COS214 Project

Functional Requirements

Transportation

The transportation system is responsible for facilitating travel between different locations. To keep citizens satisfied, it must handle a variety of transport options, control availability, and guarantee efficiency.

Core Functionalities:

- o Transport Mode Management:
  - Citizens should be able to select between different modes of transport
  - The system should track the availability of each transportation mode
- o Commute Time Management:
  - The transportation system should calculate the commute time for each citizen based on the selected transportation mode and the current stare of the transport system: traffic, availability, etc.
- o Route and Traffic Management:
  - The system should calculate the most efficient routes for citizens, considering traffic, transport availability, and distance.
  - To lessen congestion, the government needs to be able to expand routes, optimize traffic, and construct new transportation infrastructure.
- o Public and Private Transportation:
  - To give citizens a variety of travel alternatives, the system must manage both public and private transportation modes.
  - It should allow citizens to switch between them.
- o Citizen Satisfaction:
  - The system must contribute to overall citizen satisfaction. This should allow the government to make improvements accordingly.

Interactions:

- o Interaction with Government:
  - The government sets transportation policies and allocates funds, affecting transportation efficiency and infrastructure.
  - The transportation system must adapt to government policy changes and communicate these to citizens.
- o Interaction with Citizens:
  - Citizens select preferred transport modes, impacting how services are provided.

- Citizen feedback directly influences transport system adjustments and improvements.
  - o Interaction with Buildings:
    - Transportation routes must connect residential, commercial, and landmark buildings.
  - o Interaction with Utilities:
    - Public transport modes rely on utility services (e.g., electricity for trains).
    - Transportation services must monitor utility statuses and adjust accordingly.

Buildings

The **Building Component** plays a crucial role in the city's simulation, providing the necessary infrastructure for citizens, businesses, and utilities. Buildings represent residential, commercial, industrial, and landmark locations that affect and interact with various city systems like transportation, utilities, and government policies.

Core Functionalities:
1. **Building Type Management:**
   - o The system must classify and manage buildings based on their type (residential, commercial, industrial, landmark).
   - o Each building type should have distinct characteristics, influencing its interaction with citizens and city services.
   - o The system should allow the construction of new buildings and the modification or demolition of existing buildings.
2. **Building Capacity and Occupancy:**
   - o Each building must have a maximum capacity (e.g., how many citizens can live in residential buildings or how many workers can be employed in commercial/industrial buildings).
   - o The system must track the current occupancy of each building, ensuring that they do not exceed capacity.
   - o The system should allow dynamic adjustments to building capacities based on expansions or upgrades.
3. **Maintenance and Upkeep:**
   - o Buildings require regular maintenance to ensure functionality and safety.
   - o The government must be able to allocate funds for building maintenance and repairs, impacting the city's budget.
4. **Utility Integration:**
   - o Buildings must interact with utility systems (e.g., power, water, waste, sewage).
   - o The system should ensure that buildings receive necessary utilities and adjust their functionality based on utility availability.
   - o If a building loses access to utilities, the system should reduce the functionality of that building (e.g., a residential building without power affects citizen satisfaction).
5. **Taxation and Revenue:**

o   Buildings must contribute to city revenue through property taxes
o   The system should calculate taxes based on building value, type, and current tax policies.
o   The system should allow adjustments to tax rates through government policies, influencing building owner satisfaction and city growth.

6. **Building Satisfaction Contribution:**
o   The system should track how building conditions affect citizens' quality of life and overall city satisfaction.

7. **Building Upgrades and Expansion:**
o   The system must allow for building upgrades, such as increasing capacity, or improving maintenance.
o   Expansion of buildings should be tied to city growth, population, and government policies.
o   The system should also allow the construction of new buildings based on city needs and resources.

8. **Building Health and Safety:**
o   The system must track the health and safety status of each building (e.g., fire safety, structural integrity).
o   Buildings with poor safety conditions should impact citizen satisfaction, cause population decline, or even lead to building evacuation.
o   The government must be able to pass policies or allocate resources for safety inspections and improvements.

Interactions:

1. **Interaction with Government:**
o   Government departments (e.g., taxation, public services) must be able to influence building conditions, upgrades, and taxation rates.
o   Buildings should respond to government policies on zoning, expansion, safety regulations, and utility allocation.
o   Government decisions on building regulations should directly impact building functionality, citizen satisfaction, and overall city growth.

2. **Interaction with Citizens:**
o   Residential buildings must accommodate citizens based on occupancy and capacity, affecting their quality of life.
o   Commercial and industrial buildings must provide employment opportunities and services to citizens.
o   Citizens' satisfaction should depend on building conditions, available utilities, and proximity to key services (e.g., schools, hospitals, shops).

3. **Interaction with Utilities:**
o   Buildings must be integrated into the utility system, receiving power, water, waste, and sewage services.
o   The system should adjust building functionality based on the availability and quality of utilities (e.g., power shortages reduce building efficiency).
o   Utility availability should influence building expansion decisions and impact government infrastructure projects.

Examples of Building Types and Their Influence:

1. **Residential Buildings:**
   - Influence citizen satisfaction based on comfort, access to utilities.
   - Contribute to city population growth based on capacity and living conditions.
2. **Commercial Buildings:**
   - Provide job opportunities and services to citizens.
   - Contribute to city revenue through business taxes and attract economic activity.
3. **Industrial Buildings:**
   - Influence economic growth through manufacturing, logistics, and trade.
   - Impact employment rates and city expansion.
4. **Landmark Buildings:**
   - Improve city attractiveness and citizen satisfaction.
   - Require high maintenance and government funding for upkeep.

Summary of Building Component Interactions:

- **With Citizens**: Provides housing and employment, directly impacting satisfaction.
- **With Government**: Subject to policies, taxation, and building regulations.
- **With Utilities**: Dependent on essential services for functionality and safety.

City Growth

City growth is a dynamic process influenced by multiple interconnected factors. The simulation must model these aspects to ensure realistic and interdependent urban development.

1. Population Growth

- **FR 1.1**: The system must simulate population growth based on birth rates, migration, and economic opportunities.
- **FR 1.2**: The system must dynamically adjust the city's population size as citizens are born, migrate into the city, or leave.
- **FR 1.3**: The system must increase demand for residential buildings as the population grows.

2. Housing Needs

- **FR 2.1**: The system must allow the construction and expansion of residential buildings to accommodate the growing population.
- **FR 2.2**: The system must track the number of available housing units and ensure they are sufficient for the population.

- **FR 2.3**: The system must generate alerts or trigger actions if the population outgrows the available housing capacity (e.g., need for new residential zones).
- **FR 2.4**: The system must reduce population growth if housing demand exceeds supply, creating a realistic bottleneck.

3. Economic Development

- **FR 3.1**: The system must support the growth of the commercial and industrial sectors to create jobs for citizens.
- **FR 3.2**: The system must dynamically adjust the number of available jobs in the city based on the expansion of commercial and industrial buildings.
- **FR 3.3**: The system must simulate economic prosperity by linking job availability with population growth in the city.
- **FR 3.4**: The system must provide the ability to expand industrial areas, triggering a cascading effect on job creation, which in turn influences population growth.

4. Infrastructure Expansion

- **FR 4.1**: The system must allow for the development of utilities (e.g., power plants, water supply, waste management, sewage systems) to support city growth.
- **FR 4.2**: The system must provide transportation infrastructure development (e.g., roads, public transit, airports) to facilitate mobility within the city and between other regions.
- **FR 4.3**: The system must dynamically adjust the utility demand based on population and building expansion (e.g., more power is needed as the population and buildings grow).
- **FR 4.4**: The system must link the infrastructure to economic and population growth, where inadequate infrastructure can hinder growth or cause a decline in population or industry (e.g., lack of transportation or utilities reduces the attractiveness of the city).

5. Interconnected Growth

- **FR 5.1**: The system must ensure that changes in one sector (e.g., population growth, economic development) have a cascading effect on other sectors (e.g., housing needs, infrastructure expansion).
- **FR 5.2**: The system must ensure that economic growth influences population growth, housing demand, and utility needs.
- **FR 5.3**: The system must simulate a feedback loop where a growing population increases demand for infrastructure and services, which in turn supports further population and economic growth.

- **FR 5.4**: The system must automatically balance the growth process based on available resources and services (e.g., lack of resources, infrastructure, or jobs slows down growth).

6. Growth Management

- **FR 6.1**: The system must allow city administrators (players) to manage and control the growth process by adjusting policies, taxes, and budgets.
- **FR 6.2**: The system must allow for prioritization of different aspects of growth (e.g., focusing on industrial development over residential expansion).
- **FR 6.3**: The system must provide mechanisms to manage resources and allocate them toward expanding buildings, infrastructure, or economic sectors.
- **FR 6.4**: The system must allow for monitoring the city's growth progress and impact on citizen satisfaction (e.g., quality of life metrics).

Resources

Managing resources is essential for sustaining the operations of the city. The simulation must track and manage the consumption and allocation of resources to ensure efficient city expansion, service provision, and economic development.

1. Materials Management

- **FR 1.1**: The system must track various construction materials, including wood, steel, concrete, and other relevant resources.
- **FR 1.2**: The system must manage the supply of materials for the construction and expansion of buildings, infrastructure, and public services.
- **FR 1.3**: The system must update the material inventory dynamically based on construction projects and city expansion.
- **FR 1.4**: The system must trigger alerts when material levels are low and provide mechanisms to replenish or acquire more materials.
- **FR 1.5**: The system must allow the user or AI to allocate materials toward different projects based on priority (e.g., building homes, expanding industry, or infrastructure development).

2. Energy Management

- **FR 2.1**: The system must track the generation and consumption of energy, including power generated from power plants.
- **FR 2.2**: The system must provide a way to allocate energy to various city components (e.g., residential buildings, commercial zones, industrial sectors, and public services).

- **FR 2.3**: The system must dynamically adjust energy demands based on city expansion and population growth.
- **FR 2.4**: The system must simulate energy shortages if the demand exceeds supply and provide mechanisms for the construction of additional power plants or the import of energy.
- **FR 2.5**: The system must track energy efficiency and provide mechanisms to implement energy-saving measures (e.g., renewable energy sources, energy-efficient buildings).

3. Water Management

- **FR 3.1**: The system must track the availability, supply, and consumption of water for residential, commercial, industrial, and public services.
- **FR 3.2**: The system must ensure water distribution to all parts of the city and allow for the expansion of the water supply system as the city grows.
- **FR 3.3**: The system must simulate water shortages if the demand exceeds supply and provide mechanisms to develop new water sources (e.g., reservoirs, water treatment plants).
- **FR 3.4**: The system must manage water consumption and allow for water conservation strategies to reduce waste and optimize usage.
- **FR 3.5**: The system must simulate the consequences of insufficient water supply, such as decreased citizen satisfaction and economic slowdown.

4. Budget Management

- **FR 4.1**: The system must track the city's financial budget, including income (e.g., taxes, fees, subsidies) and expenditures (e.g., infrastructure development, public services).
- **FR 4.2**: The system must provide a way to allocate budget resources across different city sectors, including housing, commercial, industrial, utilities, and transportation systems.
- **FR 4.3**: The system must simulate budget deficits and surpluses, allowing for corrective actions such as adjusting taxes, reallocating funds, or borrowing money.
- **FR 4.4**: The system must allow users to set financial policies that affect the city's income and expenses (e.g., tax rates, budget distribution).
- **FR 4.5**: The system must link the budget with city growth, ensuring that financial constraints affect expansion plans, resource management, and service provision.

5. Efficient Resource Management

- **FR 5.1**: The system must simulate the efficient allocation of resources (materials, energy, water, budget) based on the city's needs and development plans.

- **FR 5.2**: The system must ensure that a shortage in one resource impacts city growth and services, triggering a cascading effect (e.g., lack of materials delays construction, insufficient energy affects economic productivity).
- **FR 5.3**: The system must provide mechanisms to balance the resource allocation to ensure sustainable growth, avoiding rapid expansion that depletes resources too quickly.
- **FR 5.4**: The system must provide feedback to users about the current resource status, offering options for optimizing consumption, upgrading facilities, or acquiring additional resources.
- **FR 5.5**: The system must integrate resource management with other city mechanics (e.g., population growth, economic development, infrastructure expansion) to create a realistic simulation of interdependent urban systems

Citizens

Functional Requirements for Citizens

1. **Population Management**
   a. **Dynamic Growth**: Citizens should have the ability to join or leave the population based on factors such as employment opportunities, quality of life, and government policies.
   b. **Demographic Tracking**: Citizens will maintain attributes such as employment status allowing for a realistic simulation of population dynamics.
2. **Employment Interaction**
   a. **Job Search**: Citizens should actively seek employment based on available job listings influenced by industrial and commercial buildings within the city.
   b. **Employment Status Update**: Citizens need to update their employment status (employed, unemployed, or temporarily employed) based on job availability, personal skills, and economic conditions.
3. **Service Utilization**
   a. **Access to Services**: Citizens should interact with various services such as healthcare, education, security, and entertainment based on personal needs and satisfaction levels.
   b. **Service Feedback**: Citizens will provide feedback or ratings on the quality of services, which can influence government decisions and resource allocations.
4. **Satisfaction Measurement**
   a. **Satisfaction Tracking**: Citizens should track their satisfaction levels based on factors such as taxes, amenities, and overall quality of life.
   b. **Response to Changes**: Citizens will adjust their satisfaction ratings in response to changes in government policies, service quality, or local conditions.
5. **Government Interaction**
   a. **Policy Response**: Citizens should respond to changes in government policies, such as tax adjustments or new regulations, which may affect their employment, services, or overall quality of life.

    b. **Civic Participation**: Citizens can engage in civic activities, such as voting or public discussions, to express their opinions on government actions and influence policy decisions.

6. **Utility Usage**
   a. **Resource Management**: Citizens should interact with utility services (e.g., water, electricity) to monitor usage, report outages, and respond to changes in pricing or availability.
   b. **Environmental Awareness**: Citizens will make decisions based on environmental factors, such as conservation efforts or sustainable practices, influencing their resource consumption.

7. **Community Engagement**
   a. **Social Interactions**: Citizens should interact with other citizens to form relationships, which can impact their overall satisfaction and sense of community.
   b. **Participation in Local Events**: Citizens can attend local events or activities that promote community bonding and enhance their overall experience within the city.

8. **Adaptation to Economic Changes**
   a. **Economic Awareness**: Citizens should be aware of economic conditions that affect job availability and service costs, allowing them to make informed decisions about employment and resource usage.
   b. **Behavioral Adjustments**: Citizens may adjust their behavior, such as spending habits or job-seeking strategies, in response to economic changes or government interventions.

Interaction with City Components

- **With Government**: Citizens will engage with government policies and decisions, influencing their employment, services, and overall satisfaction. Their feedback will be essential for policy development.
- **With Utilities**: Citizens will monitor and manage their usage of utilities, reporting issues or making adjustments based on availability and pricing.
- **With Buildings**: Citizens will interact with residential, commercial, and industrial buildings to find housing, employment, and access services. Their choices will affect population distribution and resource utilization.
- **With Services**: Citizens will seek and evaluate services provided by the city, influencing service quality and availability through their interactions and feedback.

Government

The government system acts as the overseer of the city and is responsible for the management of the city through taxation management, providing public services, budget management, and enacting policies

Core Functionalities:

Taxation Management:

- The Government should issue tax rates to generate revenue to run the city but should be reasonable enough to maintain citizen satisfaction and business profits.
- The system should allow for the government to set and modify the tax rate, notify the city and its citizens of the tax rate, and track the tax revenue generated as well as citizen satisfaction.

Public Services:

- The Government should ensure that citizens are provide with the necessary public services such as health, education and law enforcement.
- The system should be able to take requests for any of the specified services and execute commands for those requests as well as track and maintain citizen satisfaction.

Budget Management:

- The Government is responsible for management of the city's budget and allocating it to the resources, services and developments where necessary.
- The system should be able to set the budget of the city and allocated where it is seen fit through monitoring of available resources, service requests, population growth and citizen satisfaction.

Policies:

- The Government should be able to enact policies that the city and its citizens should follow.
- The system should be able to execute policy Commands to the city, citizens should be notified of the policies that are enforced, the system should also be able to monitor satisfaction results based on the policies.

Interactions:

Interactions with Citizens:

- Government must execute commands for public service requests from citizens.
- Government should be able to collect tax revenue from citizens.
- Government is observed by citizens and should thus notify citizens of adjustments to taxation and new policies.
- Government commands such as from taxation department and policies department should influence citizen satisfaction.

Interaction with City:

- Government issues commands on the City being taxation, policies, public services and budget allocation.
- City should provide feedback on the various commands issued by the Government.

Interaction with Transportation:

- Transportation should be influenced by the policies issued by the Government.
- The Government should be able to expand routes and as well as close routes where necessary which should influence transportation strategies and states.

Interaction with Buildings:
- The Government commands such as taxation should influence buildings and should be a way of generating revenue for the city.
- The Government should track building developments and job creation to influence employment rate.

Interaction with Utilities:
- The Government should ensure that the city has access to all utilities.
- The Government should issue policies influencing the use of utilities in the city.

Utilities

Functional Requirements for Utilities

1. **Resource Generation**:
   a. Utilities should generate essential resources required for city operations. This includes:
      i. **Power Plants**: Generate electricity to supply buildings and transportation systems.
      ii. **Water Supply**: Provide a steady supply of water to buildings and public spaces.
      iii. **Waste Management**: Handle waste removal, recycling, and proper disposal.
      iv. **Sewage Systems**: Manage sewage disposal and treatment to maintain environmental health.
2. **Resource Distribution**:
   a. Utilities should distribute generated resources (e.g., electricity, water) to buildings and public services across the city based on demand.
   b. Each utility type should have capacity constraints, which influence how resources are allocated when demand is high.
3. **Resource Monitoring**:
   a. Utilities should continuously monitor resource levels and usage to ensure adequate supply across the city.
   b. When resource levels are low, Utilities should prioritize distribution based on building type or resource consumption patterns.
4. **Interaction with Buildings**:
   a. Utilities should connect to buildings to provide required resources, impacting building functionality and citizen satisfaction.
   b. Utilities should adjust supply based on building requirements, such as increased water supply for Residential buildings or higher energy consumption for Industrial buildings.
5. **Impact on Citizen Satisfaction**:

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Utilities should influence citizen satisfaction. For example:
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Power outages or water shortages should decrease citizen satisfaction.
Efficient waste management and sewage treatment should improve citizen satisfaction by maintaining a clean environment.

<ol start="6">
Support for City Growth:
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Utilities should scale resource generation and distribution to meet the growing needs of the city.
New infrastructure (e.g., additional power plants, expanded sewage systems) should be built as the city expands.

Environmental Management:
<ol type="a">
Waste Management and Sewage Systems should minimize environmental impact by handling waste and sewage properly.
Utilities should have mechanisms to recycle resources where applicable (e.g., recycling water, composting waste).

Utilities Interaction with Other Components

1. Interaction with Buildings:

- **Request and Allocation**: Buildings send requests for resources (electricity, water) to Utilities. Utilities allocate resources based on availability and building priority.
- **Usage Tracking**: Utilities track resource consumption for each building type (e.g., Residential, Commercial) and adjust supply based on usage patterns.
- **Resource Shortages**: When resources are limited, Utilities prioritize critical buildings (e.g., hospitals) and notify other buildings of reduced supply, impacting building operations and citizen satisfaction.

2. Interaction with Resources:

- **Generation and Distribution**: Utilities generate resources and check with the Resources component to ensure availability. If resources are low, Utilities adjust generation capacity or notify the city government for additional resources.
- **Resource Recycling**: Waste Management interacts with Resources to recycle materials and minimize resource wastage, contributing to sustainable city management.

3. Interaction with Citizens:

- **Satisfaction Impact**: Utilities impact citizen satisfaction by providing essential services. Efficient and reliable Utilities increase satisfaction, while disruptions (e.g., power outages) reduce satisfaction.
- **Feedback Loop**: Citizens provide feedback on utility services, which Utilities use to improve services or expand capacity. This feedback may influence government decisions on utility funding and expansion.

- **Capacity Expansion**: As the city grows, Utilities collaborate with the City Growth component to expand infrastructure. This may include building new power plants or extending water supply networks to accommodate more buildings and citizens.
- **Resource Demand Forecasting**: Utilities work with City Growth to forecast future resource demand and plan for necessary expansions or upgrades to utility systems.

5. Interaction with Government:

- **Policy Compliance**: Utilities operate under regulations set by the Government, such as environmental standards for waste management and energy consumption limits.
- **Funding and Budget Allocation**: Utilities receive funding from the Government for infrastructure projects, such as building new facilities or upgrading existing systems to improve service quality.
- **Resource Pricing and Taxation**: The Government may influence Utilities by setting resource pricing or taxation policies, which impact how resources are distributed and priced for citizens and businesses.

Taxation Component

The taxation component is responsible for collecting revenue from citizens and buildings while maintaining a balance between tax revenue generation and citizen satisfaction. It allows for flexible tax strategies to be applied depending on the tax type (citizen or building) and tracks the effects of taxation on the city's economy and citizens' satisfaction.

Core Functionalities

Tax Strategy Management:

- The taxation component uses a flexible strategy pattern to collect taxes from citizens and buildings.
- The system should allow for setting and modifying the tax collection strategy dynamically for different entities (e.g., income tax for citizens, property tax for buildings).
- The component tracks the total tax revenue generated from both citizens and buildings.

Citizen Taxation:

- The system should apply income taxes to citizens based on their employment status and income.
- The taxation component should adjust the satisfaction of citizens based on the tax burden, reflecting how tax policies influence overall citizen morale.

Building Taxation:

- The system should calculate and collect property taxes from buildings based on property value and maintenance costs.
- The system should ensure that building tax collection influences the financial resources of building owners, which can affect job creation and building developments in the city.

Satisfaction Impact:

- Tax collection should influence citizen and building owner satisfaction, which will be monitored and adjusted as needed.
- The taxation system should provide feedback to the government on the impact of tax policies and rates on the overall satisfaction of the population.

Interactions

Interaction with Government:

- The taxation component executes commands issued by the government, such as setting new tax rates or modifying existing ones.
- It notifies the government of the total revenue collected and the satisfaction levels of citizens and building owners.
- The component responds to government policies, such as tax cuts or increases, by updating tax strategies accordingly.

Interaction with Citizens:

- The taxation component applies the selected tax strategy to citizens, calculating their tax liabilities and adjusting their satisfaction based on their tax burden.
- It notifies citizens of changes in tax rates and their tax obligations.

Interaction with Buildings:

- The taxation component calculates and collects property taxes from buildings based on their assessed value.
- It monitors and adjusts tax rates on buildings based on government policies and tracks the effects on building development and maintenance.

Interaction with Public Services:

- Tax revenue collected from citizens and buildings is essential for funding public services like healthcare, education, and law enforcement.
- The system monitors the relationship between tax collection and public service funding, ensuring that citizens receive necessary services while maintaining a balanced budget.

Interaction with City Budget Management:

- The tax revenue generated from the taxation component is fed into the city's overall budget management system.
- The system should allow for adjusting tax rates in response to budgetary requirements, ensuring enough revenue is collected to sustain public services and development projects.

Interaction with Policy Management:

- Taxation is influenced by government policies, such as tax exemptions for specific groups or industries.
- The taxation component must adjust strategies according to these policies and provide feedback on how policies affect tax revenue and satisfaction levels.