Chapter 1
Applications, Modern Trends, and Challenges of Multiscale Modeling in Smart Cities

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ABSTRACT

Megacities are intricate systems that struggle with difficulties including overcrowding, subpar urban design and planning, inadequate mobility and public transportation, subpar governance, problems with climate change, subpar water and sewage infrastructure, problems with waste and health, and unemployment. By maximising the use of available resources and space for the benefit of residents, smart cities have evolved as a solution to these problems. A smart city model sees the city as a complex adaptive system made up of residents, services, and resources that learn from one another and change across time and space. City planners must adopt a new methodical and modelling approach in order to address the fundamental concerns of dynamic growth and complexity. A method that may be utilised to comprehend complicated adaptive systems better is multiscale modelling (MM). To increase system efficiency and reduce computing complexity and cost, the MM strives to address complicated issues at several sizes, including micro, meso, and macro.

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INTRODUCTION

More than half of the overall inhabitants reside in city areas, and the population is growing daily. The 21st century is sometimes specified as the era of cities since urbanization is one of the most significant social phenomena of our time and is progressing at an ever-increasing pace. Presently, 30 megacities with inhabitants of at least 10 million people in the world, which are greater than several nations. Megacities, however, are thought of as complicated frameworks that face issues like overcrowding, absence of or faulty city framework or designing, degraded mobility and public transportation, degraded governance, problems with climate alterations, a lack of good sewage and water infrastructure, problems with waste and health, unemployment, etc. Smart cities are becoming more popular in industrialized and contemporary nations. Economical and intelligent homes, a sustainable electricity appliances, effective public transportation and metropolitan mobility, drainage, and aspects which support a cleansed environment for residents are the main infrastructural components found in a smart city. In order to manage and carry out all of the operations of a smart city smoothly and effectively, advanced IT and digitalization, the IoT, AI, and ML methods are employed.

The utilization of these elements and the services offered to citizens in a smart city transform it into an adaptable complex system. The components of a complicated adaptive system, called agents, are not fixed; instead, they master from and adapt to their interactions with other agents. The agents of a complex adaptive system may be studied, discovered, clarified, and understood using this paradigm. These agents may be anything that can produce an emerging pattern and self-organization via correlated feedback, including groups of intelligent automobiles, people, and animals. As a result, a smart city model sees the city as a complex adaptive system made up of services, resources, and residents that learn from one another and from alterations in both the geographical and temporal arena.

Inspiration and Related Survey: City planners must address these dynamic development and complexity elements, which call for novel models and a methodical approach. Better knowledge of complicated adaptive systems may be achieved by using an MM. The multiscale modeling (MM) is a novel approach to modeling that concurrently employs many models at various sizes to describe complicated adaptive systems. The models in the macro, mid and micro sizes concentrate on various resolution scales. Thus, MM in intelligent cities shows the direction for numerous growing smart implementations which seek to attain lower computational complexity, sustainability, reliability and cost, and many other goals in intelligent city frameworks like intelligent transportations, intelligent power system, intelligent healthcare, intelligent community, and intelligent industry. Various surveys and reviews of multiscale modeling (MM) in the literature either address elements of the multiscale modeling framework including designing, categorizing, assumptions, and frameworks or concentrating on various emerging areas. For instance, MM for emergent behavior and complexity was examined by the authors of (Hoekstra et al., 2008, 2010), while Tang et al. (2022) offered a study on MM for complicated dynamic concerns. Batty et al. (2012) concentrated over the uses along with the advantages of MM in the foodstuff dehydrated business, whereas the study (Attaran, Kheibari, and Bahrepour, 2022) provides a summary of multiscale modeling in the biological, bio-medical, and behavioral sciences. Moreover, Alghamdi et al. (2020) discuss and highlight issues associated with polymer dynamics, while the paper described in Nie, Chow, and Lau (2022) evaluates the use of MM in food engineering. MM in smart cities has not been the subject of any study or review effort in accordance to the author's idea.

Contributions: This article's assessment of MM in smart cities is motivated by the aforementioned. We begin by introducing megacities and talking about the issues involved in transforming them into