Lecture Notes in Networks and Systems 629

Mohamed Ben Ahmed ·
Anouar Abdelhakim Boudhir ·
Domingos Santos · Rogerio Dionisio ·
Nabil Benaya *Editors*

# Innovations in Smart Cities Applications Volume 6

## The Proceedings of the 7th International Conference on Smart City Applications

Springer

# Lecture Notes in Networks and Systems 629

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*Editors*
Mohamed Ben Ahmed
Faculty of Science and Technology,
Computer Engineering Department
Abdelmalek Essaadi University
Tangier, Morocco

Anouar Abdelhakim Boudhir
Faculté des sciences et techniques de Tanger
Université Abdelmalek Essaâdi
Tangier, Morocco

Domingos Santos
Interdisciplinary Centre of Social Science
Polytechnic Institute of Castelo Branco
Castelo Branco, Portugal

Rogerio Dionisio
DiSAC-Digital Services, Applications
and Content
Polytechnic Institute of Castelo Branco
Castelo Branco, Portugal

Nabil Benaya
FST Al-Hoceima, Physics Department
Abdelmalek Essaadi University
Al-Hoceima, Morocco

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# Keynotes

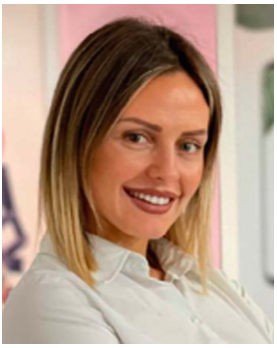
# Responsible and Resilient Smart Cities; The Model Proposed for African Smart Cities: Case Study of Cape Verde

Loide Monteiro

CEO of Smart City Foundation, Cape Verde

**Abstract.** The sustainable development challenges for small archipelagic cities are exponentially bigger when compared to the large metropolises on the continent. One of the biggest problems of these small cities face is related to disorderly urban expansion. From night to day, new peripheral neighborhoods are borne, bringing social and urban problems of an unplanned expansion. Hence, it is essential that these cities leverage their progress on sustainable pillars, creating smart solutions tailored to their challenges.

# The Extended Information Systems Success Measurement Model



Teodora Lolic

University of Novi Sad, Serbia

**Abstract.** Technological innovations such as the introduction or upgrade of information systems in work environments are, globally, one of the most common changes people face daily in their workplaces. Organizational management is consequently seeking to observe and track the return of the investment; therefore, it is necessary to enable the stakeholders to adequately measure the success of information systems. Information systems success has been an emerging research topic for the past decade and still is. Many theoretical models and frameworks have been developed with the aim of giving the most accurate measures for IS success. However, according to the current state of the art, no model for measuring the success of information systems observing the factors that emphasize the importance of people's reactions to changes in the work environment has been found.

# How Can Sensing and Communication Make Cities Smart?

Susana Sargento

University of Aveiro, Portugal

**Biography:** Susana Sargento is a Full Professor in the University of Aveiro and a senior researcher in the Institute of Telecommunications, where she is leading the Network Architectures and Protocols (NAP) group. She received her PhD in 2003 in Electrical Engineering in the University of Aveiro, being a visiting student at Rice University in 2000 and 2001. She joined the Department of Computer Science of the University of Porto between 2002 and 2004, and she was a Guest Faculty of the Department of Electrical and Computer Engineering from Carnegie Mellon University, USA, in August 2008, where she performed Faculty Exchange in 2010/2011. She was the founder of Veniam, which builds a seamless low-cost vehicle-based internet infrastructure, and she was the winner of the 2016 EU Prize for Women Innovators.

# 2050 Now – Creating the Future Sustainable Cities Today

Andy Van Den Dobbelsteen

TU Delft, The Netherlands

**Biography:** Andy van den Dobbelsteen is full professor of Climate Design & Sustainability and Sustainability Coordinator of TU Delft. Next to this he is Principal Investigator with the AMS Institute in Amsterdam. He publishes a lot and delivers lectures nationally and internationally. At TU Delft Andy teaches students how to design sustainable cities, buildings and technology. He was faculty advisor to three successful TU Delft Solar Decathlon teams and is responsible for the free online course Zero-Energy Design, winner of the edX Online Prize 2020. His short film Energy Slaves won the Dutch Oscar for commissioned films. Together with his team, Andy has led and conducted many national and international research projects around energy transition, climate adaptation, circularity and other sustainability themes.

For his work in the domain of sustainability, Andy became Knight in the Order of the Dutch Lion. In 2019, he received the Academic Society Award from the Dutch Royal Institute of Engineers for the way he communicates scientific knowledge to the general public.

# Smart City as a Distributed Platform: Towards a System for Citizen-Oriented Management

Juan Corchado

University of Salamanca, Spain

**Abstract.** This keynote will present success stories regarding especially smart cities. All these fields require the development of interactive, reliable and secure systems which we are capable of building thanks to current advances. Deepint.net, a tool developed by DCSc and BISITE, will be presented. Several use cases of intelligent systems will be presented, and it will be analyzed how the different processes have been optimized by means of tools that facilitate decision making.

# Contents

# Solving the Dynamic Ambulance Relocation and Dispatching Problem Using a Novel Metaheuristic

Maryam Alami Chentoufi(✉), Rachid Ellaia, and Mohamed Lamrabet

Laboratory of Study and Research in Applied Mathematics (LERMA), Engineering for Smart and Sustainable Systems Research Center (E3S), Mohammadia School of Engineers, Mohammed V university in Rabat, Ibn Sina Avenue, BP. 765, Agdal, Rabat, Morocco
Maryam.lami12@gmail.com

**Abstract.** Proper deployment and a good management of emergency vehicles leads to shorter response times to an emergency call and thus reduces suffering, mortality and adverse health consequences for patients. In this context, we proposed a dynamic management of emergency vehicles in Morocco through the SOS accident system. Indeed, decision-making in these emergency situations remains a difficult task, given the number of variables that come into play on the one hand and the dynamism and unpredictability of some of them on the other. The general field in which the present project falls is in Vehicle Routing Problem (VRP), which involves building routes at minimum cost so that vehicles can visit exactly once each customer who has been geographically distributed. We are going to be more particularly interested in a management of ambulances in real time since it will be done on the basis of information which will become accessible over time, which leads to the resolution of the problem of the dynamic elaboration of vehicle routes with time window (DVRPTW). To carry out the current project, we first developed a mathematical model of the response time of emergency vehicles, and calculated the travel time of the vehicles. Then, we used a novel metaheuristic based on Passing Vehicle Search and Tabu search algorithm for the optimization part, which allowed us to take into account most of the constraints that appear in the practice and which constrain emergency vehicles during their daily missions.

**Keywords:** Vehicle routing problem · Real-time emergency response · Vehicle assignment · Vehicle allocation · PVS algorithm · Tabu search · Emergency vehicles management

## 1 Introduction

With the construction of urbanization and the increasing traffic vehicles, the frequency and impact of traffic accidents are intensifying. The research on emergency rescue is getting more and more attention. When traffic accident occurs, rescue timeliness is the key to emergency rescue. Reasonable arrangement of emergency vehicle path can avoid congestion and shorten the travel time, so that the accident loss can be reduced.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Emergency systems operate in highly dynamic environments and are subject to fairly frequent disruptions. These disruptions are due to the dynamic arrival of service requests throughout the day. This project is therefore part of a context where we are seeking to define a dynamic distribution strategy for emergency vehicles to optimize response time in a changing environment while making the most of the information and technologies available, more specifically telecommunications tools and distributed architectures. The vehicle distribution strategy must adapt to the variations observed in the environment and ensure the best possible compromise between the quality of the solution provided and the computing time required. We present in the second section of the state of art the situation studied in a specific context relating to road safety in Morocco which has been discussed in several scientific articles whether at the level of analysis of statistical data of road traffic mortality in Morocco [1], or at the level of study on the evolution of road safety in Morocco [2] and the quality of its management system [3]. In Sect. 3, we modeled the emergency vehicle response time, which is the period between receiving the call and arriving at the incident scene of an ambulance. Next, we will find the optimal path between the accident site and each of the emergency vehicles available, while calculating the travel time generated by our model for all vehicles. We then present a novel metaheuristic based on Passing Vehicle search and Tabu search algorithm to identify the emergency vehicle that will have the shortest travel time. Section 4 will be devoted to the discussion of the various results obtained.

## 2 State of Art and Related Works

### 2.1 The Vehicle Routing Problem

The vehicle routing problem is a combinatorial optimization and operations research problem; it falls under the category of transportation problems which is based on the fact that a fleet of vehicles must be routed to visit a set of customers at a minimum cost, subject to vehicle constraint and driving time constraint. In the case of medical emergency management, this problem includes dynamic elements, and unknowns that will be managed by graphical information systems (GIS) and global positioning systems (GPS), and consequently manage vehicle routes.

To solve Dynamic VRPs, several works based on metaheuristics have been proposed over the last decade, including:

- Among the most cited articles in the DYNAMIC VRPS literature, the study by Bent and al [4], which presents a multiple plan approach (MPA) and another multiple scenario approach (MSA).
- Novoa and al [5] adopted a dynamic approach based on the rollout algorithm [6] to solve static VRP with stochastic demands. In this problem the customer demands follow a known probabilistic distribution and the exact customer demand is only revealed at the time of delivery.
- The work done by Potvin and Benyahia, where they associated each vehicle with a vector of attribute values reflecting the effect of inserting new service requests into its current route, while using the genetic algorithm (GA) [7]. On a similar problem Cheung and al [8] also applied their own implementation of the genetic algorithm.

This time the problem is characterized by tough windows of time when mail collection and delivery must take place. Always with the genetic algorithm, but this time on another version of the Dynamic VRPs, Hemert and Poutre [9] introduced the notion of successful regions, which are poles, where there are more likely potential customers. The problem addressed this time is a problem of collecting loads from customers and delivering to a single central depot.
- The article of Azi and al [10] whose idea is to set the routes, from the start, of the vehicles from the depot and the decision to be taken for dynamic requests only concerns their acceptances or rejection according to their proximity to the vehicles. Routes already planned. This work was based on the Neighborhood Search (NS) algorithm.
- In their article, Montemmani and al [11] have broken down the planning period into sub-periods during which a re-optimization takes place which takes into account new dynamic queries. The static problem is solved using the ant colony system.

In this context, several projects have been launched to create tools to optimize, monitor and manage emergency interventions. Among these projects, we can cite the MERCURE project, which is based on a monitoring system that optimizes resources, travel times and takes care of all the constraints relating to the medical field such as the level of emergency, pathology, medical skills, localization..., which allows to quickly and dynamically solve the problem of management of emergency vehicles with a high level of precision, and this thanks to the most recent models and algorithms seated of emergency vehicles with a high level of precision, and this thanks to the most recent models and algorithms seated of emergency vehicles such as the global location coverage model (LSCM), which aims to minimize the number of ambulances needed to cover all demand points. As well as the Maximum Coverage Locating Problem (MCLP) model, which aims to maximize population coverage subject to the limited availability of ambulances. However, to get closer and closer to reality, several dynamic models are starting to emerge to periodically update ambulances, which do not depend only on sophisticated system technologies, but also on the availability of search heuristics. Fast and accurate, allowing variations in travel time during the day to be included in the shortest path calculations.

As part of our project, we will build on the projects and models launched previously, to establish our own model that shapes the vehicle dispatch system, considering communications from the transportation network, and the vehicle dispatch center, which minimizes response times for emergency vehicles, so that they interact more quickly with their environment, by using the hybridization of the algorithms we have just mentioned.

### 2.2 Moroccan Road Safety Policy

The road safety policy in Morocco has seen an important turning point in the management of the problem of traffic accidents. In order to create a general mobilization and federate all efforts around the subject, the Government has put in place an Integrated National Security Strategy covering the period 2017–2026. It is part of a long-term vision aimed at the development of responsible behavior and the emergence of safer roads, the objective being to reduce the number of deaths due to accidents by 50 pc by 2026, or less than 1,900 dead and not more than 3,000 in 2020.

Morocco has adopted a new road safety strategy for 2026 which sets an ambitious and quantifiable target for reducing road fatalities by half compared to its current level, as a solution of this issue.

In this context, the idea of the proposed project focuses on four axes:

– Help provided to victims of traffic accidents through the SOS accident application.
– Management of accidents on the road.
– Assessment and decision support in terms of accident risks.
– Post accident care.

### 2.2.1 Help Provided to Victims of Traffic Accidents through the SOS Accident Application

First, we are going to set up an application (Android and iOS) that would allow Internet users to be quickly put in touch with the nearest security post to report an emergency situation, especially in the event of an accident (Fig. 1). Indeed, the SOS accident application would put the driver in touch with the medical regulation center, by also providing the geolocation data of the telephone (Fig. 2) and the data entered during the creation of his account on the application, in order to allow rapid and appropriate emergency response. Overview of the use of the application:

After installing the application, the user is prompted to create an account and provide the following information (Fig. 3):

– Last name *;
– First name *;
– Address *;
– CIN *;
– Phone number *;
– Blood groups, Rhesus; (Possibility to import the receipt).
– Allergy: Yes / No (If Yes, give the user the possibility to import the proof).
– History of illness; Yes / No (If Yes give the user the possibility to import the medical file).
– etc…

This falls within the framework of the ambition: "Assistance provided to victims of traffic accidents". Indeed, the effectiveness of road accident rescue services is often a question of time. People who receive prompt and adequate treatment are more likely to survive. In order to improve the quality of assistance (support on the scene and during the transfer of victims).

### 2.2.2 Back Office Application Dedicated to Emergency Personnel

Another back office application dedicated to emergency personnel is offered as part of this project, it allows:

Management of internet users' requests through (Fig. 4):

- The consultation on the map of the geographical position of ambulances and that communicated by the requesters for help (from the SOS accident application).
- Communication of the command to the ambulance and transfer of the GPS position to reach the victim and take charge.
- Entering requests received by phone.
- Search (by Application No., by region, by CIN).
- The update…,
- etc.

The follow-up of emergency requests through:

- The implementation of indicators and dashboards for piloting and monitoring accidents.
- The creation of a repository of data for the management of indicators related to road accidents.

Principle of vehicle geolocation: The geolocation of vehicles makes it possible to know at any time, in near real time, where the vehicles equipped with geolocation devices are located.

The GPS geolocation system connects to the satellite positioning network to know its location. The data is then transmitted to the driver and / or to the operator of the medical regulation center, generally by mobile cellular networks. Operation of the emergency vehicle geolocation system Emergency vehicle geolocation systems (ambulances) work with two key elements:

- GPS trackers connected to the satellite positioning network and installed on all vehicles in the fleet, allowing emergency vehicles to be geolocated,
- Fleet management software, connected to the trackers, generally by the mobile cellular network, which indicates the positioning of vehicles equipped with these trackers.

Overview of the use of the application:

- At the level of the SOS accident application, the user connects to the application and makes a request for the nearest ambulance to join him immediately,
- At the Back office level, the operator consults the geographical position of the ambulances and that of the user on the map to find the nearest available vehicle,
- The operator communicates the command to the ambulance and transfers the route to reach the victim and take charge of him to his vehicle's GPS.