COS 214 Civ-Zero Project Report

The O.W.C.A ("Organization Without a Cool Acronym")

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

u23571561 - Jacques Sietsema Klooster
u23538172 - Richard Kruse
u23547104 - Reece Jordaan
u20498952 - Shaylin Govender
u23668882 - Luke Gouws
u23545080 - Aidan McKenzie
u23565536 - Aryan Mohanlall

Research Brief

Research:

Urban development encompasses the planning, building, and upgrading cities and towns to improve living standards, support economic growth, and create sustainable environments. Some of the key issues in urban development include Population Growth and Housing, Transportation and Mobility, Sustainability and Environmental Impact and Economic Development. To combat this it is important to plan a good design and develop the most essential services and buildings first.

Important aspects of the city are buildings funded by the government to facilitate the residents' needs and wants. This includes (as previously mentioned) transportation, hospitals, law enforcement, schools, shopping malls etc. These are vital to ensure that the population is happy and wants to continue living there.

Green space is important for cities since it can mitigate the effects of pollution and reduce the heat trapped by the surrounding buildings. It can also increase the happiness and satisfaction of all residents around the spaces. It improves morale and overall mental health as nature can have a soothing and overall positive effect on people around it. Green settings can also enhance exercise-associated improvements in affective state and attentional capacity. Engagement with nature has also been shown to offer benefits for mental health and well-being, making it a valuable upstream intervention for promoting mental health.

References:

- https://www.gov.za/sites/default/files/gcis_document/201409/saurb.pdf
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- https://en.wikipedia.org/wiki/Urban_planning
- https://practicegroup.co.za/types-of-urban-development-planning
- https://www.sciencedirect.com/science/article/abs/pii/S0264275101000269
- https://shorturl.at/bL23x
- https://pmc.ncbi.nlm.nih.gov/articles/PMC5663018/#:~:text=Simple%20exposure%20to%20nature%20environments,to%20reflect%20on%20life%20problemshttps://shorturl.at/bL23x

Functional Requirements

Basic structure:
The city will be organised into a grid-like structure to allow for easy allocation, deallocation and locating of entities of the city. Iterators will be used extensively to traverse the elements of the city where we then make calls to the relevant classes to handle each case of the element for a controlled flow of the whole system.

Subsystems:
For the city to operate, we will allocate subsystems for different areas of the system.

- Government - This will be used here to control the flow of the population and bring about progress in the system, this will range from taxes, policies and services of the city.
- Utilities - This unit will provide buildings and infrastructure with the resources needed to operate, calls from the government will also affect the behaviour of this system. All infrastructure will depend on this subsystem.
- Citizens - This unit will model the life of the system allowing for actual execution, this unit will also interact with every other system. This is dependent on every other subsystem of the city.
- Factories - The Factory Method will be used to create every type of infrastructure to simulate the construction of buildings and the physical growth of the city.
- Buildings - by making use of inheritance this will simulate physical entities of the system that Citizens will interact with allowing for the use of more design patterns from other subsystems.

UML diagrams link: (Provided in another pdf as well)
https://lucid.app/lucidchart/6e509cca-4ff4-4916-80f2-b78223818bf3/edit?invitationId=inv_b33ae7ae-4790-4b55-aff6-ef27bfa26008&page=0_0#

Urban development:
The city is arranged on a grid. This allows for global access to all elements of the city. The elements of the city are classified as Entities, all specialisations of an element of a city are derived from the Entity class. These specialisations include:

- Road
- Transport(BusStop, TrainStation, Airport)
- Building(EconomicBuilding, ResidentialBuilding,ServiceBuilding,Amenity)
- Utility(PowerPlant, WaterSupply,WasteManagement,SewageSystem)
- Industry(WoodProducer, StoneProducer, ConcreteProducer)
- State(UnderConstruction, Built)

Factories will be used for the building and creation of all Entities, these will be controlled by the various Managers. Managers form part of the Facade design pattern and are responsible for the development of all Entities. The Managers include:

- CityManager
- BuildingManager
- UtilityManager
- ServiceManager
- TransportManager
- AmenityManager
- GovernmentManager
- PopulationManager
- ResourceManager

The coordination of public services and the economic state of the City system is controlled by the Government Manager. This will allow for the overall growth of the system. These include:

- Policies - influence the amount of water or electricity produced
    - Water Policy
    - Electricity Policy
- Utilities - responsible for essential services in a city
    - PowerPlant
    - WaterSupply
    - WasteManagement
    - SewageSystem
- Industry - responsible for all resources produced
    - StoneProducer
    - WoodProducer
    - ConcreteProducer

Assumptions:
In the simulation, it is assumed that there is no object or class to represent a person. There is also no specified job or career to choose, the flow of money is dependent on the presence of residential, industrial and economic buildings as well as the global satisfaction. There is also no direct consumer of waste and sewage within the system, all waste and sewage is handled by the relevant Utility services.

Design Patterns:

- Decorator pattern - The Decorator pattern was used for upgrades of utilities and industry entities. Upgrades allow for a higher output at the cost of more resources.
    - Participants
        - Component / ConcreteComponent -
            - PowerPlant
            - WasteManagement
            - WaterSupply
            - SewageSystem
            - WoodProducer
            - StoneProducer
            - ConcreteProducer
        - Decorator -
            - PowerPlantUpgrade
            - WasteManagementUpgrade
            - WaterSupplyUpgrade
            - SewageSystemUpgrade
            - WoodProducerUpgrade
            - StoneProducerUpgrade
            - ConcreteProducerUpgrade
        - ConcreteDecorator -
            - PowerPlantLevelOne-LevelThreeUpgrade,
            - WasteManagementLevelOne-LevelThreeUpgrade,
            - WaterSupplyLevelOne-LevelThreeUpgrade,
            - SewageSystemLevelOne-LevelThreeUpgrade,
            - WoodProducerLevelOne-LevelThreeUpgrade,
            - StoneProducerLevelOne-LevelThreeUpgrade,
            - ConcreteProducerLevelOne-LevelThreeUpgrade

- Memento pattern - the Memento design pattern was used to store and manage previous Policies
    - Participants
        - Memento -
            - Memento
        - Caretaker
            - Caretaker
        - Originator
            - Policy

- Factory Method design pattern - the Factory Method was used for the creation of all buildings in the city
    - Participants
        - Creator
            - EntityFactory
        - ConcreteCreator
            - TransportFactory
            - EconomicBuildingFactory
            - ResidentialBuildingFactory
            - ServiceBuildingFactory
            - AmenityFactory
            - UtilityFactory
            - IndustryFactory
        - Product
            - Transport
            - EconomicBuilding
            - ResidentialBuilding
            - ServiceBuilding
            - Amenity
            - Utility
            - Industry
        - ConcreteProduct
            - BusStop
            - TrainStation
            - Airport
            - Factory
            - ShoppingMall
            - Office
            - Apartment
            - House
            - Hospital
            - PoliceStation
            - School
            - Park
            - Theater
            - Monument
            - PowerPlant
            - WasteManagement
            - WaterSupply
            - SewageSystem
            - StoneProducer
            - WoodProducer
            - ConcreteProducer

- Iterator design pattern - The Iterator pattern was used to traverse the city grid allowing for controlled access to each entity of the city
    - Participants
        - Iterator
            - Iterator
        - ConcreteIterator
            - CityIterator
            - TransportIterator
            - EconomicBuildingIterator
            - ResidentialBuildingIterator
            - ServiceBuildingIterator
            - AmenityIterator
            - PowerPlantIterator
            - WaterSupplyIterator
            - SewageSystemIterator
            - WasteManagementIterator
            - ConcreteProducerIterator
            - WoodProducerIterator
            - StoneProducerIterator
        - Aggregate
            - Not Implemented
        - ConcreteAggregate
            - City

- Singleton design pattern - the Singleton pattern was used for the creation of the game itself, this also ensures there is only 1 instance of the game and city.
    - Participants
        - Singleton
            - CivZero
        - Client
            - Main

- Facade design pattern - the Facade pattern is used in controlling and managing the city, since there are different entities and sectors of a city, the Facade pattern allows specific subsystems (managers) to handle requests and work
    - Participants
        - Facade
            - City
        - Subsystems
            - CityManager
            - BuildingManager
            - UtilityManager

                - TransportManager
                - ServiceManager
                - AmenityManager
                - GovernmentManager
                - PopulationManager
                - ResourceManager

- Visitor design pattern - the Visitor pattern was used to define new operations on Manager classes allowing us to extract more data from entities
    - Participants
        - Visitor
            - CityVisitor
        - ConcreteVisitor
            - ResourceVisitor
            - PopulationVisitor
            - TaxCalculationVisitor
            - SatisfactionVisitor
        - Element
            - City
        - ConcreteElement
            - CityManager
            - BuildingManager
            - UtilityManager
            - TransportManager
            - ServiceManager
            - AmenityManager
            - GovernmentManager
            - PopulationManager
            - ResourceManager
        - ObjectStructure
            - Not implemented

- State design pattern - the State pattern will be used in deciding on when a building is built or not, this will influence how that building is treated when it comes to taxation and calculating global satisfaction
    - Participants
        - Context
            - Entity
        - State
            - State
        - ConcreteStates
            - Built
            - UnderConstruction

- Prototype design pattern - the prototype pattern will be used to create identical entities on the go, this prevents having to create a new entity from scratch with default attributes
    - Participants
        - PrototypeManager
            - PrototypeManager
        - Prototype
            - Entity
        - ConcretePrototype
            - EconomicBuilding
            - ResidentialBuilding
            - ServiceBuilding
            - Amenity
            - Utility
            - Industry
            - Transport

- Observer design pattern - the observer pattern is used to alert all residential buildings to update their satisfaction values. This is used so that when the next game loop is called, all residential buildings can return their new updated satisfaction values to change the city's overall satisfaction score

- Strategy design pattern - the Strategy pattern is used when having to choose a suitable policy concerning water and electricity based on the satisfaction of the population
- Participants
    - Context
        - City
    - Strategy
        - WaterPolicy
        - ElectricityPolicy
    - ConcreteStrategy
        - LowElectricityPolicy
        - NormalElectricityPolicy
        - HighElectricityPolicy
        - LowWaterPolicy
        - NormalWaterPolicy
        - HighWaterPolicy