UNIVERSITÀ DEGLI STUDI DI TORINO

I@UNITO – Visiting Scientists

Scientific area	Scientific responsible	Host Department	Type of activity	Start of mobility	Language
Area 1 – Operations Research and Management Science	Roberto Aringhieri	Informatica	Research	From March or April 2017	English
Type of fellowship	Senior (equal or more than 40 years old) 1 month				
Title of the research project	Online and offline optimization methods for the ambulance redeployment and dispatching problem.				
Description of the research project	**Introduction**. Most of the world today faces the enormous task of making advances in health care providing health services in a safe, efficient and equitable way while, at the same time, keeping costs affordable. National Health System (NHS) sustainability is challenged by fast medical progress, population ageing [a1] and increasing demand for quality care by more informed patients. In this context a better management of the Emergency Care Delivery System (ECDS) could ameliorate the forefront of the public health services. ECDS is usually composed of an Emergency Medical Service (EMS) serving a network of Emergency Departments (EDs). ECDS plays a significant role within the health care system of a country, as it constitutes the main access point to NHS. In a nutshell, both academic literature and ECDS manager expertise argue that the efficiency of an ECDS largely depends on how the fleet of EMS vehicles is managed with respect to the emergency demand, and the interplay between the EMS and the ED network. The integration of health ICT infrastructure with other public ICT infrastructures (e.g., real time traffic information) could be exploited to improve the ECDS performance. **Purpose of the project**. The main objective of this project is to develop a set of online and offline optimization algorithms capable to select the best ambulance for an emergency request taking into account real time information about traffic and ED workload, which are available in Torino. **State-of-the-art**. Ambulance management is a big research question concerning several aspects such as, for instance, the deployment and redeployment of ambulances [a2,a3]. In this project, we focus our attention on the problem of managing the ambulances in real time. To the best of our knowledge, this problem has received limited attention in literature [a4,a5] due to the fact that the problem requires the availability of several ICT infrastructures to deal with. **Ideas and Assumptions**. Demand for ambulances is known to fluctuate spatially and temporally by day of the week, and time of day [a6,a7]. Indeed, daily practice shows that EMS is an extremely dynamic system in which the emergency demand (stochastic					

in nature) changes during the day and over the district. Furthermore, the introduction of a simple ambulance real time tracking system – to avoid wasting time during ambulance assignment – has been positively evaluated especially during a peak of emergency demand [a8].
Further, in Torino we can have access to the health care big data and to real time information concerning the traffic and the workload of the emergency department.

Development of the project.
Redeployment. At the operational-level, the ambulance redeployment means to move an ambulance – or a set of ambulances – to an uncovered location in order to meet the forecasted emergency demand in the next-hour(s). This can be done by moving an ambulance currently not serving any emergency request. This is called standard redeployment.
A better way to obtain the same result is that of properly design the routing of an ambulance. This is called smart redeployment and it exploits the fact that many emergency requests can be successfully served by different EDs. In this case, we would like to design the ambulance routing in such a way to end its service to the ED nearest to the uncovered location.
Finally, an automatic redeployment is the case in which an ambulance will finish its service near an uncovered location allowing the requested redeployment without moving an ambulance or re-designing the routing of an ambulance.
Dispatching and workload distribution.
Usually, a dispatching decision consists in the assignment of the closest idle ambulance. This simple rule cannot be the best choice when two (or more) vehicles are at the same distance, approximately. Furthermore, the availability of real-time traffic information and ED workload can provide more insights supporting better decisions: actually, the nearest ambulance could not be the fastest getting the scene.
A sequence of dispatching decisions can be listed: (i) to assign the closest ambulance in time, (ii) if the are more than one ambulance that could be serve the emergency request within a given time threshold, we select the ambulance that not deteriorate the ambulance cover taking into account the expected emergency demands, (iii) if the emergency request is not urgent and can be served by more than one EDs, the last decision deals with the choice of the best ED in such a way to balance the workload among the EDs.

It is evident that dispatching and redeployment decisions are strictly connected, especially when many ambulances are involved by such decisions.

Our research will consist in developing a set of offline and online optimization algorithms to deal with the joint decision problem of dispatching and redeploy ambulance in real time. Such algorithms will be evaluated both in terms of efficiency – measured by a better ambulance management in terms of time and spatial distribution – and fairness – measured in terms of equality to the access.

[a1] Regional population projections EUROPOP2008 – Issue number 1/2010
[a2] Brotcorne L, Laporte G, Semet F. Ambulance location and relocation models.

	European Journal of Operational Research. 2003;147:451-63. [a3] Goldberg J: Operations Research Models for the Deployment of Emergency Services Vehicles. 2004 Jan-Mar EMS Mgmnt J 1(1):20-39. [a4] Gendreau M, Laporte G, Semet F. A dynamic model and parallel tabu search heuristic for real time ambulance relocation. Parallel Computing. 2001;27:1641-53. [a5] Cuninghame-Greene, R.A. and Harries, G., 1988, "Nearest-neighbour rules for emergency services," Zeitschrift fur Operations Research, vol 32-5, pp. 299-306. [a6] Channouf N, L'Ecuyer P, Ingolfsson A, Avramidis A. The application of forecasting techniques to modeling emergency medical system calls in Calgary, Alberta. HCMS. 2007;10(1):25-45. [a7] Setzler H, Saydam C, Park S. EMS call volume predictions: a comparative study. Computers & Operations Research. 2009;36(6):1843-51. [a8] R. Aringhieri, G. Carello, and D. Morale. Supporting decision making to improve the performance of an Italian Emergency Medical Service. Annals of Operations Research, 236(1):131-148, 2016. Advance online publication 5 November 2013.
Profile Description	The ideal candidate should have a strong background in operations research and management science and its application to health care related problem. Previous research experiences in the management of an emergency medical service are highly appreciated.
Research objectives	We are working on the management of the emergency medical services since 2006, dealing with several aspect of the problem. We expect to share our knowledge on the problem with the candidate, and vice versa. This will improve the knowledge of the problem of each participants. Further, in Torino we can have access to the health care big data and to real time information concerning the traffic and the workload of the emergency department, enabling such an innovative research. One of the main research objectives is therefore to to exploit such experiences, datas and information to propose an innovative ambulance management system in real time. Such a tool could be the basis for some research proposal at EU level and Italian and/or country of the candidate level.
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