Research Brief

Overview

Urban Development:

Management, construction, and transformation of structures and territories in the cities is referred to as urban development and its key components are improvement of infrastructure, economy, housing and social welfare. It encompasses an organised approach where the goal of urban development is to grow cities while containing population growth, resource consumption, and their economic activity.(*United Nations, 2016)*

City Management Principles:

A City strives to ensure that the needs of its residents are met to fulfilment.*(Bhatta, 2010)*

Core principles include:

Sustainability: Being responsible when managing resources (e.g., water, power) to avoid depletion and to secure availability for future generations.

Infrastructure: Supplying the area with basic services of transportation, utilities, healthcare, education and housing(*Hawkesworth & Kwon, 2017)*

Citizen Satisfaction: Provision of needs of the citizens, which are housing, safety, and even level of resources so as to remain at higher satisfaction level.

Role of Various City Components:

Buildings: Residential, commercial, and industrial buildings contribute to the economy and the satisfaction of the citizens.*(Burgess, 2000)*

Utilities: Power plants, water supply, waste management, and sewage systems guarantee that necessary resources are available on a consistent basis.*(Bakker, 2010)*

Transportation: Networks such as Transport allow for enhancement of economies through mobility.

Government:A group of officials in charge of laws and how the laws are supposed to be followed, such officials will manage how taxes will be spent paying for infrastructure and public goods.*(Bourne & Rose, 2010)*

Resources: Elements such as water and energy as well as raw materials that build up construction that fuels the city.

Influence of Urban Components on Design Patterns

The components of urban development and city management principles directly shaped the design patterns utilised in the City Builder Simulation. Each pattern is purposefully selected to address specific functionalities, ensuring a cohesive and robust simulation.

1. **Memento Pattern**:The extent of urbanisation means that sometimes the state of the simulation must be remembered in order to allow for effective decisions and an efficient experience for the users. The Memento pattern works in this case since it allows the users to store the state of the simulation and then later recall it.
2. **Prototype Pattern**: When considering a city as a dynamic environment where buildings and more infrastructure can be built with a need for variation and duplication, it becomes evident why the Prototype pattern can be used to build buildings that build themselves. This decision is appropriate considering the underlying principle of urban planning that requires that a large number of similar buildings be generated quickly without much effort and as a result this design would promote the effective utilisation of renewable resources.
3. **Decorator Pattern**: Building cities for people and incorporating attributes like Boreholes and Solar Systems, the Decorator pattern is useful because it extends the buildings. This promotes the core principles of city governance that allow institutions to tap into renewable resources and enhance efficiency for the good of the environment and the community.
4. **Composite Pattern**: The structure of apartment buildings is supported by the Composite pattern that combines separate apartment units into a single apartment building. Design like this is compatible with urban development concepts that favour the efficient use of land and increased density of development since it simplifies the management of large numbers of housing units.
5. **Observer Pattern**: Effective interaction management among urban components is essential. For instance, the Observer design pattern is used to manage updates and notifications between utilities and buildings.
6. **Iterator Pattern**: Iterator pattern offers traversal of the citizens and buildings of the city. Because of the population and infrastructure diversity, this pattern reduces workload on the management of the several entities which makes such activities like taxation easy.
7. **Command Pattern**: In accordance with city management principles and practices, the Command pattern is used dealing with tax collection routines.
8. **Facade Pattern**: The Facade design pattern plays a critical role in the City Builder Simulation by providing a unified interface to various subsystems. These subsystems correspond to the different design patterns utilised throughout the simulation. By employing a Facade, the complexity inherent in managing these patterns is significantly reduced, allowing for a more streamlined user experience.
9. **Builder Pattern**: To address the gap, Builder pattern is implemented so that citizens may be created with other characteristics including adult and child objects and

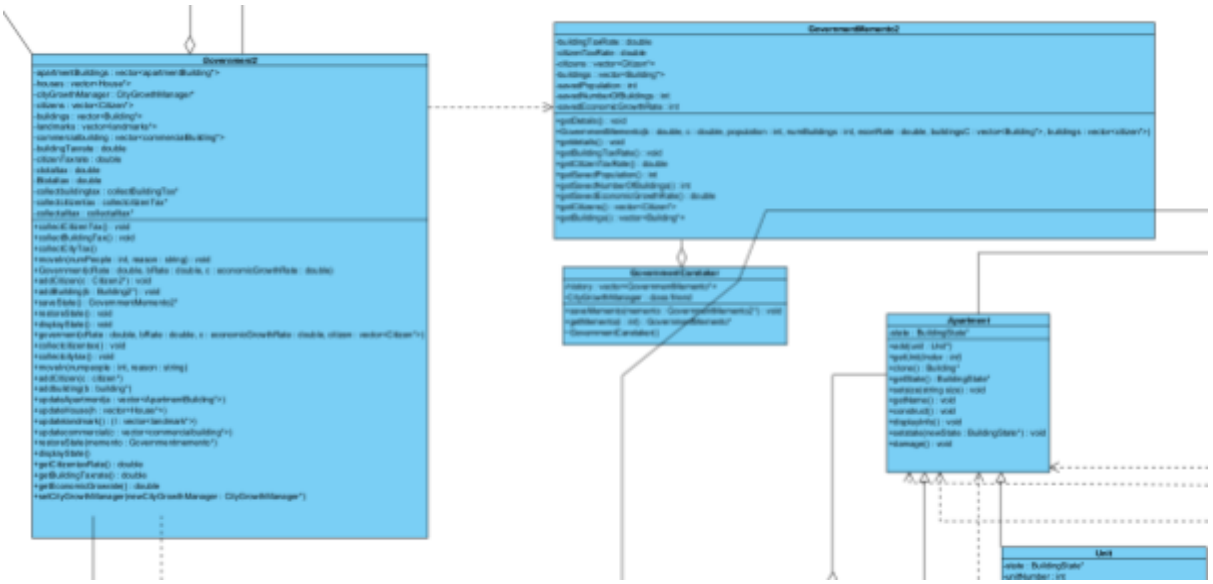
various attributes during creation. This flexibility is in the principle of satisfaction of the citizens since the simulation enables the society to be adjusted for varying requirements of the population.

10. **Factory Method Pattern**: The Factory Method pattern is used for creating of different types of buildings and utilities and complements urban planning`s objective of enhancing developmental growth through diversified infrastructure facilities.
11. **State Pattern**: The State pattern keeps track of the various stages of buildings (under construction, operational etc) demonstrating the flexibility in the ever changing face of the city. This design decision makes it possible for the simulation to be realistic in terms of how construction of a building proceeds.

Design Pattern Application Report

1. Memento Pattern - *Storing Simulation State*

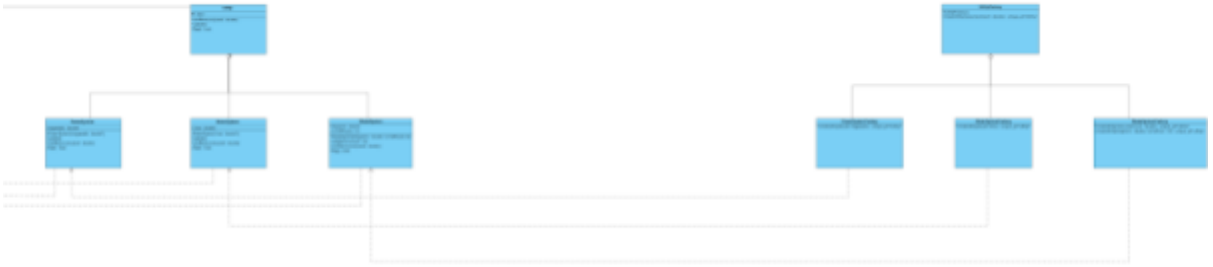
The Memento pattern effectively handles certain difficulties that arise during urban growth by allowing the user to save and restore the simulation's state. When a user updates the city's infrastructure, resources or citizens, they can save the simulation's current state for future use.



2. Factory Method - *Building and Utilities Creation*

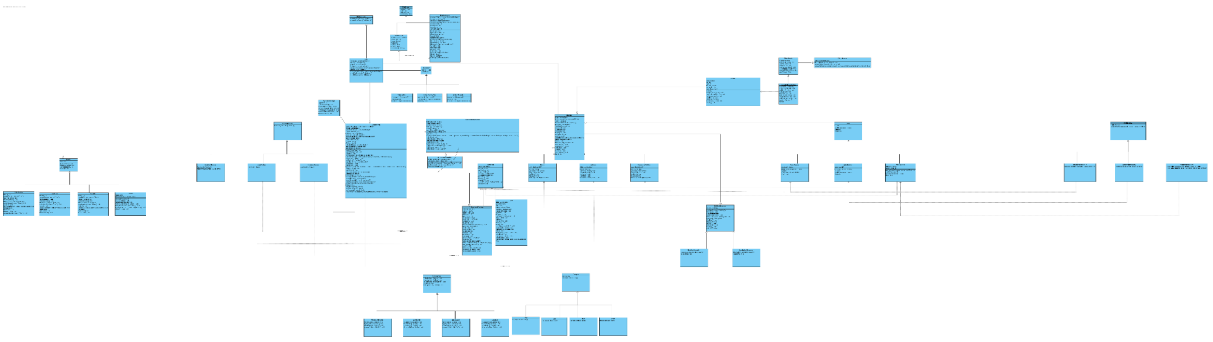
The Factory Method pattern is applied for the purpose to create a number of buildings and other utility types, which provides for more adaptiveness & flexibility to the simulation in construction activities across the city. Since the Factory Method abstracts the instantiation

process, the simulation is capable of accommodating a wide range of demands as urban needs change.



3. Prototype Pattern - *Cloning Buildings*

In a dynamic city setting, the Prototype enables buildings to create replicas of themselves with minor differences in characteristics. This is especially useful when several examples of the same building type must be produced quickly. Buildings produce themselves to fulfil the need of fast building creation to meet the citizens needs.



4. State Pattern - *Building States*

The State pattern is used to manage the various states of buildings, such as under construction and operational. This design choice reflects the dynamic nature of urban environments, allowing buildings to transition smoothly between different states. By implementing the State pattern, the simulation accurately models the construction process and its impact on city management, ensuring a realistic representation of urban development.

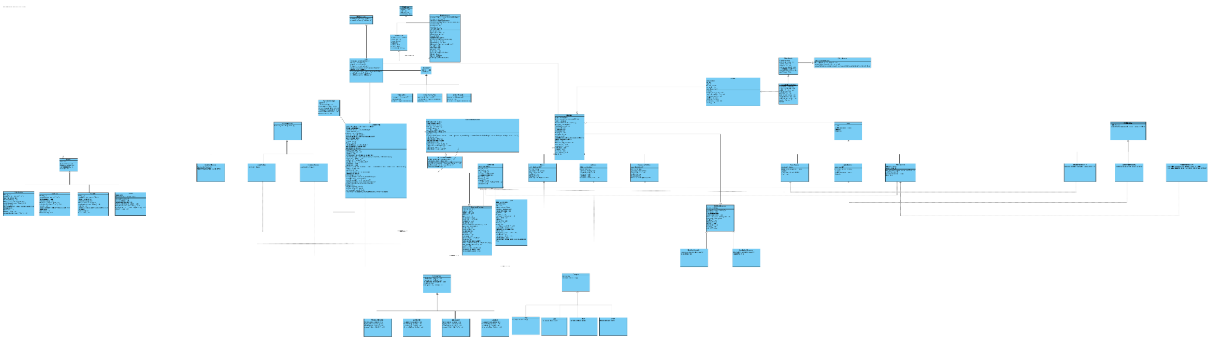
This diagram shows how the state of Buildings can change according to the user of the simulation through called different functions.

5. Composite Pattern - *Apartment Buildings*

The Composite pattern is utilised to manage apartment buildings by combining individual apartment units into a single cohesive structure. This pattern allows for flexible management of residential buildings, enabling the simulation to reflect real-world scenarios where multiple units share common resources.

6. Observer Pattern - *Notifying Utilities*

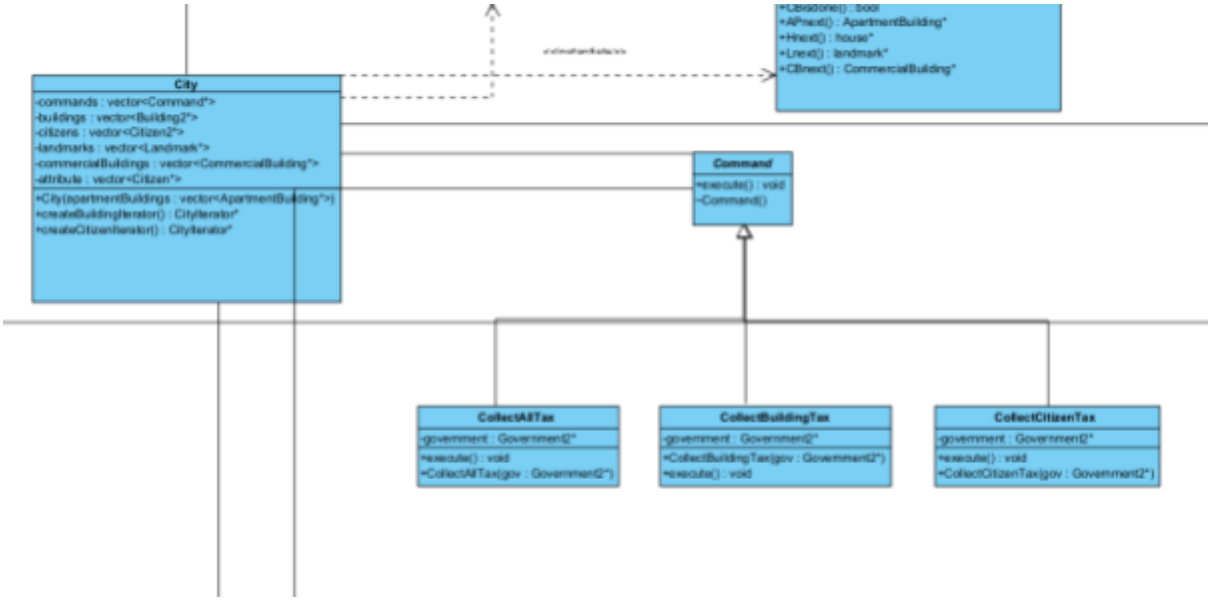
In the City Builder Simulation, the Observer design pattern plays a crucial role in maintaining the functionality and responsiveness of services. The primary application of this pattern is to notify the services to update or restock as needed. This dynamic communication enhances the simulation's realism by ensuring that services are always operating efficiently and are able to meet the demands of the citizens.



7. Command Pattern - *Collecting Tax*

In the City Builder Simulation, the Observer design pattern plays a crucial role in maintaining the functionality and responsiveness of services. The primary application of this pattern is to notify the services to update or restock as needed. This dynamic communication enhances

the simulation's realism by ensuring that services are always operating efficiently and are able to meet the demands of the citizens.



8. Iterator Pattern - *Traverse Citizens and Buildings*

The Iterator pattern facilitates the traversal of citizens and buildings within the city. Given the diversity in population and infrastructure, this pattern alleviates the management workload associated with multiple entities, simplifying tasks such as taxation.

9. Builder Pattern - *Citizen Creation*

The Builder pattern facilitates the creation of citizens with customizable attributes, enabling the simulation to create both adult and child citizens. This flexibility is crucial for modelling a diverse population that meets various community needs.

10. Decorator Pattern - *Building Decoration*

The Decorator pattern enhances the functionality of buildings by allowing them to adopt additional features, such as Boreholes and Solar Systems.

11. Facade Pattern - *Simplified System Interface*

This approach allows for easier interaction and management of complex functionalities, enabling users to engage with the simulation without needing to understand the underlying complexities of each design pattern. An option based interface is used to navigate through the simulation.

Branching Strategy

Most of the design patterns are implemented in their own dedicated branch, these branches are merged into the main branch

Main: The Building Structure, Facade and Services was implemented in this branch

Command: The command design pattern was implemented in this branch

Decorator: The decorator design pattern was implemented in this branch

Citizen: The citizen design pattern was implemented in this branch

Memento: The memento design pattern was implemented in this branch

Iterator: The iterator design pattern was implemented in this branch

References:

1. Bakker, K. (2010). **The politics of water: A survey**. *Water Policy*, 12(3), 291-307. doi:10.2166/wp.2010.051
2. Bhatta, S. (2010). **Urban development: Planning, policy, and practice**. *Journal of Urban Planning and Development*, 136(1), 37-48. doi:10.1061/(ASCE)0733-9488(2010)136:1(37)
3. Bourne, L. S., & Rose, D. (2010). **Urban governance and public participation**. *Canadian Journal of Urban Research*, 19(1), 1-24.
4. Burgess, E. W. (2000). **The city: Suggestions for the investigation of human behavior in the urban environment**. In R. E. Park & E. W. Burgess (Eds.), *The City* (pp. 1-12). Chicago: University of Chicago Press.
5. Hawkesworth, I., & Kwon, H. (2017). **Public services and infrastructure**. *Public Administration Review*, 77(3), 389-399. doi:10.1111/puar.12634
6. Porter, M. E. (1995). **The competitive advantage of nations**. *The Free Press*.
7. United Nations. (2016). **New urban agenda**. Retrieved from https://www.un.org/en/conferences/habitat3