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ISBN 978-3-031-18463-5 ISBN 978-3-031-18464-2 (eBook)
https://doi.org/10.1007/978-3-031-18464-2

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

The challenges in urbanization forced worldwide governments and industries to embrace the smart city vision. A modern urban infrastructure no longer operates in isolation but instead leverages the latest technologies to collect, process, and distribute aggregated knowledge to improve the quality of the provided services and promote the efficiency of resource consumption. However, this technological development manifests in the form of new vulnerabilities and a plethora of attack vectors. The ambiguity of ever-evolving cyber threats and their debilitating consequences introduce new obstacles for decision-makers. Therefore, cyber situational awareness of smart cities emerges as a mission-critical task that requires novel strategies for practical and prompt decision-making. By synthesizing the body of existing knowledge on cyber incidents, detection, and cognition methods, this book strives to advance the adoption and deployment of corresponding strategies in the realms of smart cities.

This book overviews the drivers behind the smart city vision, describes its dimensions, and introduces the reference architecture. It further enumerates and classifies threats targeting the smart city concept, links corresponding attacks, and traces the impact of these threats on operation, society, and the environment. Besides, it introduces a data-driven situational awareness, provides an in-depth description of the respective solutions, and highlights the prevalent limitations of these methods. More importantly, the book points out promising research directions and emphasizes the demand and challenges for developing holistic approaches to transition these methods to practice to equip the user with extensive knowledge regarding the detected attack instead of a sole indicator of ongoing malicious events. To this end, the book introduces a cyber situational awareness framework that can be integrated into smart city operations to provide timely evidence-based insights regarding cyber incidents and respective system responses to assist decision-making.

What Is Covered in This Book?

Our goal is to cover the topics from the motivation behind smart cities to defining its essential elements to studying cybersecurity threats and building a foundation for cyber situational awareness using data-driven methods and deep learning algorithms. This book is divided into two parts. Part I magnifies the motivation and significance of the concept of smart city (Chap. 1) and its particular challenges concerning cybersecurity (Chap. 2). Part II studies situational awareness methods that address elements of smart city technologies (Chap. 3), defines situational awareness programs, and offers the corresponding framework for ICS deployed in critical infrastructure (Chap. 4) and its particular case - water facilities (Chap. 5). Chapter 6 points out research directions and stresses the demand and challenges for developing holistic strategies and techniques to enforce cyber situational awareness methods in practice. Each chapter in the book can stand alone, defining a particular aspect of smart city or cyber situational awareness for it. There is a sequence in each chapter that builds on the previous one to provide a conceptual understanding of the smart city concept and detailed cybersecurity threats coupled with an approach for getting started with building cyber situational awareness.

Chapter 1: Rise of Smart Cities
Facing the socioeconomic challenges in urbanization, worldwide governments and industries embrace the smart city concept and establish transformation projects that demonstrate tremendous growth. These projects combine information and communication technologies to engage and integrate citizens, visitors, and business communities into an intelligent ecosystem to support better decision-making and cocreating solutions for urban issues. This engagement positively shifted essential city operations toward sustainable, effective, and efficient functions. This chapter strives to shed light on the drivers behind the concept and sets the scene for the smart city by providing its definition, separating building blocks, and highlighting contemporary technological advances.

Chapter 2: Cyber Brittleness of Smart City
This chapter shifts the focus on the cyber fragility of the smart city concept, elaborates on fundamental peculiarities of smart city cybersecurity, and raises awareness regarding past real-world cyber incidents that affected smart cities. It examines prevailing threats targeting smart cities that are identified from actual and potential cyberattacks.

Chapter 3: Cyber Situational Awareness Frontier
Cyber situational awareness or network security awareness is a vital component of a holistic view of cybersecurity. This chapter puts forward a new perspective on sustained cyber situational awareness for smart cities. It explores monitoring and attack detection methods to support the perception of cyber awareness. Further, it examines risk assessment methods and contextualized threat intelligence, which

enable the characterization and anticipation of advanced and coordinated threats via assessing their possibilities and impact. Finally, the chapter explores the strategies that model dependencies among smart cities' components to clarify how threats affect the entire ecosystem.

Chapter 4 Cyber Situational Awareness for Industrial Control Systems (ICS) Deployed in Smart City
The increased number of cyberattacks against critical infrastructure, in particular, their vulnerable network-assessable automated control systems, paved the way for new approaches to defining cyber situational awareness and forensic methods for smart cities. This chapter defines the activities required to enforce a sound situational awareness program and elaborates on design challenges that hinder the transition to operation in ICS realms. This chapter introduces a framework to integrate into operation to enhance situational awareness by providing evidence-based insights about ongoing cyber incidents and respective system responses to assist decision-making.

Chapter 5: Case Study: Situational Awareness for Water Treatment Systems
Cyberattacks on water systems can cause significant damage to the ICS equipment and render chemical or biological hazards, which can have social and financial implications. This chapter recaps the history of cyber incidents against water systems and conveys the significance of cyber situational awareness in this environment. To this end, this chapter offers a business case for applying the cyber situational awareness framework to the small-scale water treatment plant, similar to those found in small cities.

Chapter 6: Looking ahead: Future Perspectives and Opportunities of Cyber Situational Awareness for Smart City
Smart cities worldwide suffer from rapidly evolving cyber threats and attacks that exploit advanced heterogeneous technologies. Thus, failing to manage these cyber threats impairs the trustworthiness of smart cities' endeavors. Although research and operational communities are actively developing the methods to address this imperative task, numerous observations require attention. This chapter encapsulates several issues on sustained cyber situational awareness for smart cities and elaborates on several possible research directions to address these topics.

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January 2022

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Part I
Cybersecurity of Smart City

> *Great results can be achieved with small forces.*
>
> **— Dalai Lama**

Chapter 1
Rise of Smart Cities

Facing the socio-economic challenges in urbanization, worldwide governments and industries embrace the smart city concept and establish transformation projects that demonstrate tremendous growth. These projects combine information and communication technologies to engage and integrate citizens, visitors, and business communities into an intelligent ecosystem to support better decision-making and co-creating solutions for urban issues. This engagement positively shifted essential city operations toward sustainable, effective, and efficient functions. The application of smart technologies and data harnessing methodologies developed numerous solutions to cities' key challenges (including rapid urbanization, increased homelessness, rise in crime, climate change, and more). From improving traffic conditions to optimizing energy consumption, smart cities enhance the quality of life of their residents by reducing carbon emissions while optimizing utility costs. This chapter strives to shed light on the drivers behind the concept and sets the scene for the smart city by providing its definition, separating and elaborating on each building block, and highlighting contemporary technological advances.

This chapter first overviews the challenges of modern cities in Sect. 1.1 and sets the scene for the smart city concept in Sect. 1.2 by providing a definition and exploring its dimensions from architectural, technological, economic, and social perspectives. Finally, Sect. 1.3 concludes the chapter.

1.1 Forces of Change

Despite the global pandemic and ongoing wars, the world's population is rapidly increasing; it has almost reached 8 billion as of May 2022 [4]. With the immense growth, the world witnessed an increasing concentration of residents in the cities: more than half the world's population currently lives in urban areas (Fig. 1.1), and the trend is projected to continue. Accordingly, the United Nations predicts that two-

N. Neshenko et al., *Smart Cities: Cyber Situational Awareness to Support Decision Making*, https://doi.org/10.1007/978-3-031-18464-2_1

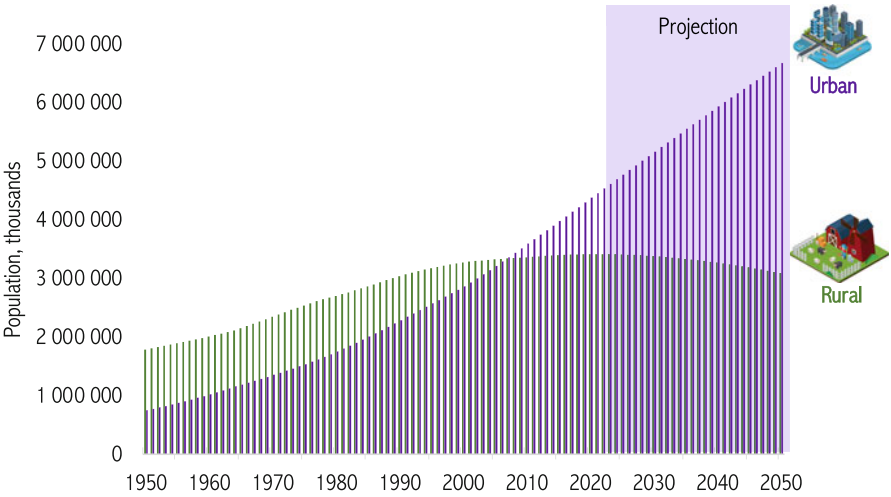

Fig. 1.1 Global urbanization, 1950–2050, thousands. Source: United Nation Department of Economic & Social Affair

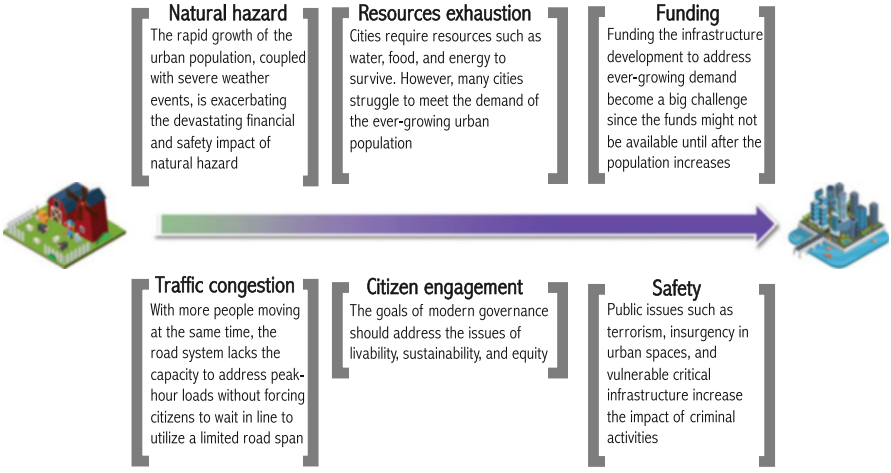

Fig. 1.2 Major challenges of modern cities

thirds of the world population will live in towns and cities by 2050 [19], implying that around 1.5 million people around the globe will move into urban areas every week [22].

This unprecedented population boom will put tremendous strain on urban infrastructure and comes with a myriad of challenges and opportunities. Natural hazards, resource exhaustion, sustainability of fiscal policies, traffic congestion, safety, and citizen engagement are only a few challenges modern cities face (Fig. 1.2.)