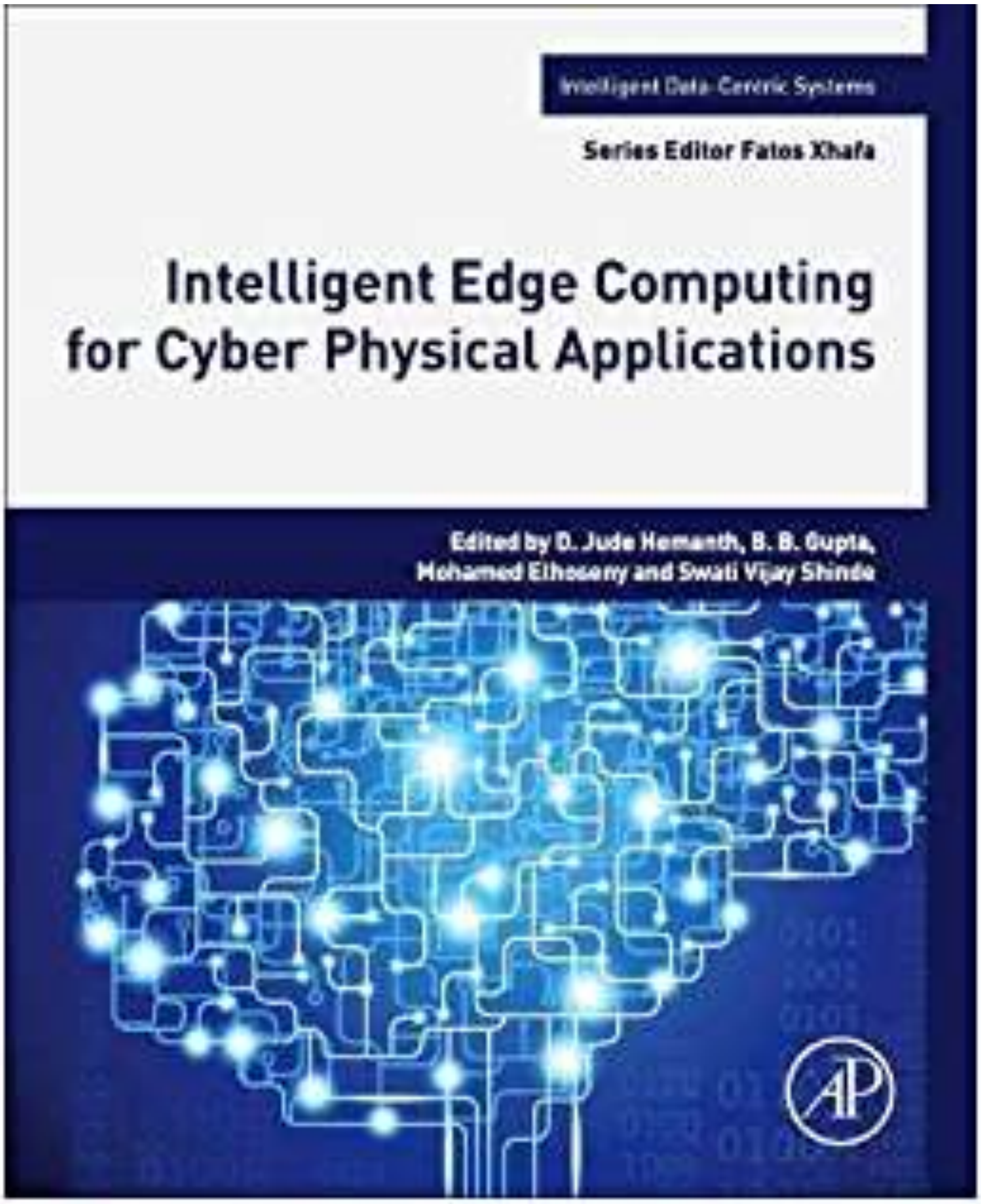
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CHAPTER

IoT-based BIM integrated model for energy and water management in smart homes

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4.1 Introduction

Smart home is a concept that mainly focuses on enhancing the comfort of occupants and facilitating household activities [1]. Smart homes can be improved with Information and Communication Technologies (ICT) to provide the user with context-aware automated or assistive services in the form of ambient intelligence, remote home control, or home automation. The idea of "smart" homes is to integrate smartness into homes to guarantee residents' convenience, safety, and security while conserving energy. The smart home is commonly addressed as a smart house, home automation, intelligent home, adaptive home, or warehouse [2].

The first definition of a smart home was provided by Lutolf [3] in 1992. The idea of a smart home is the integration of different services in a home by using a common communication system. This system provides an economical, secure, comfortable, and energy-efficient operation of the home, which includes a high degree of intelligent functionality and flexibility. It also uses internet-connected devices to enable the remote monitoring and management of appliances and systems, such as lighting and heating.

Energy and water management are the key elements in a smart home, and a smart home functions to reduce energy consumption and manage water in and around the home effectively. According to Lashkari et al. [1], energy consumption has increased due to the rising population and expanding economy. With the improved quality of life, energy consumption will continue to increase, and the increment rates are expected to continue. High energy consumption will lead to high emissions of greenhouse gasses (GHG), which has a serious impact on the global environment. In 2004, the building energy usage in the European Union (EU) was 37% of the final energy, which is higher than other sectors such as industries (28%) and transport (32%). Unlike other sectors,

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there are various attractive opportunities for buildings to reduce energy consumption to have lower costs and higher returns. Meanwhile, energy consumption in the residential sector in the year 2007 represented 21% of the total US demand. After the initial increase from 17% to 20% from the year 1950 to 1960, the amount has remained between 19% and 22% to date [4]. A huge amount of home energy is consumed ineffectively. It is reported that residential buildings are responsible for 40% of global power consumption [5]. The poor technology of energy management systems is the main cause of energy waste in homes.

Sustainable development goals (SDG) aim to ensure affordable, reliable, and sustainable modern energy for all occupants. Sustainable development requirements and the significant increase in energy costs necessitate the reduction in energy consumption without compromising on the comfort of the consumers. Integration of intelligent management systems in buildings will lead to less consumption of energy and save cost at the same time. The concept of smart homes has therefore received overwhelming attention in the last decade due to its potential in providing comfort to the occupants along with energy management.

On the other hand, the water industry is facing new challenges in managing sustainable urban water systems. External factors such as the impact of climate change, drought, and population growth in urban centers have increased the responsibility to adopt more sustainable management of the water sector [6]. Some of the main challenges in water management include cost coverage, monitoring of nonrevenue water (NRW), and knowledge of customers' demand for fairness in revenue [7]. It is important to have proper water management due to the growth in population and concentration of water needs. It is therefore necessary to use advanced technologies and the adoption of more robust management models to meet water demands [8].

Water stress has become a major issue due to the scarcity of freshwater reserves in different regions of the world. In 2025, it is estimated that almost half of the urban population will live in the water-stressed area as this precious source is becoming scarce rapidly [9–12]. According to studies, a possible solution to avoid a worldwide water crisis is by adopting water management and control systems based on automated solutions such as the IoT. The integration of the IoT methods is considered one of the best possible solutions that would enable the maintenance of a sustainable and cost-effective water supply [10,13–15]. Some of the advantages of water management in smart homes integrated with IoT technology include a better understanding of the water system, detection of leaks, conservation, and monitoring of water quality [16].

In the past three decades, a revolutionary approach like BIM has been developing in the field of construction and design. Xu et al. [17] defined BIM as "a model-based process of generating and managing coordinated and consistent building data that facilitates the accomplishment of established sustainable goals." This signifies that BIM has reached a level to facilitate high-level analysis as well as evaluations for buildings. These can be performed through techniques such as acoustic analysis, carbon emission, construction and demolition, waste management, operational energy, and water use. Additionally, BIM could be expressed in a 3D model of multidisciplinary data for various analyses [18]. The innovative development of BIM could provide opportunities to support green buildings through the application of high-tech programs or devices such as the IoT and smart devices.

In the context of smart homes, IoT refers to the nature of the interconnection of sensing and actuating devices and the ability to share information through a unified framework that could develop a common operating picture to enable innovative applications [19]. The IoT is an