes and new features.

1.3 Overview

This deliverable is structured as follows: In the next chapter, we will give an overview of the persuasive eco-feedback strategies implemented in the second prototype. The following chapters then detail the areas of the PEACOX app that realise the strategies. In the second prototype strategies are built into route recommendations (Chapter 3), route choice suggestion messages (Chapter 4), challenges and rewards (Chapter 5), the CO_2 tree (Chapter 6), and the statistics (Chapter 7).

2. Persuasive Strategies in the 2nd PEACOX prototype

This section gives an overview about the persuasive strategies that have been selected to be implemented in the second prototype. Based on literature, the most of the most commonly used strategies are described in Cialdini (2001) and Fogg (2003). A detailed report about the research strategies can be found in deliverable *D5.1 Persuasive Strategies Report*. We chose a selection of strategies to be implemented in the first prototype of the system (cp. D5.4.1), which was refined and extended for the second prototype. The following table shows how these persuasive strategies from literature map to individual features of the second PEACOX prototype. The strategies are grouped by the five areas in the application in which they are implemented: route recommendations, route choice suggestion messages, challenges and rewards, CO_2 tree, and statistics.

Persuasive Strategy	Description	PEACOX Implementation
	Route Recommendations	
Tailoring	Tailor feedback to each individual user	Personalised route recommendations
Reduction	Reduce complexity of the task	Step-by-step process when searching for route; reduced result set of possible route choices
Tunnelling	Guide the user towards the desired choice	Route recommendations highlight preferred route options
Real World Simulation	Simulate effects of choices prior to taking action	Prognosis of emitted CO_2 for each trip option
	Route Choice Suggestion Messages	
Authority	Provide expert advice	Expert Recommendations for specific route
Simulation	Provide means for observing the link	Highlight the routes that will help users to save more

	between the cause and effect in regard to their behaviour	emissions
Suggestion	Hint on the desired route	Recommend the eco-friendliest route
Social Comparison	Compare with other users	Provide means for comparing performance with the performance of other users
Self-Monitoring	Provide means for users to track their performance or status	Provide feedback on the user's performance
Reminders	Remind users of their target behaviour	Remind users that they should try to save CO_2 emissions.
Praise	Praise users on their achievements	Provide positive feedback if users are saving emissions
	Challenges & Rewards	
Consistency	Users that commit to an behaviour are more likely to follow	Users can voluntarily commit to challenges to reduce their CO_2 emissions
Tailoring	Tailor challenges to each individual user	Personalised challenges for specific user groups
Competition	Let users compete against each other	Some challenges call for the 'best' to win
Cooperation	Let users cooperate with each other	Some challenges ask users to cooperate for a common goal
Conditioning	Reward desired behaviour	Give out credits (badges) for successfully completed challenges
	CO_2 Tree	
Self-Monitoring	Allow users to track their	Tree presents an individual

	own behaviour	user's personal CO_2 status
Reduction	Reduce feedback complexity	Emission data reduced to a single value
Liking	Create sympathy for system	Attractive visualisation in form of a tree
	Statistics	
Self-Monitoring	Allow users to track their own behaviour	Statistics give detailed feedback on CO_2 and PM_{10}
Social Proof	Compare with other users	Statistics leader board ranks users according to their CO_2 emissions
Suggestion	Suggest desired behaviour	Statistics give recommendation for actions that reduce CO_2 emissions

The following five chapters will discuss how the persuasive strategies are implemented in detail.

3. Route Recommendations

When a user searches for a route from A to B, they are exposed to a number of persuasive strategies (see

Table 1). First, the step-by-step process when searching for route and the limited result set of possible route choices reduced the complexity of the task (*reduction*). These results are also adapted to each individual by providing personalised route recommendations (*tailoring*). Through this, the user is also guided towards the desired choice (*tunnelling*), as some route options are highlighted. Additionally, the environmental impact of choosing a route is simulate before the user is actually taking the route by displaying the grams of CO_2 that will be emitted (*real world simulation*).

More specifically, the user interface is designed to offer proper motivation for selecting sustainable transportation options, while the information and choices shown to user are calculated using the principles of choice architecture.

Table 1. Persuasive Strategies and Our Approach.

Persuasive Strategies	Key Choice Architecture and Interface Implementation elements
Reduction	Condensed complex route options into three simple alternatives. Filtered trips in order to present a few meaningful alternatives.
Tailoring	Balanced trip results based on user preferences and CO_2 emissions thereby avoiding choice overload.
Tunneling	Users are guided through the route search with a bias towards eco-friendly routes based on the power of defaults: - users are not required to decide on specific modes of transportation in the search process - environmentally friendly options are included by default.
Cause-and-Effect Simulation	Display of estimated CO_2 emissions per alternative trip
Suggestion	Grouped trips per mode of transportation thereby structuring the choice set. The environmentally friendly options are displayed in a more prominent

	position in the interface.

Reduction is designed such that the decisions of which route options to set and which transport mode to choose are both reduced to a few meaningful alternatives. If we consider *Reduction* in combination with *Tailoring*, the presented trips should be in accordance with the individual's travel preferences. The problem is handled as choice overload and can be described as follows: given a user *u,* we want to find a subset *S* of *AvailableTrips(u)* such that */S/ = PresentedTrips* and the choice of *S* provides a good balance between the user's perceived trip utility and his or her CO_2 emissions. The approach has remained similar to the first prototype and is based on the calculation of trip utility that leverages users preferences provided via the route-planning interface. These preferences are then transformed into a user's perceived trip utility value. The utility and the CO_2 emissions of a trip are provided as input to an algorithm that selects */S/* trips to be presented to the user in a simple and non-cluttered user interface, focusing on the primary task of the user, i.e., getting from A to B.

Tunneling is handled by a route planning wizard that quickly lets the user search for routes to a specific target destination, while also providing options to set trip preferences. Users are not required to decide on specific modes of transportation in the search process and environmentally friendly modes are included by default. If users omit these modes, we follow a forced choice approach and include results with public transportation, walking, bicycle and park and ride in case these make sense as follows: i) if the destination is in a walking distance we include trips that involve walking, ii) if the user selects public transportation, the option of using a bicycle is also displayed iii) if the user selects the option of car, then the options 'park and ride' and 'public transportation' will be included in the result set as well.

Cause-and-Effect Simulation uses CO_2 emissions modelling to calculate the estimated emissions for any given route. For each route displayed in the result set, a corresponding number in grams of CO_2 is shown. The absolute value in contract to a relative scale allows direct comparison of different transportation modes in terms of ratio, making high-polluting options such as the car clearly visible. Thus, the user is informed about the environmental effects before he or she is actually causing them.

Suggestion is performed through the structuring of choices. Our approach is to group the available options in order to allow for optimal comparisons. To this end, we group trips

based on one of the major transportation modes, i.e. walk, bicycle, public transportation (this includes 'bike and ride') and car (this includes 'park and ride'). Moreover, in order urge users to consider the environmentally friendliest option, the groups are ranked according to CO_2 emissions. In most cases, this leads to a ranking in the following order: walking, cycling, using public transport, and driving.

4. Route Choice Suggestion Messages

Alongside the route options, persuasive messages can be displayed that are designed to encourage a user to choose the respective route. The messages can be written in different styles, representing different types of persuasive strategies: The can provide expert recommendations (*authority*), they can announce routes that will help users to gain extra credits (*simulation*), the can be subtle hints on the most eco-friendly route (*suggestion*), they highlight the relative performance of the user in comparison with others (*social comparison*), they can inform users on their performance (*self-monitoring*), they can praise users when they are saving emissions (*praise*), or they can provide reminders of the target behaviour, i.e. saving emissions (*reminders*). The design of the messages in the user interface is presented in Figure 1.

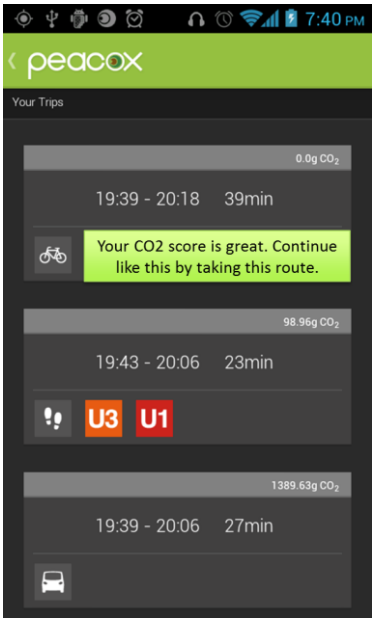

Figure 1: PEACOX application trip selection screen.

The architecture of our approach is provided in Figure 2. Our implementation leverages contextual parameters, elements of the user profile and a message pool that contains all the defined messages. The adaptation engine is responsible for filtering and selecting which

message will be presented to the user. Note that there can be cases when no message is presented.

Contextual elements include, properties of the selected destination (including whether it is in a walking distance), properties of the alternative trips (including if the duration of car and public transportation trips is comparable, the difference of the emissions between car trips and public transportation trips), properties of the users' behaviour (number of car or public transportation trips we have tracked, trend of the emissions the user causes, position of the users in comparison to others in terms of emissions production). User properties include the travel history, travel habits and the log of persuasion attempts already applied to the user. The message pool currently contains a list of 12 messages covering the persuasive strategies mentioned above. PEACOX D5.5 provides a detailed description of our approach.

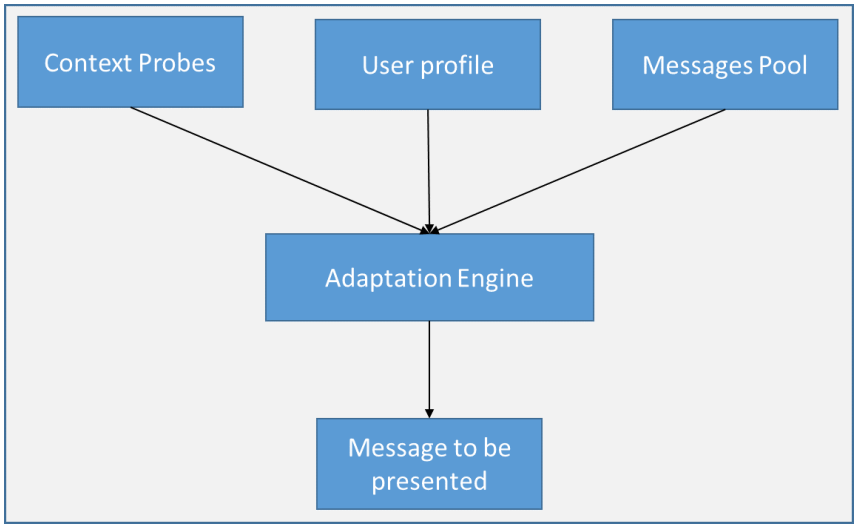

Figure 2: Architecture of the PEACOX Persuasive Messaging System.

5. Challenges & Rewards

Challenges and rewards use a number of game-like strategies to encourage users to use more eco-friendly route options. The strategies include *consistency*, i.e. users can commit voluntarily to various challenges to reduce their ecological impact. These challenges are personalized (*tailoring*) to specific users and user groups. Challenges can be structured to measure users against each other (*competition*) or to encourage them to work together (*cooperation*). Successfully completed challenges are rewarded to encourage further participation (*conditioning*).

5.1 Challenges

The general idea of the challenges throughout the field trials is that users commit voluntarily and publicly to a specific task, which makes it more likely that they act accordingly (*consistency*). An additional aspect is *tailoring*, meaning that challenges can be tailored to the specific user (e.g. past behaviour or mobility-type) and context (e.g. whether conditions).

Other persuasive strategies easily applied with challenges are *competition* and *cooperation*. Competing with others allows social comparison inducing ambition and cooperation with others can increase commitment to a task. The challenges used in the field trials of the second PEACOX prototype will make use of these persuasive strategies.

5.1.1 Types of Challenges

There are different types of challenges applicable in the context of PEACOX. The following criteria allow differentiating several challenges:

1. **Goal of the challenge**: the goals of the challenges can vary (achieve a specific score independent from the score of others versus achieve the highest score compared to others).

   Examples are:

   - Achieving a specific score: beat the high score or the average score; lower emissions than your average, lower emissions than PEACOX average, lower emissions by 10 percent.

- Having the highest score compared to others: longest distance, longest time, highest number of trips, lowest emissions, least car trips, follow the PEACOX route recommendation as often as possible.

2. **Single-, Sub-Group and Group-Challenges**: challenges can be done alone in sub-groups or by the whole group together. This introduces different levels of competition.
3. **Specific versus general challenges**: the challenges can target the whole group of participants (general) or be specific for a subgroup. Specific challenges can be:
   - *User-specific*: the challenge is adjusted to past behaviour of the user → when the participant made little use of bicycle, the challenge is to try the bicycle this week; when the participants did a lot of short car trips the challenge is to try bike, public transport or walking next time.
   - *Mobility type-specific*: the challenge is in accordance to the pre-assessed mobility type of the user → car drivers could be challenged to go one week without a car; public transport users should go by bicycle or walk; cyclists and pedestrians should cycle/walk as many kilometres as possible.
   - *Context-related*: also the current context, like the weather conditions can define specific challenges → participants can be challenged to cycle when it is a sunny Sunday or when it is a cold and rainy day.
4. **Duration:** finally challenges could be short-term (related to one action, e.g. to use public transport for the next trip to work) versus longer-term (related to a series of actions to achieve a specific score, e.g. to do as many trips as possible with the bicycle next week).

5.1.2 Implementation of the Challenges

To complement the functionality implemented in the second PEACOX prototype for the challenges, we will use Facebook as social medium to communicate challenge information and rewards as well as to form sub-groups.

To accomplish that, the participants of the field trials have to join a Trial-Facebook group. The Austrian and Irish participants have their own group, to avoid language problems. However, the performance of the two different sites can be compared and feed back to the participants (competition).

The participants' performance in the challenges are manually monitored by us and accordingly rewarded within the Facebook group.

The *procedure for implementing the challenges* is the following:

- Through a web interface we are able to create challenge notifications, which are shown in the PEACOX app. In order to announce challenges specific for only a part of the participants, it is also possible to define which participants should receive the notification.
- The notifications consist of a short text (e.g. "New challenge is online") followed by a link to the according Facebook event page (created in the Facebook group), including further information about the current challenge.
- By confirming the event, participants can accept challenges. The participation is voluntary.
- Participants who reject the event are not part of the challenge. We only monitor the performance of the participants who accepted the challenge manually via the tracked data of the PEACOX app.
- After the end of the challenge, the results and rewards will be posted in the Facebook event page. For longer-term challenges also interim results are posted to motivate participants to continue.
- This procedure will be repeated for every challenge during the field trial.

5.2 Rewards

The field trials also include rewards for the participants performing well in the defined challenges. Rewards like points or badges (see **Fehler! Verweisquelle konnte nicht gefunden werden.** for an example) have been a topic in recent research activities (e.g. Antin & Churchill, 2011; Denny, 2013; O'Rouke et al., 2014). Rewards are supposed to serve as external motivator to support the desirable behaviour. However, their effectiveness because of poor design or lack of informative feedback was frequently criticized. This is why we aim to create badges which are meaningful by providing actual performance feedback directly related to the users' mobility behaviour.

We will use *virtual badges* to award for successfully completing a challenge. Badges (see Figure 3 for an example) can be used, which consist of a pictorial element and a short text. Depending on the challenge the badges can be single- or group-badges.

Figure 3: Example for a badge

The bagdes are based on a *comprehensive point system*, to reflect the participants' performance as well as different levels of achievement (by matching point ranges/badges to specific user states). This system supports the gamification aspect of sub-goals which should motivate the participants to continue their chasing for points.

It is important that the reward system is informative and indicates the actual level of performance. The rewards will be posted in the Facebook group to highlight the accomplishments of successful participants.

5.3 Conclusions

One goal of the second field trial is to compare part of the above described types of challenges and rewards in terms of participants' preference and persuasive effectiveness. Therefore a within-subject design with repeated measures will be used in the field trials, to assess the effect of the challenges on the participants' opinion and behaviour.

6. CO_2 Tree

The CO2 tree is a simple means for users to track their personal CO2 emissions (*self-monitoring*). It is basically a visualisation of past CO_2 emissions in the form of a tree that is losing or growing leaves depending on a user's previous behaviour. Its key strength is the simple visualisation of the eco-friendliness that can be understood at a glance (*reduction*). It is also pleasing to look at and the design as a tree is meant to create sympathy for it to grow leaves (*liking*).

6.1 Design

The tree is centrally placed on the home screen of the application. Every time the app is launched, the tree will be visible to the user giving them quick information about their personal CO2 status. The tree shows a varying number of leaves that fill up or get removed depending on the user's emission behaviour (Figure 4). At a minimum, the tree has only a stem and no leaves. At a maximum level, all 74 leaves light up.

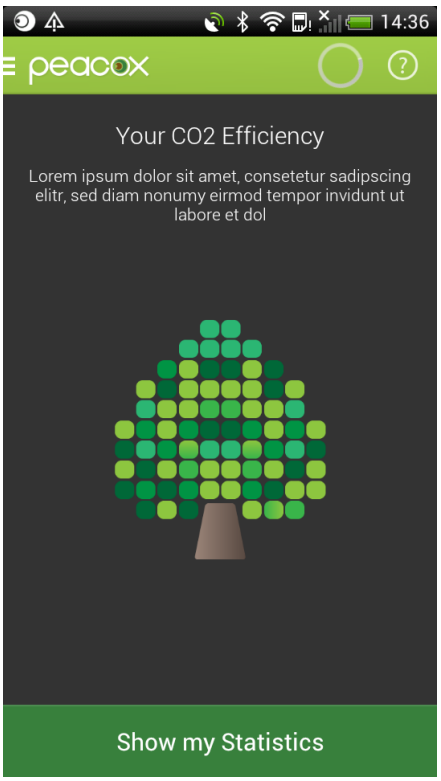

Figure 4: The CO_2 tree at maximum growth level

6.2 Logic

As a starting point for the implementation it needs to be considered that the CO2 feedback needs to accommodate for a range of behaviour types. For example, a person that is primarily cycling will have almost zero emissions. On the other hand, a person that has to drive a car every day for their job will in comparison have a lot of emissions. The issue of what are "sustainable" emissions or not is very complex and involves a number of factors outside the control of the individual, including the length of their intended journey.

That said, based on experience, the following emissions would indicate viable thresholds for the PEACOX tree to lose or gain leaves:

- 0-50 grams/km gains a leave
- 50-100 grams/km gains no leave
- over 100 grams/km loses a leave

However, if such static thresholds are applied, this will result in an always-full tree for the cyclist and an always-empty tree for the car driver. The aim of PEACOX is, however, not to punish car drivers for their behaviour, but to support and encourage positive behaviour changes. Thus, also small improvements should be reflected in the tree. This means that the conversion of grams of CO_2 emitted into leaves on the tree needs be adaptive.

While emissions are usually measured in absolute mass terms, e.g. grams of CO_2 produced, it is important to treat these values on a per km basis for the tree. Otherwise a user taking a short trip will gain points for all options even if they drive.

Based on these considerations, we developed an algorithm for the tree that presents a combination of rewarding users when they are doing well on an absolute scale (i.e. having low emissions) and on a relative scale (i.e. reducing their emissions, even if on a high level). The algorithm is presented in the following table as pseudo code:

`Define: variance = 0.05`	`//we compensate for 5% variance in emissions to avoid random (positive and negative) rewards due to measurement errors`
`avg_emission7 = get average emissions for last seven days`	`//This is a sliding window (i.e. if today is the 22nd, from the 15th to the 21st) and divide it by the total travel distance during that time frame`
`If emission7 is between 0 and 50`	`//User is doing well on an absolute`

grams/km then: user gains a point	level.
else:	
avg_emission7_14 = get average emissions for seven days before that	//i.e. if today is the 22nd, get emissions from the 8th to the 14th and divide it by the total travel distance during that time frame
difference = avg_emission7_14 - avg_emission7	//is there a difference between the last 7 days and the 7 days before? If positive, emissions have decreased.
if difference >= avg_emission7 * variance then: tree grows a leave	//is this difference larger (or equal) than the allowed variance?
else:	
if difference < avg_emission7 * variance OR avg_emission7 is between 50 and 100 then: tree grows no leaves	//is this difference smaller than the variance or even negative, or are the emissions between 50 and 100 grams? This means the emissions are stable or within the zero-reward range on an absolute scale
else:	
tree loses a leave	//the user loses a point only if emissions are increasing AND are above 100 grams/km. This ensures that if the user is improving emissions, the tree grows a leave, even if emissions are higher than 100 grams/km. If emissions are changing but are within a certain range (+/- 5%) the user does not get rewarded or punished.

Table 2: The pseudo code for the tree algorithm

7. Statistics

The statistics section in the app provides comprehensive and detailed information on the past behaviour of the users. The design of realises a number of persuasive strategies. First, it allows users to track their own individual behaviour by giving feedback on emissions (CO_2) and exposure to emissions (PM_{10}) (*self-monitoring*). Additionally, it allows users to compare themselves with others using the leader board (*social proof*). Finally, it points out possibilities to improve the eco-friendliness of one's mobility behaviour by giving personal recommendations for actions that reduce CO_2 emissions (*suggestion*).

7.1.1 CO_2 and PM_{10} Statistics

Users can view their CO_2/km value in the form of a ring graph and can select different parameters to show various statistics (Figure 5 left). On this screen users can also see which means of transportation have caused the most CO_2 consumption and PM_{10} emission in order to educate better how the CO_2 value is generated and what users can do to improve their travel behaviour in the future.

On the week and month detail screen (Figure 5 middle and right) users can visualize their CO_2/km, total kilometres, total minutes of all trips this week/month, and PM_{10} emission. Below the graphs users can also view a list showing average CO_2 /PM10 values for each day.

Figure 5: Statistics in day view (left), week view (middle), and month view (right)

7.1.2 Comparison/Leader Board

On the comparison screens users can match themselves with the average CO_2 consumption per km of all other users. Statistics can be viewed by the means of a ranking system (Figure 6 left), which is used to provide a game-like setting or by graphics which compare results of two users by displaying circles (Figure 6 right), which feature their respective CO_2 values in exact numbers as well as per differing sizes according to the respective CO_2 value.

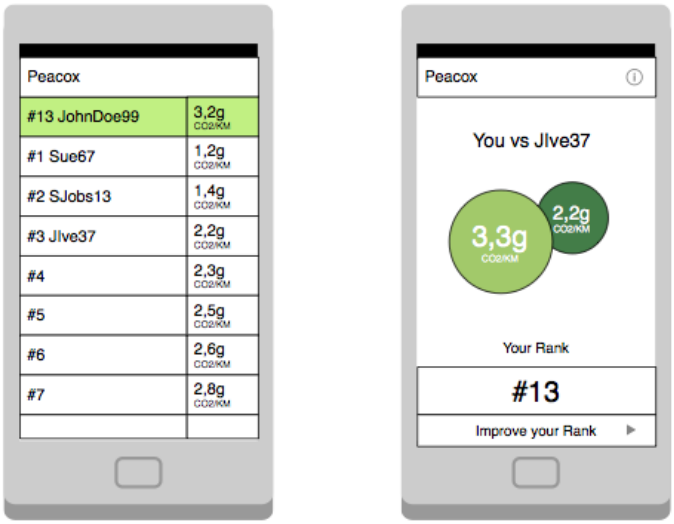

Figure 6: Statistics Leader Board comparing a user with all others (left) or with a particular user (right)

7.1.3 Recommendations to Lower CO_2 Emissions (Shift Potential)

Shift Potential shows users how users can improve their travel behaviour and CO_2 consumption by analysing segments and used means of transportation for each segment (Figure 7). For instance, if a user is choosing to drive by car a lot for short distances, these segments get added to the Shift Potential and the application will recommend using a less CO_2 consuming means of transportation for these short trips to optimize CO_2 consumption.

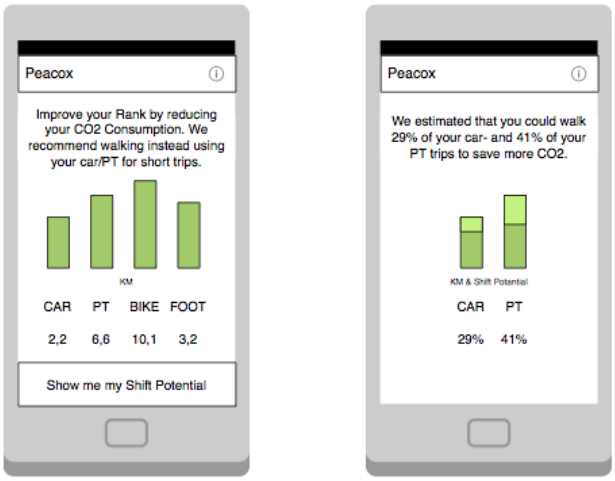

Figure 7: Showing shift potentials (left) and estimations of the impact in emissions (right)

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