Gaming Concepts and Incentives to Change Driver Behaviour

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Abstract— ***In this paper we present a novel concept that deals specifically with changing driver behaviour in order to reduce traffic congestion. The project I-GEAR (incentives and gaming environments for automobile routing) aims to understand the motivations that drivers have while undertaking the daily commute and then to provide them with a range of incentives to change their behaviour. A key focus within the project is on ways in which the problem could potentially be solved without recourse to an expensive infrastructure project. Our solution to this problem was to move the problem of traffic management onto everyday mobile devices. In the following paper we outline the background to the problem, concepts relating to pervasive gaming, existing explorations of incentives and gaming approaches as well as our basic concept and project methodology.***

Keywords-component; behaviour, vehicle, human-factors, games

I. INTRODUCTION

Road congestion is a serious problem within Europe and is estimated to cost around €105bn per year, or approximately 1% of GDP [1]. This is a major problem for many European states and in particular Luxembourg with its unique position of having a high number of cross-border commuters. For example the City of Luxembourg with a population of 90,000 adds a further 120,000 commuters during weekdays from the surrounding countries [2]. The problem is further amplified due to Luxembourg having the highest rate of car ownership in Europe and being the 10th most congested [3]. The delays resulting from congestion are estimated to increase driving time by around 21% [4]. The problem is likely to increase further as Luxembourg diversifies its economy towards aspects such as logistics.

This paper first gives an overview of gaming and incentive ideas as applied to the in-car context. Particular emphasis is given to both an already existing and successful system and the novel / different approach that I-GEAR suggests. We will explain why Luxembourg calls for a specific solution. Furthermore, we explain why the in-car environment is a potentially unsafe environment when introducing new devices and new tasks for the driver. In a second part, these specific human-computer-interaction issues are illustrated and explanations are given on how we deal with these issues in I-GEAR. We also outline in more detail how such a game concept could look like.

As the project has just started we are not in a position to provide empirical results, rather the paper will focus on how I-GEAR could provide an alternative approach to the problem of traffic congestion.

II. BACKGROUND

Location-aware systems are now having an impact in many fields from gaming and social networking through to traffic applications. I-GEAR seeks to bring together three main concepts: serious gaming, pervasive gaming [5] and location-aware traffic management. Serious gaming is based on the idea of gamification [6] which essentially brings core aspects of gaming into non-game settings. In our particular approach we will use persuasive gaming [7] to subtly encourage drivers to undertake a particular behaviour e.g. going to a café for 30 minutes rather than waiting in a traffic jam. Other social incentives are proposed for example competing or collaborating with other drivers to obtain points and bonuses. Such approaches have already been employed within FourSquare[1] ® where if people are the most frequent visitors to a particular location they become it's Mayor and some businesses provide benefits for their Mayors. Another recent success story shows the potential of mobile and location-aware applications that allow the driver to avoid road congestion. The idea of Waze[2] ® is to rely on community shared information for navigation and traffic anticipation. The community input allows it to be adaptive, location-specific and real-time. It integrates information about the car's planned trajectory (speed cameras, upcoming traffic issues, road works, weather-induced issues, etc.) as well as data from the car itself (velocity, identified user on board). In addition to a message exchange service, and its crowd-sourcing characteristics, this application builds on gaming ideas in order to get users more involved: driving through less covered zones or any other location where additional community input earns you more points. As of January 2012, Waze ® counts

[1] https://foursquare.com/
[2] http://www.waze.com/

more than 12 million users and thus shows user acceptance of such a system can be achieved. As to our knowledge, Waze ® represents the closest blend of ideas and features as compared to the I-GEAR objectives. Although the US map in Waze ® is fully covered, European countries only recently started to integrate Waze ® and Luxembourg is not covered yet, even though there are plans to extend coverage to additional European areas.

III. The Impacts on HCI / Safety Issues

Introducing game-like environments into the car environment has a strong potential impact on driving tasks. Hence we face a set of key human-factors challenges regarding the overarching desire to maintain driver safety. Firstly, there is a risk that by increasing the number of potential tasks the driver must undertake and control, cognitive overload may occur especially in more demanding situations. Secondly, games by their nature normally ask that players focus their attention on the gaming experience; the driver may therefore be distracted from safety related tasks. These two major issues present a key challenge in that there is an increased risk of drivers becoming distracted or overloaded by the fact that a certain amount of cognitive resources that would have been available for driving tasks end up being allocated to gaming tasks. The potential consequences vary from simple inconsistent driving behaviour to serious incidents and even accidents. In order to address this particular challenge, the field of air traffic control and pilot training provides some insight (see figure 1). For example safety regulations require the operators to stick to different "layers" of operation in accordance with the situation. Each layer represents a set of situational descriptors coupled with specific degrees of freedom when operating or controlling the aircraft. These layers are considered to be hierarchical such that a basic and fundamental layer regards safety and allows operation in a totally safety-oriented way only. On top come additional layers such as passenger comfort or fuel economy. Those additional layers, while still requiring the strict safety objective, allow some additional freedom of operation to add e.g. increased travel comfort.

Drawing on this framework, we will base our interface designs and scenarios on three layers

(1) Safety
(2) Comfort
(3) Efficiency

Layer (2) tasks may only be deployed if all layer (1) tasks are unconditionally assured, layer (3) tasks may only be accomplished if (1) and (2) remain guaranteed. In case of any incident, layers (3) and (2) are considered of low priority so that safety remains a constant top requirement whatever situation may arise. The same framework of ideas will be deployed to in-car man-machine interactions in I-GEAR and will allow for further scientific insight, going well beyond a simple adoption of existing tools like Waze ®.

Figure 1 The Layers Used in Pilot Training or Air Traffic Control to provide a focus on Safety Under Different Contexts

IV. User Adoption and the Need for Incentives

In contrast to pervasive games, traditional computer games want people to be isolated within the unique game work, for example within Grand Theft Auto ® they are driving through the streets of a city causing chaos and breaking the law. The boundaries within this game world are clear, for example the rules, behaviours, objects and social norms are unlikely to be acceptable outside of the gaming environment. This boundary, according to Montola [5], is known as the Magic Circle and, as noted by Csíkszentmihályi [8], with respect to flow theory that once people are within it they have a desire to perform certain actions and gain competencies and in doing so they become immersed in the game. However, this view is problematic when applied to location-aware games which are pervasive as the boundary between the game and non-game world become blurred [5]. In many cases this is specifically the desire of the designers as they are seeking to blend reality and the additional information in a new way that should result in people feeling present in a new "place".

Montola [5] further notes that pervasive games expand the experience across social, temporal and physical boundaries. Social boundaries are broken in the sense that not all people who impact upon the game are specifically playing. For example, in traffic jams it is clear that the driving behaviour of others will have an impact even if they specifically are not part of the game. From a temporal perspective, unlike traditional board games a driving game should be playable over a long period of time. Finally, physical expansion essentially removes the boundary of a traditional physical board game and replaces that with potentially the entire road network. Although these elements sound ambitious, the concepts of physical and temporal expansion are already being extensively used within applications such as Geocaching.

As noted by Broy and Goebl et al [9] car journeys are often perceived as quite dull and in their work they were exploring ways to involve all passengers as well as the driver in some form of game. Although their approach was more routed in classic games, e.g. a music quiz or drawing, their relatively limited study pointed to the benefits of such an approach with participants indicating that it was fun. Therefore the idea of extending games while driving to the problem of traffic congestion, which is potentially both boring and frustrating, remains appealing. Furthermore, it is also potentially appealing if options can be provided that involve the passengers, too.

Associated with the games are the incentives provided to end-users in order for them to change their behaviour. To date most states penalise drivers who break the rules (e.g. speeding) or do not reward good behaviour or changes to be behaviour (e.g. leaving home later to cut down on traffic congestion). However, this is despite some work which points to the impact of incentives on driver behaviour. One study in the Netherlands paid drivers to leave home at different times in order to reduce traffic problems [10]. In this study drivers were paid €3, €5, or €7 in order to leave home at a different time in the morning. The study indicated that the €3 payment had the highest marginal impact. Within I-GEAR we will explore social incentives through aspects such as competition and collaboration between drivers as well as direct and indirect financial and non-financial benefits. Drawing from existing initiatives like Waze ® we can build on valuable lessons learnt and ideas that have proven to work. Still, there is a high chance user adoption and incentives may depend on specific geographical and cultural aspects that cannot be easily compared to a situation in Northern America where other systems have proven to work. Indeed, currently the European context proves to be largely different regarding several aspects:

- Road layout and geographical situation: urban areas are closer and population density is generally higher in Europe as a result of a relatively smaller geographical surface; this implies shorter road distances in an area that always balanced road vs. rail construction instead of favouring road construction only.

- Gas price: as of April 2012, European gas prices range 175% to 238% of those in the US (184% as compared to Luxembourg); which undoubtedly has an impact on car usage.

- Political will to favour public transport over individual car use: during the last years, many European countries have shown a strong political will to offer public alternatives to individual car use. As a result, public transport more and more often gets subsidized with public money as it is done in Luxembourg, too. Not only is there a much stronger public transport offer throughout all the major cities in Europe (bus, tramway, underground metro) but also these means of transport tend to be considerably cheaper than driving by car. These public networks cover most of the economical relevant zones where population density is also higher and thus uncovered zones do not represent any important impact. Also, public transport connects the European cities in a rather efficient way with many railway connections already existing and more and more high-speed trains being put into service recently.

- Ecological awareness throughout a rather important part of the population: in Luxembourg, the ecological party has been increasing it's share of the vote. The popularity of such views is also reflected in other European countries.

Despite a more efficient public transport network, road congestion is an ever-growing problem in Europe and especially in Luxembourg. It is hard to say whether psychological factors (feeling of freedom, pleasure to drive, etc.) or practical issues (e.g. public transport is not very comfortable for families with babies and very young children, for elder people or impaired passengers) or whether it is a combination of the two that account for this.

Existing initiatives like Waze ® have shown that a community-based and game-like tool can both be accepted and become successful. Nevertheless, we have also shown that the context of the "typical" Waze ® user is not identical to the European context and especially not to the Luxembourgish context. Finally, we are also convinced that the challenges the specific Luxembourgish context arises may best be addressed through a concept that puts even more emphasis on the game aspects. Indeed, whilst already existing tools like Waze ® mainly rely on gaming incentives for increasing territory coverage, I-GEAR needs to go several steps further and have people decide for later departures, for a suggested stop at a café that offers a special deal, for sharing their car with additional passengers or even for earning credits by leaving the car at home when public transport is available. Based on existing work and systems coupled with the situation in Luxembourg we identified the following key challenges for I-GEAR:

- The identification of gaming incentives which can be applied to driving scenarios in Luxembourg;

- Learn from successful initiatives and enlarge those by I-GEAR's novel and specific approach;

- The solution to critical human factors issues potentially arising from new tasks in the driving environment;

- The development of user testing methodologies which allow us to assess the value of our games based approach to altering driver behaviour;
- Development of user interface concepts that are aware of the drivers current context (e.g. driving decisions or traffic) that adhere to the game design concepts while also aiming to keep cognitive load at a minimum;

- The definition of efficient information and training strategies in order to avoid early user acceptance issues;

V. METHODOLOGY

The objective of I-GEAR is to provide an application that can be used by drivers in Luxembourg. In order to achieve this objective we need to explore the underlying motivations of the drivers. For this we will adopt an approach known as contextual enquiry [11,p78] which is based on the principal that users' (sic) interests, emotions, hopes, passions, fears, and frustrations (that) are important and powerful factors in choosing, learning, and using a technology". As a result the project will base its work on ethnographic methods, in particular the use of contextual design [13][14] and activity theory [15][16] coupled a participatory design approaches that involve real users.

In order to address the main key challenges described before, we will rely on human-centered design processes. This means there is a thorough analysis that explores the Luxembourgish context and requirements derived from interviews with a sample of drivers. During the next steps, both the gaming concept and the application itself (including the user interface) will undergo an iterative design process that is commonly accepted to be the benchmark in human-centered design: all stages (sketches, mockups and prototypes) are checked against user requirements. This is done both on a conceptual and empirical level, i.e. usability [3] experts guarantee the design process stays on track with both heuristics and predefined requirements (conceptual level) and systematic usability tests [16] provide fine grained empirical data that inform about the relationship and matching between the design and the users' needs. Where problems arise with regard to specific design issues within the usability tests modifications will be made to the system.

In parallel, a car cockpit simulator will be developed that allows for a thorough analysis of user behavior under laboratory settings. The usability laboratory will enable us to capture and analyse specific interactions by the end-users. For example, the users (drivers) will be observed by a team of evaluators; therefore allowing specific interactions and contextual information to be noted. They will also be subject to video and audio recordings that can be analyzed and matched with direct observation data coupled with logs from external devices such as eye-trackers or tablet PCs. Furthermore, The usability lab provides a controlled environment for non-interfering observation and recording of user behaviour. One of the major advantages of the usability lab based approach lies in the non-interfering observation and the possibility of observing / recording all drivers and passengers in a controlled and safe environment.

This approach allows us to iterate as many cycles as needed until the proposed solution has been thoroughly tested and validated. As safety remains the primary goal, not only with regard to the output of this project, but also during it's development and validation stages, the laboratory coupled with the simulator constitute an environment where early stage work can be undertaken without jeopardizing driver safety. Furthermore, the simulator experimentations will permit us to set up very specific controlled experiments to examine specific issues e.g. cognitive load; which may not be suitable for exploration on the open road. Furthermore, a controlled environment is needed for investigating the range of possible interactions within a car. For example the success of I-GEAR also relies on taking into account all the interactions going on in the car, i.e. between the driver and the passengers. The laboratory setup, with the simulator being part of a larger laboratory, allows us to have detailed insight and control in these interactions by means of direct and indirect observation, recording of interfaces and camera perspectives.

All these interactions are also part of the novel gaming concept that is different from currently available systems. As a result the simulator will be used to identify user interface design issues and to explore basic gaming concepts such as collaborative driving prior to implementing them within real car settings.

As a final step, the application will be tested on the open road. One key aspect of these studies is to extend them to include not only the underlying game and user interface but also the wide social dynamic within a car. In order to support this task I-GEAR will have access to a large number of vehicles and drivers that will be provided by an external partner.

VI. TRAFFIC MANAGEMENT AS A GAME

I-GEAR relies on the concept of incentives being provided to drivers in the form of a game. Incentives have already been used within traffic management and studies have found that even for a comparatively low cost people will alter their driving behaviour [10]. I-GEAR does not claim to be able to remove costs completely, but instead aims to minimize costs by providing financial and non-financial incentives to encourage drivers to change their behaviour. I-GEAR will

[3] Usability: The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use. [11]

develop a persuasive game in the sense that it attempts to alter (or persuade) drivers to change their behaviour through the use of social, psychological, financial or game design incentives. Drivers for example may undertake individual actions such as: giving other drivers priority, taking the slow traffic lane, stopping in designated areas during peak times to reduce congestion, taking alternative routes or car sharing. Such behaviours may also benefit other drivers or groups to which the driver belongs. Part of the challenge within this approach is not only to identify relevant incentives but also gaming techniques that remove some of the need to provide purely financial incentives.

As noted earlier the project will utilize a contextual design [13][14] methodology in order to identify specific incentives and gaming strategies. It is our opinion that the nature of the project requires that we allow the end-users to identify and test the incentives that may work given their particular preferences, circumstances or hard requirements. It is also important to explore the order in which people are given incentives such that we encourage good driving patterns early on while also encouraging them to progress further up the ladder. For example we want to specifically avoid traps where one higher-grade incentive is perceived as being worth less than one which is easier to attain.

Motivations are a key part of the driving game that is proposed within I-GEAR, for example we do not envisage that one particular type of incentive will work for all drivers. Instead through the contextual enquiry process we will seek to identify combinations of incentives and motivations that are applicable either on an individual or group defined basis. In the example below we provide two different driver profiles. It should be noted these are a very rough indication and are not based on our on-going work in this area, therefore they should be taken as indicative only. Furthermore we plan to use two main forms of incentive: immediate and status. Immediate rewards will be given when a driver undertakes an action e.g. stopping at a café for which they receive ½ price coffee. Alternatively status rewards or points will be used to encourage longer-term behaviour where drivers collect points for consistently undertaking good actions. For each level of points they will receive certain benefits e.g. after 5 good actions they receive priority parking in the city centre at weekends.

A. Driver 1

On weekdays Ken drives from his home in Esch-sur-Alzette to his office at UBX in Luxembourg City's Kirchberg area. The journey normally takes 45 minutes, but traffic jams can increase this to 2 hours; note he cannot change the time he must start work. His primary objective is to reach his desired destination as quickly as possible and at the required time. His primary driving route includes the motorway between Luxembourg and Esch during peak times where he must be at work for 9am and leave at 5.30pm, he can however leave earlier on Friday at any time after 3.30pm. As a result of his profile I-GEAR offers him the following suggestions:

- Set off no later than 4pm on Friday (before the traffic jams)
- Join a driving platoon during week days
- Take an alternative route to work

If he undertakes the suggested actions he receives the following individual rewards:

- Free parking at an out of town mall on weekends
- Priority parking near his work on Mondays to Fridays

B. Driver 2

Marie a retired school teacher from Esch-sur-Alzette, she primarily uses her car to get to and from her local church or to go shopping. In general she prefers to drive more slowly and with the exception of Church meetings has no specific time when she has to attend. Church meetings take place normally from 2.30-4pm on Tuesdays and Fridays. On weekends she likes to take the bus to visit friends on the North so that she can have a glass of wine. She is offered the following suggestions:

- For shopping trips she is encouraged to leave when the roads are quieter
- On Friday she is encouraged to stop at a café between 4pm and 5.30pm
- Go shopping at an alternative mall that is located in a suburb not the city centre

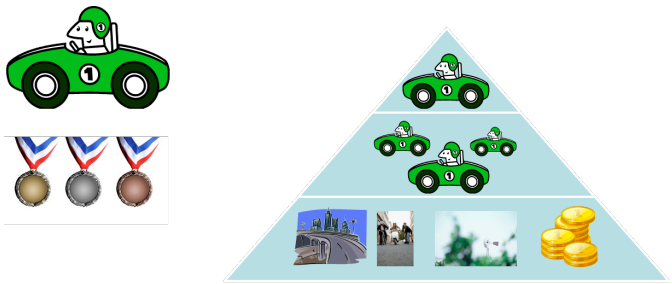
If she undertakes the above action she is eligible for the following rewards:

- A half price coffee at the café
- Free bus ticket for Saturdays
- 10% Discount at a store in the selected mall

C. Social Incentives: Driver Teams and Leagues

As noted earlier I-GEAR will also encourage drivers to collaborate and compete through the use of gaming approaches. This will be achieved by offering both individual and social incentives. After playing I-GEAR for some time Ken joins one of the many teams (see figure 2). When a driver joins a team his individual actions count towards the team score, however each team competes against another team

every week. At the end of each week the team with the highest number of good deeds is declared the winner. At the end of the year the team with the highest points will receive free car insurance for one year. In the example above, Ken joins the Kircherg Cowboys as this team represents people who commute to and from Kirchberg. In contrast, Marie joins the Diekirch devils as their profiles seem to match her driving preferences. Scores are calculated by averaging the number of good deeds per driver. The scoring system is similar to football, with points awarded for and against each team. Also points are awarded for a victory or a draw. In the example above Diekirch Devils are the current leaders as due to the five games they have played against other drivers they have won four. Such games could for example include each team being asked to take alternative routes for a period of one week, or stopping off at a set number of cafes. On an individual basis if a driver completes 3 good deeds in any one week they receive bronze status, 7 results in silver medal and 10 results in them receiving gold status. They must maintain these each week in order to keep their desired status. In return for these levels of status they receive specific perks depending on their level.



Team	Played	For	Against	Won	Draw	Lost	Total
Ettelbruck United	5	105	35	4	1	0	13
Diekirch Devils	4	90	60	3	1	0	10
Kirchberg Cowboys	4	50	45	1	2	0	5
Bentley Bonnevoie	5	25	75	0	3	2	3

Figure 2 A Sample Game Concept: Top Left, a driver can enjoy various status levels. Centre, while they drive together they are also part of a team, which is also listed in the league table (bottom).

VII. Conclusion And Future Directions

In this paper we have presented a work-in-progress system known as I-GEAR which is a project designed to optimize traffic through the use of serious gaming. At the time of writing the project had just started and the work was focused on identifying relevant motivations and incentives. As a result the project is mainly focused around future work at this stage namely: identifying incentives and motivations along with user interface challenges and issues.

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References

[1] Euractiv (2007) http://www.euractiv.com/en/transport/urban-transport/article-161223 (Accessed 29th April 2012)

[2] PWC (undated) http://www.pwc.com/lu/en/public-sector/docs/pwc-cities-lu-extract.pdf (Accessed 29th April 2012)

[3] OECD (2008). OECD Territorial Review, Luxembourg, 2008.

[4] Inrix (2010) http://www.inrix.com/pressrelease.asp?ID=111(Accessed April 29th 2012)

[5] Montola, M. Exploring the edge of the magic circle: Defining pervasive games. In Proceedings of DAC 2005 Conference.

[6] Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011). Gamification. Using game-design elements in non-gaming contexts. Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems, CHI EA '11 (p. 2425–2428).

[7] Bogost, I. Persuasive Games: The Expressive Power of Videogames. MIT Press. Pp464. 2010. ISBN: 0262514885

[8] Csikszentmihalyi, M. and I.S. Csikszentmihalyi. Optimal experience: Psychological studies of flow in consciousness. Cambridge Univ Pr, 1992.

[9] Broy, N., Goebl, S., Hauder, M., Kothmayr, T., Kugler, M., Salfer, M, Schlieper, K. and E. Andre. A Coperative In-Car Game for Hetrogenous Players. In Proc. Automotive UI 2011. Salzburg, Austra. Pp 167-174

[10] Bliemer, M.C.J. and van Amelsfort, D.H. (2008) Rewarding instead of charging road users: a model case study investigating effects on traffic conditions. Proceedings of the third Kuhmo-Nectar Conference.

[11] ISO, 1998. Ergonomic requirements for office work with visual display terminals (VDTs)-Part 11: guidance on usability--Part 11: guidance on usability (ISO 9241-11:1998).

[12] Kaptelinen, V. Nardi, B.(2006) Acting with Technology: Activity Theory and Interaction Design. Amazon Media sarl (Kindle Edition) p345

[13] Beyer, H. and K. Holtzblatt. (1998) Contextual design: designing customer-centered systems. Morgan Kaufmann Pub.

[14] Holtzblatt, K. (2004) Rapid Contextual Design: A How-to Guide to Key Techniques for User-Centered Design (Interective Technologies). Morgan Kaufmann. Pp324.

[15] Nardi, B. (1995). Context and Consciousness: Activity Theory and Human-Computer Interaction. MIT Press. ISBN: 978-0262140584

[16] Hornbak, K. (2006). Current practice in measuring usability: Challenges to usability studies and research. International Journal of Human-Computer Studies, 64(2), 79-102. doi:10.1016/j.ijhcs.2005.06.002