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Klaus Thoma, Ivo Häring, Tobias Leismann (Eds.)

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THE DYNAMIC CAPTURE OF SITUATIONAL AWARENESS REGARDING CROWDS AND ITS SMART ADOPTION INTO EMERGENCY MANAGEMENT INFORMATION SYSTEMS SUPPORTING THE ACTIVE EVACUATION ROUTE

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ABSTRACT

Towards situational awareness concerning crowds in mass gathering venues, the use of intelligent management information systems is crucial for a safe and fast evacuation of people. Therefore in this situation, humans can be overwhelmed by the critical decision they need to take, and they can fail taking that decisions, leaving the crowd to a mass panic. Taking into account this problem, is where the eVACUATE project starts, giving the current situation a newly developed intelligent fusion of sensor, geospatial and contextual information with advanced multi-scale crowd behavior detection and recognition, providing it with dynamic behavior predictions and advanced crowd dynamic models. The result is a service-oriented decision-support which can contribute to the management of these situations, giving the management responders tools to act in real-time. The eVACUATE system performance and scalability will be validated in five distinct scenarios involving incidents with large crowds at various venues with the requirements of evacuation time reductions and increases of safety and security. These are: 1) underground stations in Bilbao and 2) Marseille; 3) Real Sociedad Football Stadium in San Sebastian, 4) Athens International Airport and 5) a STX cruise ship.

Keywords: Innovation, technology, research projects, mass evacuation, simulation, crises management.

1 PROJECT INTRODUCTION

An evacuation procedure is a complex situation influenced by many parameters that can affect the correct execution of the process. This situation is usually commanded by persons responsible for comprehending the situation status and giving the appropriate orders for the correct evacuation. Moreover, human response can be affected by many circumstances, including the coming stress from the own situation, leading the person to take inefficient/wrong decisions which can lead to fatal consequences. Broadly, a crowd can be considered to be a collection of loosely coordinated individuals sharing a common and temporarily bound interest. This description covers spectators and people moving. In crowd massive evacuation, citizens react incoherently, so eVACUATE will be a perfect tool because it aims to address the needs of the safety of citizens during complex evacuation processes towards the creation of a holistic system that:

i. Will enhance the effectiveness of complex evacuation operations at any type of venue or infrastructure.
ii. Will adapt evacuation plans to the current conditions.
iii. Will dynamically survey how an evacuation is evolved.
iv. Will support civil protection authorities.

In order to improve the situation, the eVACUATE project aims to understand the complexity of large-scale disasters by tackling the operational challenges of situation awareness (SA) giving effective, safe solutions and support to the decision making commandment to achieve the efficient solution possible.

As a final point, the project will be tested over a set of five carefully selected application scenarios of severe and diverse requirements involving: underground operating authorities in Bilbao and Marseille, the football stadium of Real Sociedad, a cruise ship of STX and the International/Metropolitan Airport of Athens.

2 PROJECT OBJECTIVES

With the purpose to achieve the main objectives of eVACUATE, it is necessary to research, develop and demonstrate the capabilities of both framework and prototype, enhancing the results of complex crowd evacuation operations taking place in any type of venue or infrastructure. Thus, eVACUATE will yield a holistic system to fulfill this objectives:

i. To develop a situation awareness (SA) evacuation system able to adapt dynamically to changing situations. eVACUATE's dynamic system will be able to adapt its decision taking to several variables, such as: type of situation, humans' reaction, state of the evacuation or sensors information, to inhibit external influence.

ii. To integrate multiple information sources to command posts to deployed intervention personnel. eVACUATE will provide information to the citizens but also to the intervention personnel to increase the precision in their response.

iii. To develop a system able to share all relevant multimedia data, video, pictures, voice, force locations, plans, orders, messaging, etc. between all operating personnel in order to detect the optimal route and guide safely the persons out the venue.

iv. To develop a system applicable to a broad range of areas (e.g., large gatherings on confined outdoor areas, office buildings, underground stations) and to various incidents (natural and man-made as well as terrorism). Thus, eVACUATE will be tested in four different scenarios according the previous broad range of areas.

v. To develop respective optimal evacuation strategy. This strategy will be implemented through the active evacuation route (AER) which will be designed in real-time based on crowd behavior, the type of venue, and the crowd monitoring.

Thus, it is necessary to define a new-generation crowd evacuation support platform, supporting a vast variety of complex crowd evacuation operations, providing complete interoperability and connection between the different systems and layers and integrating different innovative and existing modules (sensors, positioning, communications) with the aim to reduce drastically data ambiguity. So, as to ensure the objectives ,it is important to study the socio-economic environment to address the crisis situations, taking into account: ethics, legal issues, regulation societal context, standardization and national and international operating procedures. Once the previous research and innovation is completed, four pilot demonstrations will be set to observe the objective's impact.

3 A NEW-GENERATION CROWD EVACUATION SUPPORT PLATFORM

With the intention of achieving the previous objectives, one of the main research and innovation areas of eVACUATE is to provide a new-generation crowd evacuation support platform, comprised of a full-set of systems and services built in accordance to innovative, integrated standards and peer-to-peer architecture. This will be achieved thanks to a complete system which will provide efficient support to the commandment, giving safe and effective evacuation strategies, based on a resilient and seamless communication platform integrated to the mechanisms already in place. This platform will allow communication between the evacuation operations center and other response units and to remotely configure communications devices by taking into account overall situation awareness information, being able to implement an efficient emergency plan context communication.

Towards this direction, newly adaptive communication architectures will be introduced and will be integrated to the employed platforms.

3.1 Crowd modeling

With regard to that model, the purpose is to describe specific application scenarios and develop crowd dynamics models for these scenarios, including both static and dynamic assessment of crowd flow, spatial analysis and network/agent-based modeling. Crowd modeling is intrinsically used in the simulation and crowd awareness methodologies, through the use of computer vision tools, for determining the optimum evacuation route under a real-time and active evaluation strategy; computer vision detects current crowd behaviors, and simulators predict future outcomes by exploiting information provided by the crowd modeling.

3.2 Smart spaces

With regard to smart spaces, possibilities increased by the availability of location tags (individuals reporting through their GPS), proximity (Bluetooth, NFC, ZigBee/802.15.4) and context observation (audio and video streams originating from microphones/cameras), as well as participatory sensing (whereby users perform sensing of their environment using smart phones). This combination of information given by the smart spaces will also provide the means to support the real-time in the evacuation routes, updating the exit signage according to the decisions taken. The fusion of information produced by the sensors installed in a facility along with the information from the users' smart phones will form a "smart space" of enhanced SA. On the other hand, the comprehensive and directive broadcast of the evacuation decisions is also part of the smart space duties.

3.3 The visualization module

One of the key elements that can permit reducing time in evacuation is the visualization of information. The visualization module of eVACUATE displays all relevant data such as crowd geometry, density, flow, congestions, groups, "specific" categories of persons (children, disabled, pregnant, etc.). This data can be visualized in 3D or by geographical reference and the user should be able to manipulate the visualization module without requiring any specific knowledge.

With eVACUATE, the user is able to visualize crowd information displayed in the COP which presents this information in a schematic manner. This enables the user to quickly understand what is happening in an emergency case and helps increasing the decision making efficiency, allowing the user to manage several layers of information, all visible in one screen. On the other hand, the visualization module is not just designed to improve decision making efficiency, it is also focuses on end-users by allowing them to

add data, icons, visualize status, choosing between different representations and by rolling back in time to see a previous state of the evacuation.

3.4 The value of time: active evacuation route (AER)

In the event of a fire or a security threat, time is critical. While time is so scarce, crisis communication about evacuation decisions should go fast and without noise. In eVACUATE, we try to prepare the way of communication and we facilitate the preparation of the content of instructive messages.

The eVACUATE ultimate's goal is to identify, designate and sustain an active evacuation route (AER) comprised of the most recently generated evacuation route that adapts dynamically according to current and evolving circumstances.

i. Providing a valuable tool to guarantee total situation awareness both to the crowds involved during a crisis but also to the crews operating in situ as well as in remote locations.

ii. Adapting dynamically evacuation plans to current conditions through a dynamic evacuation framework instead of the current passive and static one.

iii. Providing a clear, easy-to-use set of safe evacuation instructions, available over a multitude of alternative and complementary presentation channels.

iv. Setting up visible demonstrations of innovative crowd evacuation support systems in realistic situations.

v. Supporting civil protection authorities in the formation and validation of proper safety procedures for crowd management.

vi. Setting a cornerstone for the standardization of equipment, processes and methodologies for evacuation purposes on an EU level addressing the cross-cultural issues emerging from diversity imposed by citizens.

With regard to the active evacuation route, when something abnormal happens, the system can process the crowd characteristics and raise an alert if something unusual is happening. At the same time, the commander user is able to locate the problem and process it, being asked to either close the message if it was a wrong alert or report the issue. Simultaneously, it should be able to prepare and deliver alert messages and specific commands for AER, and also define the type of devices that receive the message. During all that process, the system will help the commander, showing the active evacuation route (AER) at any time. But not only displaying the route but also the currently predicted evacuation time necessary as well as possible congestions that may occur at particular spots or alternative evacuation routes with statistics, which may improve the evacuation performance. The commander user can also prepare the active signs to help the evacuees find their routes to the desired evacuation spot.

With the help of prediction of near future problems and simulation of possible actions, the system shall assist a commander user in the decision process, advising him with suggestions as to the predicted best actions at any particular time. This comes as proposed new evacuation routes, messages for public, message for crew, etc. To estimate all these tactical plans (and consequently to design strategic plans) for effectively controlling the evolution of an emergency by exploiting the estimation tools, the information observations and the crowd dynamics models. Towards this direction, we incorporate dynamic and adaptable decision making strategies through the exploitation of game theory, for real-time adjusting the AER so as to elaborate the optimal evacuation strategy.

4 EXPECTED IMPACTS

The eVACUATE project aims to research, develop and demonstrate the capabilities of complex crowd evacuation operation. The very system performance and scalability will be validated in four scenarios involving incidents with large crowds at various venues with the requirements of evacuation time reductions and increases of safety and security. Former end-user partners made their facilities available to realize the following four pilot demonstrations:

i. Anoeta Stadium (Spain)
ii. Passenger cruise ship STX-FR (France)
iii. Athens International Airport (Greece)
iv. Metro Bilbao S.A. (Spain)

On the other hand, the end-users of the eVACUATE system were identified and they will be the verifiers of the expected results.

i. The *responsible officer* will be the main user of the system. He/she can use the integrated information about the situation in the building to get an overview. He/she will take the decision to eVACUATE based on a common operational picture. This is the decision support part of eVACUATE.
ii. In a secondary way, also *service people and crew*, who are persons involved in the evacuation process, are users of the system. They provide operational information or use operational information to fulfill their duties in case of an evacuation. This is the communication part of eVACUATE.
iii. Last but not least, the *specialized configuration expert* with programming skills can be qualified as user of the system. He/she should be able to connect the system to the existing infrastructure in the building and make the configuration.

5 CONCLUDING REMARKS

This paper has dealt with complex crowd evacuation operation, presenting the eVACUATE project as it is, a new generation platform to resolve complex decision making situations. The state of the art has already been identified and there is a considerable scope for improvement. Managing situational awareness concerning crowds in specific mass gathering venues will change from the way it is happening today. And this change it is being reflected in our aims from the beginning of the eVACUATE project because it will focus on the cooperative idea of sharing know-how in crises' early stages, helping to create a EU crisis handling framework. Emergency organizations in Europe will therefore be able to harmonize their procedures through a common crisis database and help services learn from each other's experiences.

On the other hand, eVACUATE could facilitate inter-European cooperation, due to the fact that it is fully scalable and it is based on common technology (basically, telephone and Internet connection) available everywhere in Europe. Moreover, the system will allow to interconnect countries disseminating alert messages to authorities and citizens that may be affected by the abnormal situation.

To conclude, the eVACUATE book will be created to provide a set of comprehensive best practices and guidelines for setting the strategic evacuation of crowds in emergency situations with advanced crowd behavior simulations. The eVACUATE book shall provide comprehensive best practices in crowd evacuation management and directions for future research for improving those practices. On the other hand, the eVACUATE book is not the only share of know-how, nowadays, there is no standard needed for crowd evacuation operations. In regard to that matter, the eVACUATE

project also aims to develop a novel proposal of such a standard called “Common Information and Communications Technology Framework for Crowd Evacuation Operations”.

6 STATE OF THE ART

Regarding the state of the art of the project and therefore of the evacuation systems, the actual scenario shows that although systems are not finished as an ultimate solution, we can provide an initial pilot involving all elements. It should be considered that these elements will be shown in the demonstration pilot which have been selected in order to minimize errors and to provide a reliable solution with a minimum risk. On the whole, the main goal for this demonstration pilot will be focused on general behavior of the system. In this way, particular elements or integrations between them would change in regard to the initial picture.

6.1 Global architecture

Regarding the general architecture, the developing itself could be show in the next activity picture. Pretending to be a “guide” for components through the system and their communication with and between them.

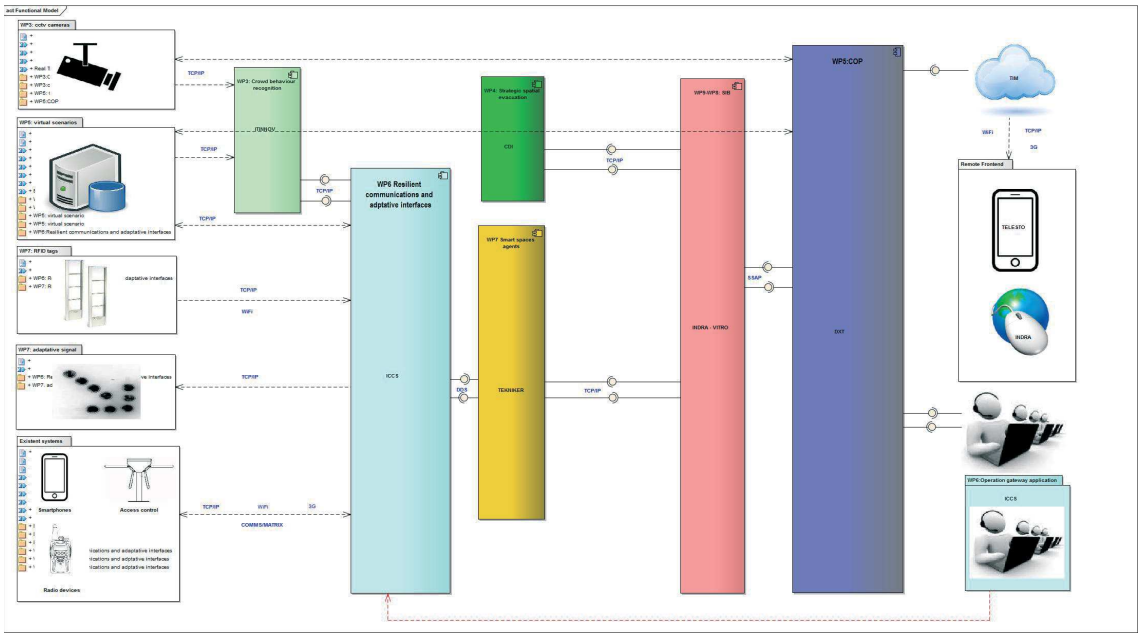

Figure 1: Above picture allows us to see the communication and directionality between components as well as protocols involved. For each component, there exists a particular activity diagram for an easier architecture understanding.

6.2 Demonstration pilot

The next demonstration pilot, which according to the prevision will take place in September, will follow the global architecture defined in the next picture, where we can observe the general overview of the pilot and the system.

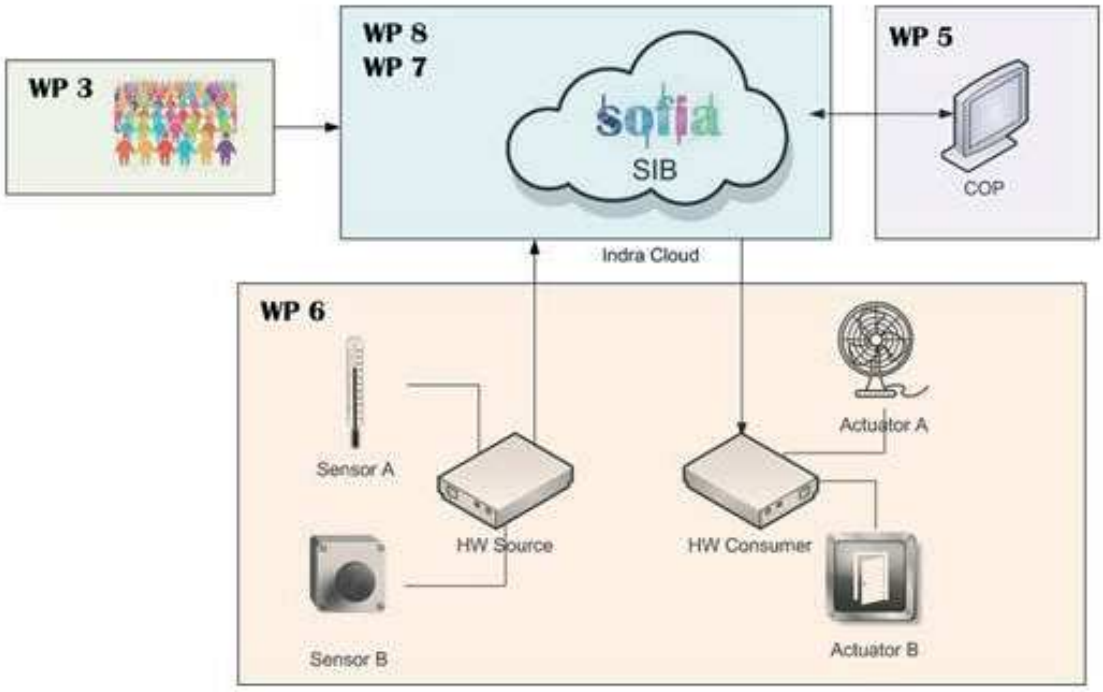

Figure 2: Specifically, this pilot will be a stand-alone demo without integrating smart space agents and SIB. It will show the use of DDS publish/subscribe mechanisms (which will be used on DDS communication gateway implementations of the eVACUATE system) for interacting with the digital signage system.

In order to show a more operative demo, it will be connected directly to the SIB and special attention will be paid to the directionality and density of crowds in simulation inputs. We will develop a "basic agent" with connection to the SIB (SOPHIA framework) and a basic ontology, so, without DDS implementation. Then, this agent will be connected to a physical device with a custom library.

As this is an initial pilot, it should present advances in many fields:

i. Showing connectivity between real gadgets and the IT world.
ii. Showing the ontology performed for the connected items.
iii. Showing some intelligence in the SIB in order to perform actions.
iv. Showing a primitive UI and COP to the end users.

6.3 Demonstration scenarios

Actually, the most advanced model for demo is Bilbao's metro station San Mames. Next, is shown this model divided by activity partitions following frame by frame the evaluation criteria and scenario definition defined in the project.

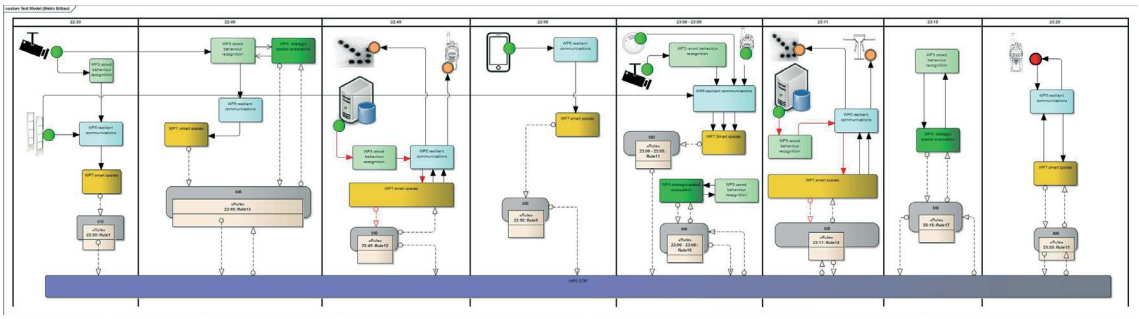

Figure 3: Bilbao's metro station San Mames.

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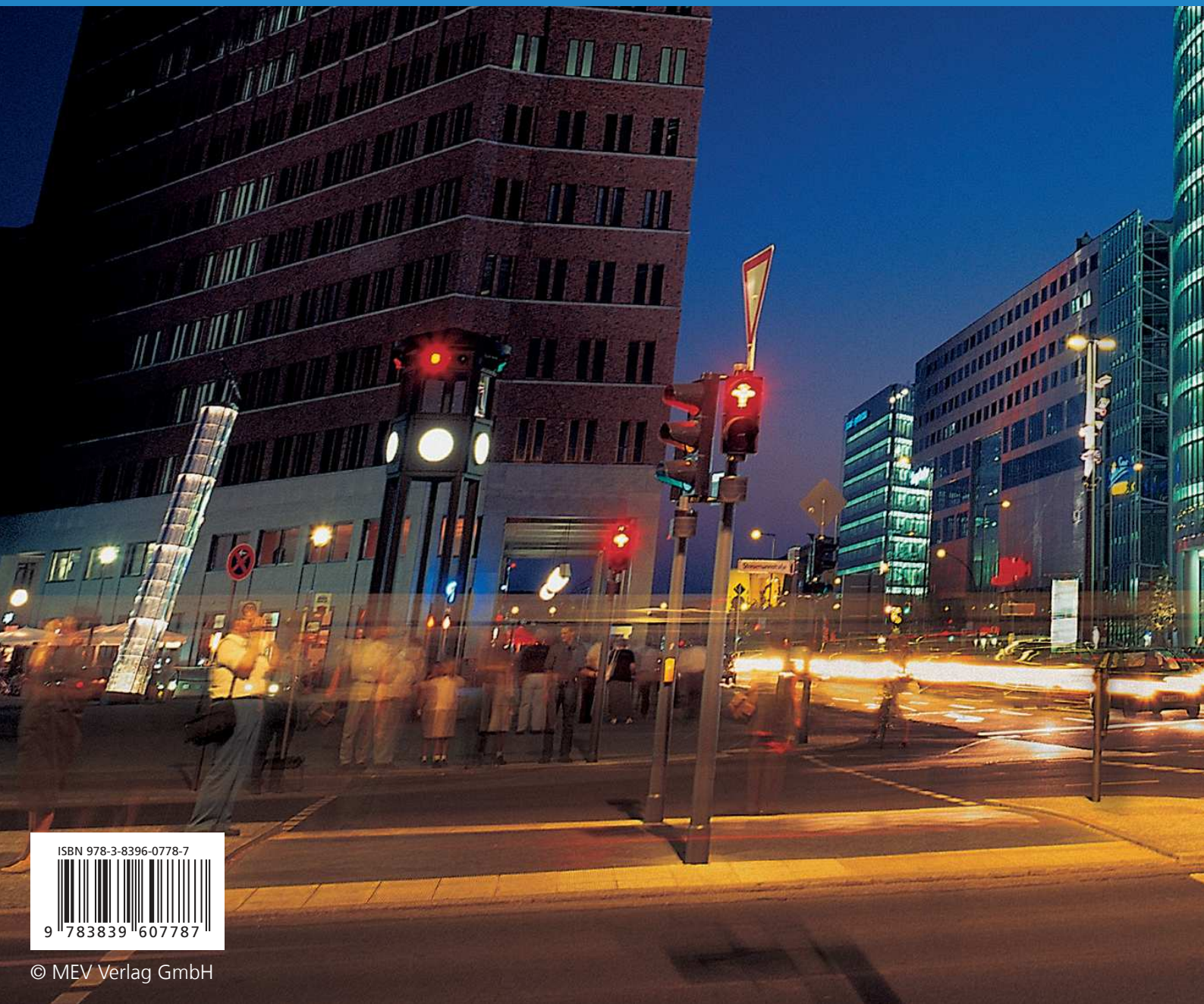

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