TEACHING MATERIAL GUIDANCE

1) Title of the material

Rosa, L.; Silva, F.; Analide, C. Mobile Networks and Internet of Things Infrastructures to Characterize Smart Human Mobility. Smart Cities 2021, 4, 894-918. https://doi.org/10.3390/smartcities4020046

https://www.mdpi.com/2624-6511/4/2/46

2) Which section of the SUMP it is relevant to?

This article is a conceptual contribution that thoroughly discusses the role of Artificial Intelligence (AI) and the Internet of Things (IoT) and applying them to mobility management. Therefore, the article can be linked to the third, fourth and fifth sections of the SUMP circle related respectively to the determination of planning framework, analysis of the mobility situation (in particular the analysis of problems and opportunities for all modes of transport - **subsection 3.2**.), scenario building and joint evaluation (development of scenarios of possible futures - **subsection 4.1**.) and vision and strategy development (arguments for stakeholders – **subsection 5.1**).

3) Which Mobility Manager knowledge this material is the most relevant to?

It is related to Transport and mobility planning (section 1 of the Mobility Manager competencies) especially 1b (employment of ITS/ICT and smart measures).

4) Problem approached and content overview

Problem approach – general understanding of the role of Artificial Intelligence (AI) and Internet of Things (IoT) and applying them to mobility management. The evolution of mobile networks and Internet of Things (IoT) architectures is making it possible to rethink the way smart city infrastructures are designed and managed and to address many of the problems associated with human mobility. Territories that adopt the era of sensors can use this disruptive technology to improve the quality of mobility of their citizens and rationalise their resources. However, with the rapid development of smart terminals and infrastructures, as well as the proliferation of diverse applications, even current networks may not be able to fully meet people's rapidly growing mobility needs. As such, they face many challenges, and various standards and designs have been proposed so far to meet them. Artificial intelligence (AI) has been used as a new paradigm to design and optimise highly intelligent mobile networks. This thesis aims to identify and discuss challenges for mobile networks, in addition to IoT and AI, to characterise intelligent human mobility and discuss some feasible solutions to these challenges. Based on this discussion, paths for future research on intelligent human mobility are proposed.

In this article, the authors discuss how IoT, AI and wireless networking technologies are important for the success of smart human mobility applications. In doing so, they explore the basic requirements of intelligent human mobility and exploit the opportunities

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generated by the continuous evolution of mobile communications and IoT architectures. Furthermore, this study aims to investigate the level of coverage of emerging technologies, IoT architectures and mobile network technologies in the human activity tracking. Finally, to present new developments in intelligent human mobility, the authors discuss future directions of new mobile technologies.

5) Who could be interested in this material?

This work is ultimately a reference tool for students, researchers and urban planners that provides clear and systematic definitions of the ambiguous terms of tomorrow's smart mobility and describes their individual and collective roles underlying the nexus.

6) What is worth mentioning as an innovative factor for the reader?

The rapidly evolving concepts of mobile networks are paving the way to achieve the goal in intelligent human mobility, combining several smart devices, IoT and AI. The paper explores the foundations of this idea and provides state-of-the-art research to monitor and analyse social network topology, spatial distribution and individual movements in urban and remote or rural scenarios. Additionally, based on a deep understanding of the correlation between these scenarios and the spatial-temporal distribution as a result of geographical location, we use a set of human mobility data sources and metrics. Human mobility data and metrics are relevant for a wide range of applications. The results of these applications based on human mobility correlations are expected to inspire strategies to understand and predict human behaviour, create new smart applications and improve existing processes. Furthermore, they should include a better understanding of the information spread by individuals, improving the networking of technological sources of this information, such as routing protocols and wireless networking capabilities. For example, to better predict human mobility, we should consider not only the artificial intelligence model but also the available mobile network that acquires the data. Network dynamics may be the key to collect human interactions with several devices. Therefore, understanding human movement leads to new models of information diffusion through wireless complex networks in geographical space.

In addition to the great advantages of IoT, AI and communication networks, this paper also presents some related challenges (such as security, reliability and big data) and their proposed solutions. In addition, this article reviews the unique features of 1G to 5G mobile network technologies that are emerging with IoT as next-generation networks to support new human mobility requirements. More specifically, detailed information on the role of the 5G mobile network in the progress of IoT and human mobility is provided. In addition, some of the problems and solutions related to this mobile generation are discussed in this paper. Also discussed are emerging technologies such as LoRaWAN, Sigfox and 3GPP, which are characterised by energy efficiency, a large number of low-cost devices, wide coverage and relatively narrow bandwidth. These LPWAN solutions are powerful approaches to human tracking. They provide an efficient framework and context for making trade-offs for deployments. This paper identifies gaps and evaluates the suitability of LPWAN implementations for human mobility applications. Additionally, a set

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of solutions such as EC-GSM, LTE-M and NB-IoT are highlighted, including the development or update of solutions of these technologies.

Some analyses related to the coverage of human mobility by mobile network technologies are also discussed. The upcoming 5G mobile technology is expected to power entirely new applications as its key strength is in the area of user mobility coverage with significant improvements in performance and scalability. The future is likely to entail hybrid networking solutions in which personal area networks (PANs), local area networks (LANs), wireless wide area networks (WWANs) and LPWANs will coexist. The theoretical contribution of this work brings the latest scientific and technological basis in the area of human mobility in smart cities. The existing literature shows that various projects (using AI or not) are trying to implement smart human mobility in cities. These projects have been developed using advanced communication technologies, using key human mobility metrics for implementation in urban areas, as well as the most appropriate artificial intelligence algorithms. Although the growing scientific activity in the human mobility sector has led to the improvement of smart human mobility, they approach different technological and scientific components without believing that there is a set of available technologies in smart cities. Therefore, this thesis harmonises the concepts of smart cities and human mobility so that the development and approach of smart human mobility concepts are easier. Further steps in this research are manifested in adapting these indicators, technologies and models to the latest methodologies, developing sustainable smart mobility plans for each city.

7) Limitations

The problem was analysed at a high level of generality. Nevertheless, the presented general conclusions may serve as an inspiration for Polish cities regarding problems that may occur during the implementation of new technologies and services using AI solutions.

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