Chapter 3
Applications of Graphs in Smart Cities

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ABSTRACT

Many megacities will emerge in the twenty-first century as a result of urbanization as a megatrend. Essential services like electricity, water, mobility, manufactured products, and healthcare will have to be delivered effectively in these densely, hugely populated centers. While these services may be regarded separately, they are in fact interconnected, particularly in light of the requirement for optimal resource use and, as a result, integration. Because the modelling foundations for these services are typically discipline specific, this offers a severe engineering challenge. Here comes the applications of graphs. Graphs can be used to model a smart city efficiently and solving graph theoretic problems can solve various real-life problems of smart cities. In this chapter a survey of works related to the applications of graphs in smart cities like modelling smart city, security, anomaly detection, transport, logistics, energy management etc. has been depicted, along with some future directions to cope with various problems.

INTRODUCTION

Smart cities are urban areas that use information and communication technology (ICT) to improve the quality of services such as energy, transportation, security, and healthcare, etc. Optimizing the use of resources to reduce overall costs and improve residents' quality of life is one of the key research areas in the smart city (Abid et al., 2020) landscape. According to IBM, a "smart city" is a functional city that uses information and communication technologies to perceive, analyse, and integrate critical data from central systems. Smart cities can intelligently meet many needs, including those related to daily life, environmental protection, public safety, urban services, as well as commercial activities.

Simply put, a "smart city" is a specific location where a "smart planet" methodology has been implemented, resulting in integrated and beneficial city management. This can also be said to be the effective synthesis of intelligent development methods, intelligent management methods and intelligent planning

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principles. By realizing smart city services and management through digital network management of urban geography, resources, environment, economy, society (Sinha et al., 2021) and other systems, while handling digitization, information and application of basic urban and environmental infrastructure, for more effective support we can provide the convenient and harmonious operation of a modern city.

The cognitive layer, the application layer, and the network layer are all part of building a smart city and they can all work together to make the world of the future discoverable, measurable, connected, and intelligent.

Numerous processes in computer science, biology, physics, and information systems may be represented using graphs (Ahmed et al., 2022). An essential area of mathematics and computer science is graph theory. The graph theory has many practical applications. Graph algorithms offer a unified method to solving problems in a variety of traditional and modern application sectors by employing the graph as an all-powerful mathematical tool. A graph is an ordered pair with the formula $G = (V,E)$, where $V(G)$ denotes the set of the graph's vertices and $E(G)$ denotes the set of all the graph's edges. A smart city may be effectively modelled using graphs, and by resolving graph theoretic issues, one can address several practical issues that arise in such cities.

In this chapter, a survey of works related to the applications of graphs in smart cities like modelling smart cities, security, anomaly detection, transport, logistics, energy management (Al-Ali et al., 2017; Daas, 2019) etc. has been depicted along with some future directions to cope with various problems.

RESEARCH METHODOLOGY

The research methodology followed in this chapter has three main stages: Identification of important dimensions, Selection of existing works, and grouping of existing literature.

Identification of Important Dimensions

In this stage, various important dimensions of a smart city have been identified. Among them, six dimensions have been considered here and applications of the graph in these dimensions have been discussed.

LITERATURE SURVEY

In this section, a detailed survey of the existing works has been given. This section contains six different subsections which depict the application of graphs in modelling smart cities, security, anomaly detection, transport, logistics, and energy management.

Graphs in Modelling Smart City

Over the past fifty years, the proportion of the number of people living in cities has been increased dramatically. This massive shift results in high-density urban areas, putting additional pressure on existing infrastructure. Currently, today's infrastructure (Alqahtani et al., 2022) provides important services which include energy, water, mobility, manufactured goods, and healthcare (Dutta et al., 2021). These infrastructures are complex and large and also they are interconnected, which is especially true of integra-