CO2Y™ – THE INTELLIGENT GREEN SOLUTION: MINIMISING CARBON EMISSIONS BY MAXIMISING SHARED TRAVEL OPPORTUNITY.

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1 ABSTRACT

It is in the interests of everybody that the environment is protected. In view of the recent leaps in environmental awareness it would seem timely and sensible, therefore, for people to pool vehicle resources to minimise the damaging impact of emissions. However, this is often contrary to how complex social systems behave – local decisions made by self-interested individuals often have emergent effects that are in the interests of nobody.

For software engineers a major challenge is to help facilitate individual decision-making such that individual preferences can be met, which, when accumulated, minimise adverse effects at the level of the transport system. We introduce this general problem through a concrete example based on vehicle-sharing.

Firstly, we outline the kind of complex transportation problem that is directly addressed by our technology (CO2y™ - pronounced "cosy"), and also show how this differs from other more basic software solutions.

The CO2y™ architecture is then briefly introduced. We outline the practical advantages of the advanced, intelligent software technology that is designed to satisfy a number of individual preference criteria and thereby find *appropriate* matches within a population of vehicle-share users.

An example scenario of use is put forward, i.e., minimisation of grey-fleets within a medium-sized company. Here we comment on some of the underlying assumptions of the scenario, and how in a detailed real-world situation such assumptions might differ between different companies, and individual users.

Finally, we summarise the paper, and conclude by outlining how the problem of pooled transportation is likely to benefit from the further application of emergent, nature-inspired computing technologies. These technologies allow systems-level behaviour to be optimised with explicit representation of individual actors. With these techniques we hope to make real progress in facing the complexity challenges that transportation problems produce.

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2 INTRODUCTION

When considering how business transportation choices are made, people tend to *optimise* towards their own interests, e.g. travel time and comfort, often to the detriment of global objectives such as minimising costs or environmental impact. To this end, multiple actors or agents *compete* for limited resources such as road space or seats within trains or buses. Roumboutsas & Kapros summarise some approaches to this based on game theory. Significantly, a new constraint is being added to the mix, that of CO2 emissions levels. As legislation (e.g. the UK's Carbon Reduction Commitment) emerges, designed to cap and reduce CO2 levels to meet international obligations, many organisations will be forced to view CO2 emissions as a finite resource.

In this paper (Section 3) we will outline computation models used previously for optimisation. We then consider the practical issues surrounding the acceptance of journey sharing within an organisation (Section 4.2). The concept of CO2Y™ is then introduced (Section **Error! Reference source not found.**), which stems from a preliminary study into a vehicle share software tool designed to help increase the propensity of users to *share* trips. We present the application of such a system to the optimisation of grey-fleet usage (Section 4.1) before discussing possible practical problems and how emergent computing might also address these.

3 COMPUTATIONAL MODELS FOR OPTIMISATION

In 1968 Hardin wrote of the Tragedy of the Commons, this expounded the theory that optimal local decisions may by individuals in their own self interest could lead to ultimate global failure. Specifically Hardin describes an example based on the use of common grazing land. It is in the interest of each farmer to place as many of their animals as possible on the common land. However when all farmers pursue this course of action, the land cannot support this level of activity and is destroyed. Thus for success the farmers must moderate their individual actions so as to preserve the land. Hardin's example may be applied to transportation, if individuals make journey choices that are optimal to them, in terms of comfort and convenience this may ultimately result in congestion and pollution making it difficult for any individuals to complete journeys in comfort or time.

Conversely mathematical models of optimisation are effective at optimising global variables such as overall mileage travelled or costs incurred. However this may often be at the expense of so-called local variables such as user preferences. Such mathematical models have two drawbacks when dealing with real world problems such as journey sharing/planning:

- The solution may be too highly optimised to be usable; e.g. unpredictable traffic congestion may delay a vehicle resulting in multiple missed journeys
- The solution may not adequately take human factors into account.

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The field of artificial intelligence has brought forth computational techniques that are capable of multi-objective optimisation. The solution outlined in this paper examines the potential use of software agents to optimise business car travel. Such techniques may often be used to find solutions that trade off between variables in order to find a compromise solution that does not fully optimise on any particular variable. For a problem such as car sharing, it is important that the solution overcomes the above two problems making it acceptable to users.

4 MINIMISING CO2 THROUGH JOURNEY SHARING

4.1 Introduction

In order to establish not only the demand, but the operational requirements for journey sharing a survey was carried out within a major Scottish public sector organisation with principle offices in Inverness and regional offices throughout Scotland. The Survey was carried out using the organisation's standard online tool for staff surveys, SurveyMonkey.com, during November 2008. The principle purpose of the survey was to establish attitudes to car sharing for business journeys within the organisation. The survey consisted of 26 questions, split over three sections and was attempted by 61 individuals. Some individuals chose to skip specific questions. For each question the answer rate is recorded. Full results cannot be presented here due to lack of space, but a summary is presented in section 4.2.

4.2 The survey

4.2.1 General Questions

The initial section of the survey established some background to the individuals, the principle facts regarding the respondents were:

- 40% of the respondents were male and 60% were female
- Their age groups were as follows:
  - Under 20: 0%
  - 20-29: 8.3 %
  - 30-39: 25%
  - 40-49: 41.7%
  - 50-59: 25%
  - 60+: 0%
- All started work before 10am with 62% starting between 8-9am
- 83% finished work between 4pm and 6pm
- All of the respondents held a driving licence.

Car sharing (from a commuting perspective) fundamentally requires that individuals can start/end work at the same time. Approximately 90% of these individuals start work between 8am-10am. Finishing times are slightly more disparate 83% finishing in the 4pm-6pm period and 17% out with this period.

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A number of questions were asked to elicit existing travel habits from those who travel to work by car. These illustrate issues surrounding the possible acceptance of more general car sharing within the organisation.

73% stated that they commute by car, slightly greater than the UK average of 71% (source: RAC foundation 2007). The principle reasons given for commuting by car were convenience, time and reliability, Interestingly, 47% already shared their car-based commute with at least one other individual, in most cases a fellow employee.

4.2.2 Business Travel Habits

This section was intended to elicit data regarding current travel practice, and potential barriers to increased car sharing. It was noted that approx 70% of respondents travelled between worksites on a regular (i.e. at least once a month) basis, whilst 50% made regular business trips to client sites not owned by the organisation. It is amongst journeys between sites that there exists the greatest potential for car sharing, as they take place between a fixed subset of sites. The potential for sharing on journeys between client sites is less as there is decreased possibility of two or more members of staff journeying between the same points. Within the surveyed organisation 57% of business travel is carried out by car (43% of such journeys make use of a pool car). It is also worth noting that 60% of respondents rarely/never shared business journeys with colleagues.

Given that the organisation surveyed already has innovative travel policies it is not surprising that private car use is low. There exists potential for the sharing of pool car journeys, as presumably a proportion of the 60% who never/rarely travel with colleagues utilise pool cars.

4.2.3 Car Sharing

Having established in section 4.2.2 that 70% of employees make regular trips between sites and that the majority of such trips are by car, it would follow that there is the potential for car sharing. Employees were then asked if they would be comfortable sharing with a colleague that they had only just met, and 80% said they would? Further questions elicited that there appears to be no strong preference between driving and being driven. There is also a positive indication towards sharing: 80% are happy to share with another employee that they have only just met and that 65% would be happy sharing with an employee from another organisation.

Employees were asked to consider a number of potential sharing scenarios and rate their reaction (see Table 1). The biggest potential problem when sharing appears to be between smokers and non-smokers, followed by a disagreement over the choice of CD/cassette being played in the vehicle. Note that the question deliberately asked about sharing with someone who had previously been smoking – we'd already discounted that smoking would

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not be permitted in company vehicles, and that in private vehicles smokers would undoubtedly seek approval.

Anecdotal evidence suggests that car/journey sharing has traditionally had a reputation of inconveniencing participants in terms of journey deviation and extra time. The majority (73%) of respondents would accept a deviation of up to 10 miles in order to share. The maximum acceptable delay in order to facilitate a journey share would appear to be 30 minutes, the optimum being not more than 15 minutes.

Finally participants were offered a free text field to mention any specific issues that that they had when sharing a car journey. The principle concerns that emerged were:

- Driving standards, an unwillingness to be driven by an individual perceived as a dangerous driver.
- Choice of music/radio station
- Smokers

	would not mind	slightly irritated	would not share again	depends on topic of conversati on /radio etc	Response Count
Sharing with someone who does not chat	**36**	13	2	3	54
Sharing with someone who talks constantly	16	**17**	7	14	54
Sharing with someone who has been smoking prior to the journey	18	**20**	**15**	0	53
Sharing with someone who is eating/drinking	**36**	14	3	1	54
Sharing with someone who listens to the car radio	**32**	5	0	18	55
Sharing with someone who listens to their own choice of CD/Cassette	20	10	2	**22**	54
				answered question	55

Table 1 "When being asked to share a car journey how would you react to the following?"

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4.3 Survey Results and Conclusions

Within the organisation surveyed a number of informal conclusions may be drawn

- That there is a significant number of journeys between a fixed set of workplaces
- That individuals are open to sharing business car journeys
- That the principle concerns individuals have regarding sharing journeys are based around human factors issues. These divide into non-negotiable almost a third would not share again with someone who had smoked prior to the journey, and the negotiable such as in-car entertainment choices.

As well as the survey outlined in section 4.2 the authors had discussions with a number of Scottish public sector organisations during 2008 regarding car sharing, an unexpected response was received. It appeared that whilst car sharing was regarded as laudable by such organisations, they were actually unable to quantify the usage of what is frequently termed their “Grey Fleet”. The Grey Fleet is made up of vehicles owned by employees, and used on business trips. It was reported that many employees would not submit an expenses claim for a short trip as the effort required to submit the claim was perceived as being out of proportion to the payment received. If this practice is widespread then it makes it very difficult for such organisations to quantify the carbon footprint of short journeys. Indeed the organisation may not even know of the existence of such journeys as formal approval would not always be sought, and therefore any auditable returns on CO2 emissions would be incomplete. Longer journeys (especially those by rail or air) will be the subject of detailed expenses claims which may be used to quantify the distance travelled and mode used and thus calculate the environmental impact of the journeys.

As a result of these initial discussions it became apparent that a major selling point of travel management software was not necessarily the use of sophisticated optimisation techniques to facilitate car shares, but a system that allowed users’ to quickly log journeys and to quantify the environmental impact of such journeys.

5 CO2Y™

5.1 The concept

The original concept of CO2Y™ was to build a product that facilitated car sharing using some clever computing techniques. As discussed in section 4 when the development team began talking to potential users and using specialist contractors to scope the marketplace the problem changed. With that in mind the experience gained in developing the car sharing software is being used to develop a journey management tool that allows organisations to monitor journeys, and quantify the carbon produced. Our research suggested that organisations would rather reduce carbon by eliminating the journey or encouraging the employee to changing travel mode at the planning stage.

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With this in mind CO2Y™ is now being focused on the logging or journeys, informing users of their carbon footprint and optimisation through journey sharing is now a secondary consideration.

5.2 Software

The CO2Y™ software tool may be accessed through a web interface (see Figure 1). The web interface has been built using propritory tools provided by Google. In order to estimate the carbon footprint of a journey, emissions data within the AMEE[1] platform is accessed.

In order to log and optimise travel activities, access to a source of graphical Data (maps and distance values etc) is of vital importance. Research amongst suppliers of such data during the early stages of the project showed that access to an on-line source of data was significantly less complex and time consuming than acquiring data and hosting it within the project.

CO2Y™ uses a journey matching algorithm based on software agent technologies that receives information on users' travel requirements and flexibility and then identifies trips that may be shared. The journey matching algorithm is based upon software agent technologies. Each user is represented by a software agent that resides on the server. When a new journey is logged into the system the users' agent "advertises" that journey to other agents within the system. When an agent receives an advert it compares the advertised trip to its own to see if any of them are compatable (i.e. the users could share). If a compatible journey is found the agent may respond to the originator indicating the potential of a share. Initial tests have demonstrated that the agents are capable of highlighting potential journey shares. In the prototype users can indicate their flexibility with regards to time and additional travel. It is envisaged that, in a production version, additional facilities would be added to allow users to specify custom criteria. A feedback mechanism allows users to build up a score-based reputation that allows potential sharers to assess their compatibility with new journey partners. This mechanism can also be used to highlight not only when previous shares between two individuals have taken place, but if both parties have shared a journey with a mutual friend.

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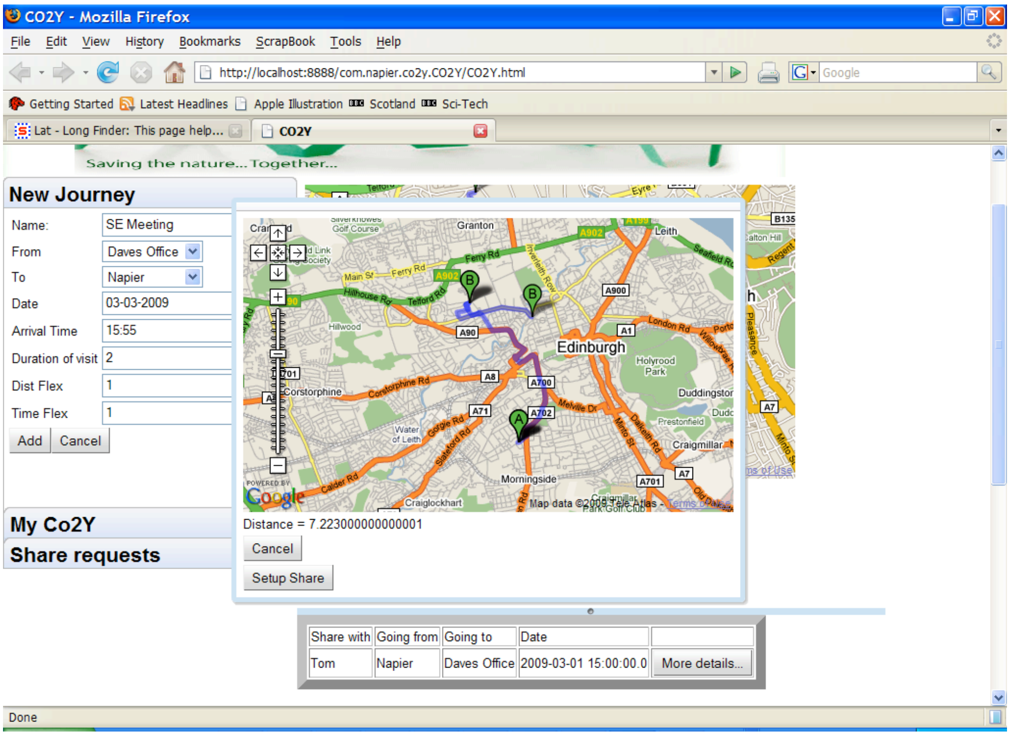

Figure 1 The prototype CO2Y™ interface.

6 DISCUSSION & CONCLUSIONS

This project initially set out to investigate the potential for a car sharing tool for use within businesses. The proposed technical approach was to utilise software agents. Whilst the survey described in section 4.2 suggested that within the organisation surveyed there was scope for sharing cars on company business and a willingness amongst employees to share journeys. However more generalised discussions with other organisations and specialised market research undertaken in late 2008 suggested that organisations were at that time unlikely to invest in a complex journey sharing system. However the onset of the UK Carbon Reduction Commitment is starting to cause concern that an organisation may need to buy unnecessary carbon credits because of a lack of clear data about use requiring a cautious overestimate to avoid breaching legislation. With this in mind, recording journeys, quantifying the carbon footprint of each journey and presenting that information to management and employees might be construed as a more relevant focus for systems developers at present,

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Notes

1. AMEE- the world’s energy meter www.amee.com .

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