International Journal of Advances in Computer Science & Its Applications
Volume 6 : Issue 1 [ISSN 2250-3765]
Publication Date : 18 April, 2016

OCTOPUS

Online Collaborative TOll-card-sharing PUblic System

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***Abstract*—We present OCTOPUS, an internet based system that allows users to voluntarily share prepaid "aller-retour" toll cards of limited lifetime or/and use a car pooling service. Users have to register and provide details about the resource they either possess or wish to make use of. OCTOPUS is then responsible for processing and matching user requests utilizing geographical information also allowing users to select their matching members just using their smartphone or any mobile device with an internet connection. OCTOPUS is yet another proof of concept that internet and the web can actually promote resource sharing for social welfare in our modern society.**

***Keywords*—OCTOPUS, internet, web, culture, smartphone, wireless, geographical information, online matching, resource sharing, collaborative consumption, social welfare.**

I. Introduction

The rapid progress in electronics and internet-based communication has made it possible for a huge number of tiny mobile electronic devices, like smartphones or tablets, to be continuously communicating over the internet. In turn, this has highly motivated and supported a wide range of internet-based applications which exploit information and resources provided by online users towards a common goal. Collaborative online applications utilizing internet and the web together with the ability of thousands of users to remain online have attracted interest of researchers and developers in recent years.

Moreover, apart from powerful technological achievements, internet and the web form a continuously evolving cultural environment with economic, political and social coefficients. Collaborative consumption [10,11,12] constitutes an emerging sharing economic and cultural model accommodating systems, like for instance Netflix [13] and Zipcar [14], which promote sharing, offering people the benefits of ownership with reduced personal burden and cost.

The notion of sharing towards the collective management, use and exchange of resources has manifested its presence in several contexts. Wikipedia is the well-known free encyclopedia developed collaboratively by the people who actually use it [1]. Dropbox [2], a personal cloud storage service has evolved to a very popular example of a global collaborative online environment for document and file sharing. Seti@home [3] is a famous project launched in 1999 to explore D. Gedye's proposal to use a virtual supercomputer composed of large numbers of Internet-connected computers for supporting the attempt of detecting intelligent life outside Earth.

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Mnemeden [4] is a participatory and multi-local performance of mnemonic concepts based on an internet-constructed platform, allowing many users to simultaneously create, perform and maintain personal memory theatres on any subject. Also, collaborative online applications have been developed for car sharing [5], commute-bus sharing [6] and car pooling [7], as well as for other aspects of everyday life and activity (GoogleMaps, OpenStreeMap, eBay, etc).

II. Motivation

Our motivation for OCTOPUS has been the following: people travelling using their cars usually buy prepaid toll cards issued for a pair of opposite-direction passes (e.g., while driving over bridges). However, due to unpredictable factors like for example time delays or unexpectedly modified schedules, they usually use the card for only one leg of the prepaid journey thus failing in exploiting the economic benefit theoretically offered by the prepaid card. At the same time, the vast majority of these travellers have at least one smart device with an internet connection. So, an online internet-based system built on data voluntarily shared by users would make an appropriate collaborative consumption environment exploiting unused resources towards social welfare.

OCTOPUS is an online collaborative application which works on data provided by registered users and aims at (i) facilitating the efficient sharing of prepaid toll cards and (ii) providing a local car pooling service. OCTOPUS users either need a card for a single pass or have a semi-used card which they wish to share or wish to participate in a car pooling instance. OCTOPUS processes this input and responds quickly providing optimal solutions to user requests. Ranking is determined by an online matching algorithm which combines geographical data for user location retrieved automatically and details of user requests. Once a matching is made, user lists are updated accordingly so as to include fresh valid data. User registration is free of charge; it aims at providing OCTOPUS with toll card details and user requirements. OCTOPUS is running on a Linux server and is built using mobile web technologies, namely html5, php, sql; it is compatible with all commercial browsers and a wide range of mobile devices.

III. System description

The main OCTOPUS components are its user interface, its data base and its matching mechanism.

A. User interface

OCTOPUS homepage (Figure 1) provides application information and functionalities for user registration.

Figure 1: OCTOPUS homepage

In addition, it contains an area map where registered users' location and details are depicted (Figure 2). The particular area we currently focus covers the "Charilaos Trikoupis" bridge, inaugurated in 2004, connecting Rion and Antirrion over the Patras Gulf, Greece (http://www.gefyra.gr/). Several people cross the bridge on a daily basis, mainly for professional reasons, and usually use a prepaid "two-directional" toll card. The geographical position of all registered users expecting to be served appears on the area map.

Figure 2: OCTOPUS map

Figure 3: Sign-up

For exploiting OCTOPUS, a registered user first must sign up to the system, creating an account, a sort of atomic profile. Users provide an email address, username and password as well as a cell phone number (Figure 3). After the completion of the registration process, users can modify details in their profile.

Once a user is connected to OCTOPUS, she can submit a new request offering or requiring a prepaid card for a single leg of a route, view, modify and manage already submitted requests, or view the list of available matching vehicles for each pending request where a pairing selection can be made (Figure 4).

Figure 4: OCTOPUS user menu

Whenever a matching pair is generated, both members receive an online notification together with an email and an sms confirming the matching and providing details about the corresponding users and vehicles.

Figure 5: OCTOPUS notification for a matching pair

Furthermore, given that a considerable part of the local population lives on the one side of the bridge and works on its other side, OCTOPUS provides a car pooling service. Users who either wish to share their vehicle or need to be considered as passenger in an available vehicle can register a request.

B. *Matching procedure*

Information for users and requests is saved and organized in the OCTOPUS database (MySql version 14.14 distribution 5.1.73). User details include id, username, password, name, email, cell phone number (Figure 6).

Figure 6: User details in OCTOPUS database

Request details include destination, date and time, frequency, card availability, vehicle type and plate number, user geographical location, car pooling service request, passenger number (Figure 7).

Figure 7: Request details in OCTOPUS database

OCTOPUS administrator can have a complete view of the database contents and obtained matchings together with all relevant details. Through the menu, the administrator can observe all system decisions and matching history (Figure 8).

Figure 8: Administrator view of the OCTOPUS database

A selected part of the information in the OCTOPUS database is also depicted in the form of a short text notice together with user details and geographical position on the area map (Figure 9).

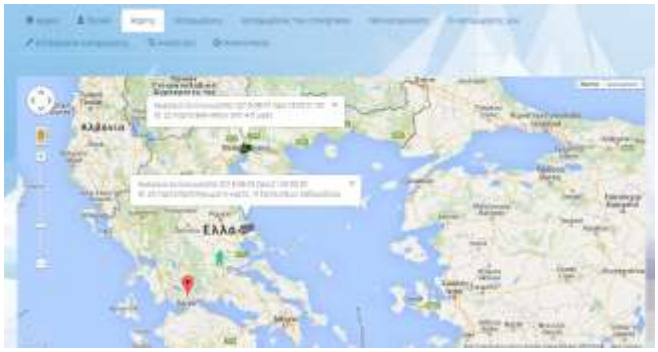

Figure 9: Short text and geographical position of users requiring OCTOPUS service

OCTOPUS determines pairs of registered users who can share a resource, i.e., a prepaid toll card and/or a vehicle. To this objective, we have implemented an online matching algorithm which receives as input user details and requests and returns as output pairs of users who must co-operate in order to successfully share a resource. Whenever a new user request appears, it is classified into one of six sets V_i, $1 \le i \le 6$, as follows:

- V1 contains users who require car pooling and possess neither a toll card nor a vehicle
- V2 contains users who require car pooling and possess both a toll card and a vehicle
- V3 contains users who possess a vehicle but not a toll card and drive towards Rion
- V4 contains users who possess a vehicle but not a toll card and drive towards Antirrion
- V5 contains users who posses a vehicle and a toll card and drive towards Rion
- V6 contains users who posses a vehicle and a toll card and drive towards Antirrion

We construct three bipartite graphs $G_1(V_1,V_2,E_1)$, $G_2(V_3,V_6,E_2)$ and $G_3(V_4,V_5,E_3)$ wherein we construct matching in an online manner. In particular, an edge $e \in E_1$ (E_2 or E_3, respectively) implies that a user from V_1 (V_3 or V_4, respectively) and a user from V_2 (V_6 or V_5, respectively) have been paired and, therefore, can share a resource. Thus, as sets V_i, $1 \le i \le 6$, are populated, OCTOPUS matching mechanism determines the edges in E_i, $1 \le i \le 3$. Pairing two users involves (i) appropriate destinations and (ii) time proximity. For example, users in G_1 (car pooling) can be paired as long as they share a common travel direction while pairing users in G_2 or G_3 requires that they travel towards opposite directions. Furthermore, generated matchings should be feasible in the sense that "time stamps" of requests should guarantee that paired users can actually obtain a physical meeting during the toll card lifetime.

OCTOPUS executes a greedy online matching algorithm based on the algorithms of [8] and [9]. In particular, incoming requests are ranked according to their time "stamp" into the system and partitioned into the six OCTOPUS sets. Then, pair members are selected randomly from a pool of feasible members. OCTOPUS returns the best possible solution in the form of an immediate notification to users as well as via email and sms notifications (Figure 5). Whenever a pair is actually established, its members are notified via an email and/or sms and their particular request becomes unavailable for further processing. Served or invalid requests are immediately removed. Payment arrangements between pairs are not part of the OCTOPUS objectives.

IV. Technical framework

Currently, this initial version of OCTOPUS runs at http://solon.ceid.upatras.gr/bagiakou/ at the web server of the Department of Computer Engineering and Informatics (CEID), University of Patras (GR) utilizing the computing infrastructure of the Department.

Figure 10: OCTOPUS server

OCTOPUS is running on a Linux (version 2.6.32) machine with a 2.6GHz CPU and a 64-bit version of the x86 instruction set architecture (Figure 10). The server runs PHP 5.3.3 (client) and MySql version 14.14 distribution 5.1.73. OCTOPUS is available in Greek and English. Emails are delivered through the CEID mail service. Short message service is supported by an open source sms gateway. Security issues as well as uninterrupted availability of the application are currently supported by network services and policies of the University of Patras.

v. Testing

Tests regarding the functionality of the application and the efficiency of use of geographical information have been conducted on a limited set of users in real time. OCTOPUS response has been fast and efficient as far as selected solutions are concerned.

We have used Opera Mobile Emulator (http://www.opera.com/) and mobiletest.me (http://mobiletest.me/) for testing and adjusting the appearance and functionality of the OCTOPUS user interface for a variety of modern mobile devices (Figure 11).

Figure 11: OCTOPUS on Google Nexus 7 emulator

Tests regarding the correctness and practical efficiency of computed solutions have been mainly conducted in vitro involving artificial users placed on randomly generated positions on the map of a wider area centered at "Charilaos Trikoupis" bridge. We plan to extend our tests to address more realistic scenaria.

vi. Future plans

OCTOPUS reflects our effort to exploit the combination of modern mobile, internet-connected, "smart" hand-held devices with human willingness for collaboration in order to support an aspect of social welfare.

Our future plans for OCTOPUS include the implementation of an option for direct connection via Facebook or other social networks.

Regarding the management of payments between paired users, currently OCTOPUS does not support online transactions. It is within our future plans to include a secure online payment mechanism so that OCTOPUS offers a more integrated service to its users and facilitate toll-card sharing avoiding transactions in cash.

Moreover, we plan to investigate the existence of potential legal issues regarding the shared used of prepaid toll cards and try to resolve them so that we can evaluate OCTOPUS in real life situations and thus highlight its benefits.

Acknowledgment

We would like to thank Nikos Mitsis, senior network administrator at the department of Computer Engineering and Informatics, University of Patras, for his invaluable help and continuous support.

References

[1] https://www.wikipedia.org/

[2] https://www.dropbox.com/en/

[3] http://setiathome.ssl.berkeley.edu/

[4] P. Kouros, "Mnemeden: a net.performance of Mnemonic Conceptions," Sky Art Conference 2002. l. Knot and B. Kracke, eds., Massachusetts Institute of Technology, Center for Advanced Visual Studies. Also: https://mnemeden.wordpress.com/articles/16_10_02/

[5] "World Carshare Cities: Inventories". World Carshare Consortium. Retrieved 2009-06-09.

[6] Harvard Business School Club of New York - What's Mine Is Yours: The Rise of Collaborative Consumption". Hbscny.org. 2011-06-16. Retrieved 2015-03-13.

[7] V. Ciancaglini, L. Liquori, L. Vanni, "CarPal: interconnecting overlay networks for a community-driven shared mobility," In Proceedings of the 5th International Symposium on Trustworthly Global Computing (TGC '10), LNCS 6084, Springer, pp.301-317, 2010.

[8] R. M. Karp, U. V. Vazirani, and V. V. Vazirani, "An optimal algorithm for on-line bipartite matching," In Proceedings of the 22nd annual ACM symposium on Theory of Computing (STOC '90), pp. 352–358, 1990.

[9] T. Kesselheim, K. Radke, A. Tönnis, B. Vöcking, "An Optimal Online Algorithm for Weighted Bipartite Matching and Extensions to Combinatorial Auctions," in Proceedings of the 21st European Symposium on Algorithms (ESA '13), LNCS 8125, Springer, pp. 589-600, 2013.

[10] R. Botsman and R. Rogers, "Beyond Zipcar: Collaborative Consumption", Harvard Business Review, October 2010. (https://hbr.org/2010/10/beyond-zipcar-collaborative-consumption)

[11] A. Sundararajan, "From Zipcar to the Sharing Economy", Harvard Business Review, January 2013. (https://hbr.org/2013/01/from-zipcar-to-the-sharing-eco)

[12] J. Hamari, M. Sjöklint, A. Ukkonen, "The Sharing Economy: Why People Participate in Collaborative Consumption," Journal of the Association for Information Science and Technology, 2015. doi:10.1002/asi.23552

[13] https://pr.netflix.com/WebClient/Login.jsp

[14] https://en.wikipedia.org/wiki/Zipcar