

Smart City

Design - Team Gold



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Meet the team



Tony
Cairuz

I'm passionate about sports, especially skiing, and I was proud to become the champion of skiing in Lebanon for a while. Outside of sports, I'm studying Computer Science and working alongside my studies.



Nick
Kooshki

I am currently a senior at ODU with a major in computer science. My biggest interests in technology are computer hardware alongside reviewing MacBooks and exploring the latest artificial intelligence trends and capabilities.

Meet the team



Carlos
Moll
Rolon

I am currently a senior at ODU studying Computer Science. I enjoy being able to problem-solve through code. Some hobbies of mine outside of school are lifting weights, listening to music, reading manga, and cooking.



Derrick
Stewart

I'm a senior at ODU studying Computer Science. I enjoy technology, music, and working on creative projects.

Meet the team



Weston
Carmack

I'm currently a senior in computer science here at ODU. My favorite programming languages are C++ and Python, and plan on picking up Rust in the future. Outside of class I enjoy watching football, Formula 1, working out and attending car shows.



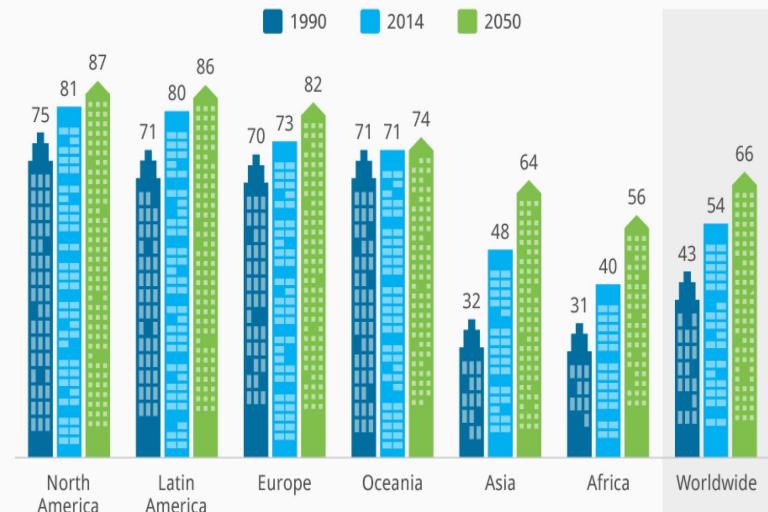
The Problem

Background - Rapid Urbanization

- By 2050, the UN projects 6.5 billion people will live in urban areas, most in developing countries, intensifying demand for public services [number analytics].
- As people migrate across the world, cities have seen an increase in population size which has lead to overcrowding in the communities that have been established in these cities for a long time.

54% of the World's Population Now Lives in Cities

% of the population living in urban areas



Source: United Nations

Mashable statista

How does rapid urbanization affect us and why is it important?

- Health Issues [2]
 - We see health issues such as respiratory disease, tuberculosis, mental health problems and higher mortality rates.
- Traffic Jams and Overall Congestion [1]
- Poor Quality Housing [1, 2, 3]
 - Homes can be illegally converted in order to accomodate more guest leading to poor living conditions.
- Inadequate Waste Management [1]
- Water Scarcity [1]
- Increased Crime Rate [1]



Why has this not been solved?

- Current infrastructure is not sustainable to deal with rapid urbanization and there is little investment towards those systems. [4]
- There is insufficient communication between local government agencies and the organizations that support them.
- Efforts to address the problem have relied on governments and city officials with no voice for the people.



Who are the people affected?

- Residents living in these high-density areas experiencing rapid urbanization. This group is the most affected. [1]
- Commuters who have to travel to these areas in order to work are dealing with congestion and high volume of traffic. American motorists lost an average of 42 hours to highway congestion in 2023. [9]
- City officials who have to work with the communities are facing these challenges as they are trying to coordinate efforts. [1]
- Business owners who are having their businesses affected by long wait times.



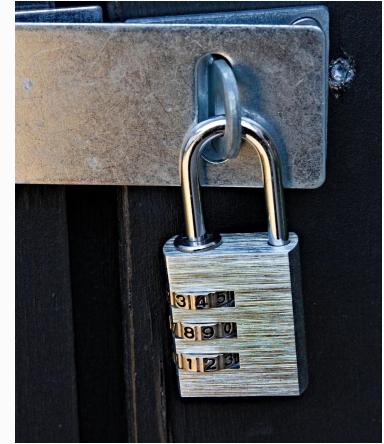
Problem Statement

- **What's happening?**
 - Rapid urbanization and poor planning create overcrowding, reducing quality of life.
- **Why It's Happening**
 - Mass migration to urban areas
 - Data gaps leading to poor urban planning causing:
 - Health Issues
 - Traffic Jams
 - Poor Quality Housing
 - Inadequate Waste Management
 - Water Scarcity
 - Increased Crime Rate
- **Impact**
 - Longer commutes, unaffordable housing, and reduced community well-being.

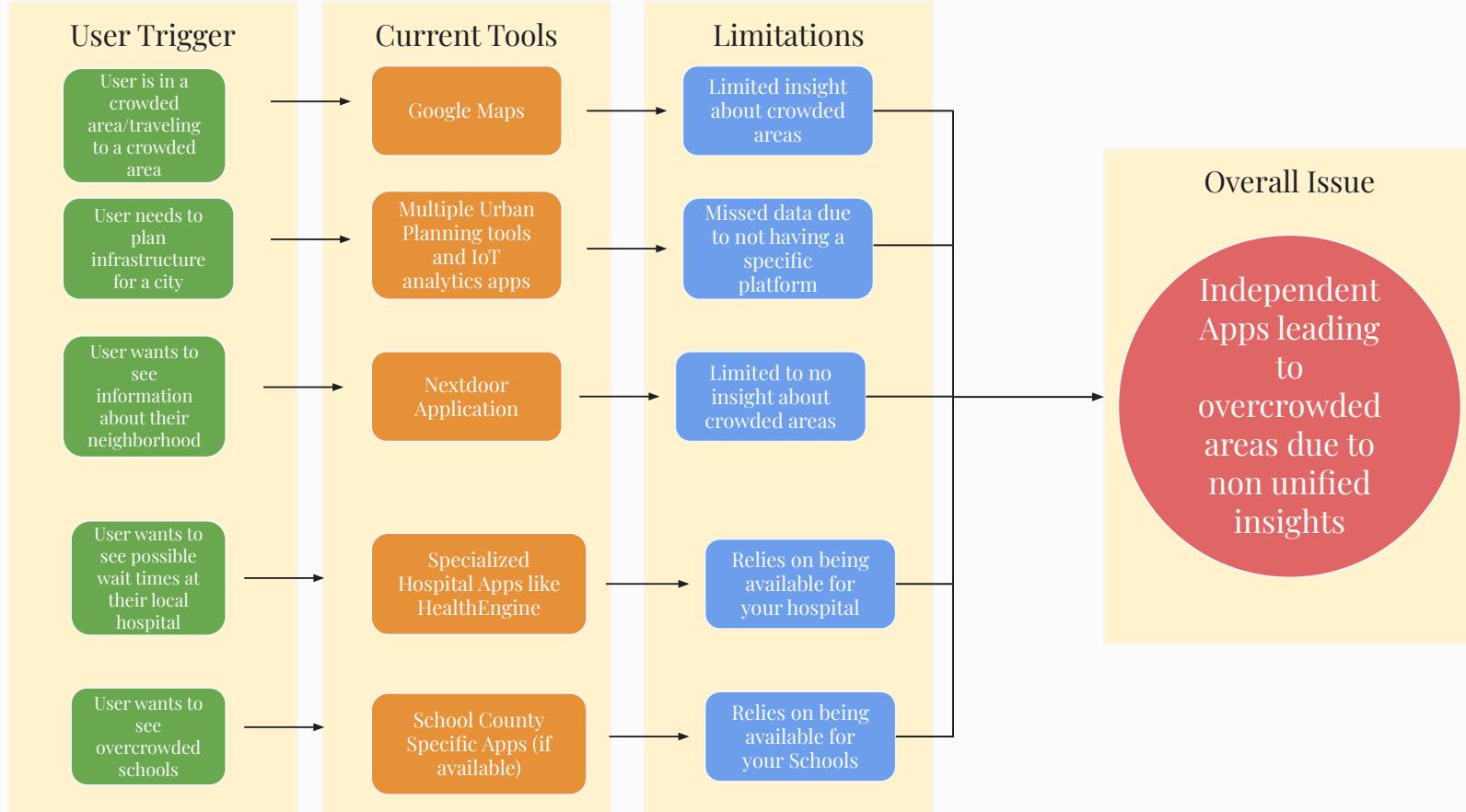


Problem Characteristics

- Congestion
- As more people move into cities they experience congestion when traveling in their day to day lives.
- If only there was a way to see how crowded areas in their communities will be and provide suggestions based on that.
- Community Interaction
 - With small community driven efforts and no platform to congregate leaves people feeling lost and out of touch with their own communities
 - If only there was a platform for the people to share data and events regarding their community in order to drive improvements.
- Poor Infrastructure
 - Deteriorating infrastructure with minor investments leads to poor quality of life for the people living in these conditions.
 - If only there was a way to leverage underutilized and underfunded infrastructure to provide better living conditions for the people



Current Process Flow





The Solution

Smart City: A Community-Driven Data Platform

- Crowdsourced Data leveraging **IoT, APIs, and future AI integration**
- Helps residents avoid overcrowding & plan smarter
- Provides governments with accessible, real-time insights



What Users Gain Today



Find
less-crowded
clinics & schools



Get alternate
transit routes



Share & view
community
updates



Save time and
reduce stress

Citywide Impact (Long-Term)



Historical Trend Analysis



Community Insight
Dashboard



Open Data Access

Why Smart City Wins



Holistic Coverage (health,
transit, education)



Citizen Feedback Loop

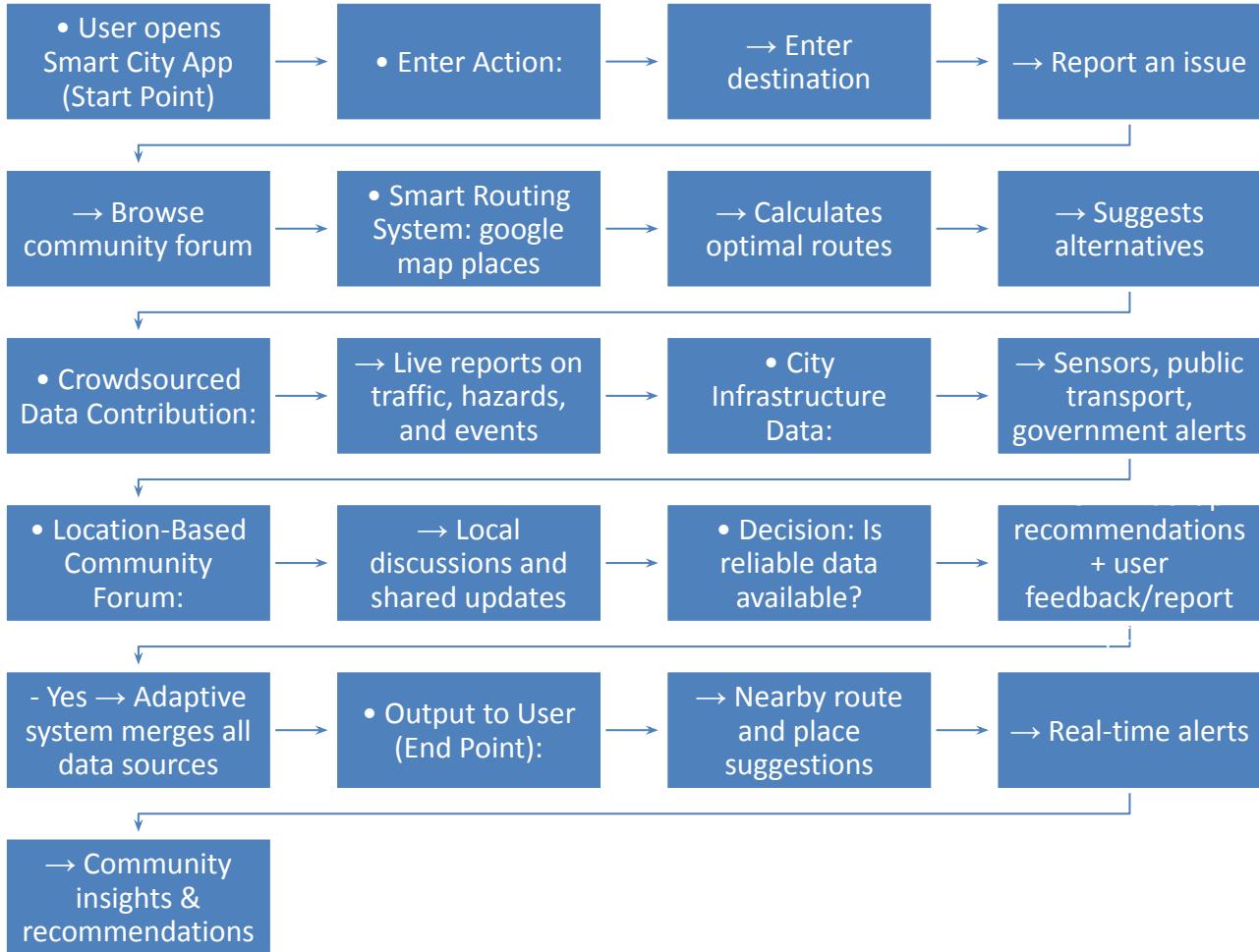


Privacy-First Design

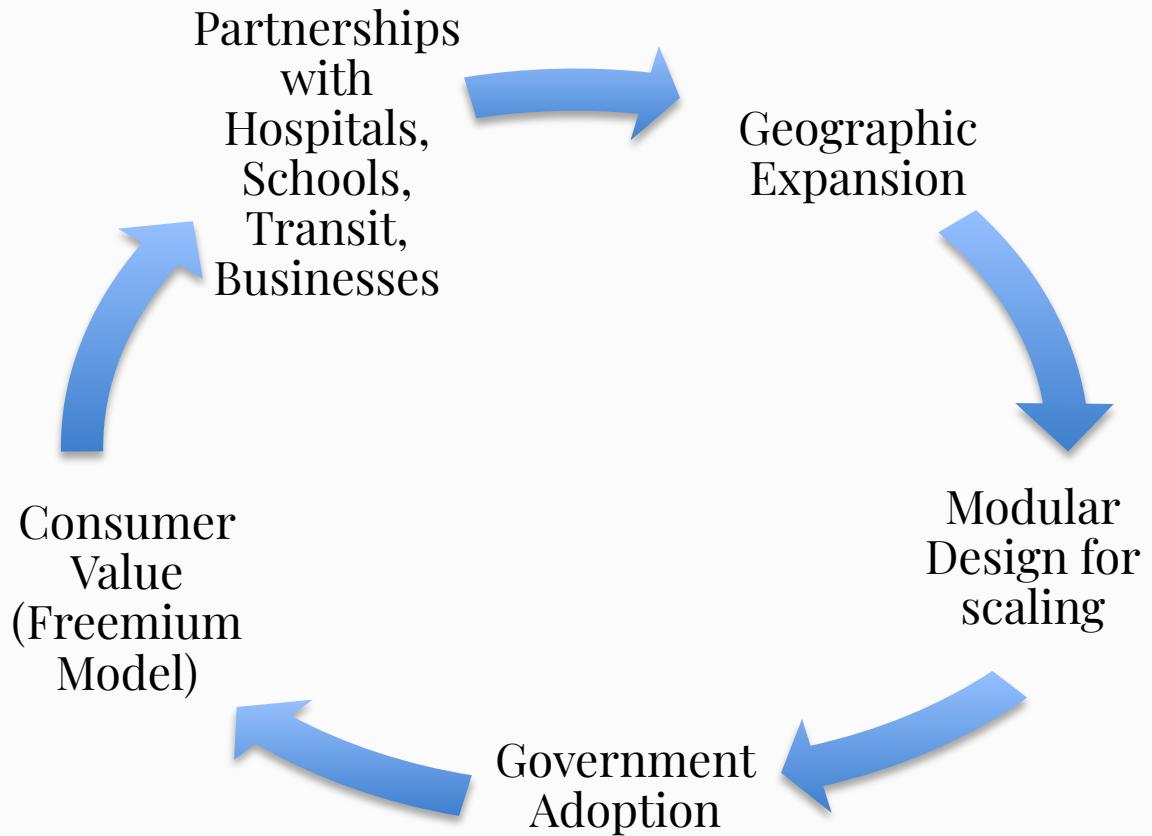


Open Data for Innovation

Solution Process Flow – Smart City App



Growth Potential



Hurdles to Overcome



Public Acceptance ➔ Privacy
campaigns, gamification,
partnerships

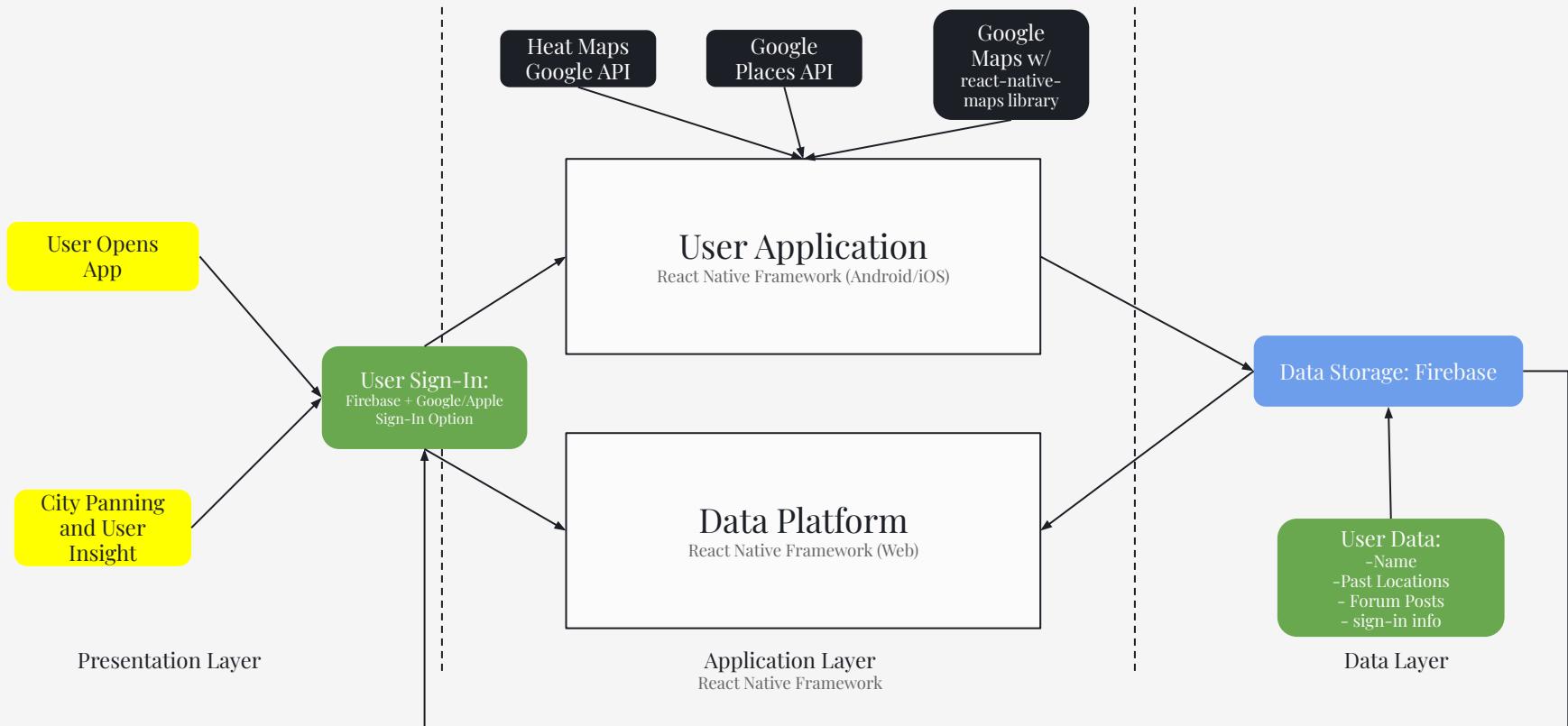


Safety Concerns ➔
Aggregated data, anomaly
detection, access control



Sustainability ➔ Seed
datasets, phased rollout,
municipal partnerships

Major Functional Components Diagram



Major Functional Components

01

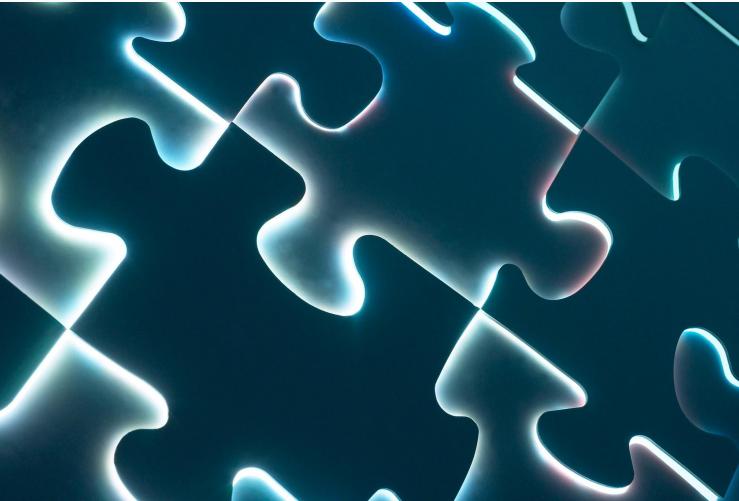
User Interface

An interface that can offer navigation assistance while also providing a community forum in order for residents to be able to discuss topics.

02

Data Processing and Data Storage

A module to handle short-term data processing that occurs when the user shares their data. A second module to handle long-term data storage and track historical trends.



03

Insights and Support

Help provide insights to city planners and shareholders based on the long-term data handling. Key in establishing communication with customers.

04

Artificial Intelligence

In the future: Use of artificial intelligence algorithms in order to predict needs for city planners. Also potential to use AI in order to offer real time suggestions for users.

What Smart City Will Do

- Allow users to search for nearby locations
- Provide real time AI powered routing to avoid congestion and suggest alternatives
- Show live wait times for clinics, schools, and other crowded locations
- Enable crowdsourced community updates (events, traffic, safety alerts)
- Give city officials a dashboard for better coordination and planning
- Improve daily navigation and quality of life for residents and commuters
- Protect users' privacy by using Firebases built-in encryption both in transit and at rest vis HTTPS
 - Added protection with logical data isolation and access tracking

What Smart City Will NOT Do

- Build or repair physical infrastructure (roads, housing, utilities)
- Replace or act as an official government system, it only supports them with data
- Directly address crime, poverty, or housing shortages
- Guarantee 100% accurate predictions, insights depend on user contributions
- Eliminate congestion completely, it reduces and helps manage it, not remove it entirely

Customer Risks

Risks

C1R: Viewed as low value – users may think Smart City is unnecessary because they could already access traffic updates

C2R: Doubts about accuracy – users think Smart City's real time updates aren't accurate

C3R: Too Many Updates – too many updates could make users mute the app or uninstall it

C4R: Hard to Use – The app may feel confusing for new users since it includes many different tools and features.

Mitigations

C1: Viewed as low value – Highlight what makes Smart City unique, such as real-time AI updates, community features, and all-in-one access.

C2: Doubts about accuracy – give a confidence rating on updates to show how accurate an update is

C3: Too Many Updates – tailor updates to the user allow them to select which updates they receive

C4: Hard to Use – Simplify the interface with clear buttons, a clean layout, and short tutorials to help users get started easily.

Risk Matrix			Impact				
			Very Low	Low	Medium	High	Very High
Probability	Very High	5					
	High	4				C4R	
	Medium	3	C3M	C1R, C4M	C2R, C3R		
	Low	2	C2M	C1M			
	Very Low	1					

Security Risks

Risk Matrix			Impact				
			Very Low	Low	Medium	High	Very High
	1	2	3	4	5		
Probability	Very High	5		S4M S3R		S4R	
	High	4			S2R		
	Medium	3		S3M S1R			
	Low	2	S1M		S2M		
	Very Low	1					

Risks

S1R: Surveillance through IoT sensors, public APIs and crowdsourced data to know where people are at all times

S2R: All information in one place makes the app a prime target for cyber attacks

S3R: Companies may exploit user data for profit, sharing it with advertisers or other entities.

S4R: Governments may use this information to limit free speech or movement in certain countries outside the U.S. that don't have laws preventing this.

Mitigations

S1M: Data Anonymization; showing "high crowd level" vs a hard number

S2M: Use Firebases provided built-in encryption for in transit, at rest and logical isolation for stored data.

S3M: Enforcing clear opt-in data sharing options and rate-limiting to mitigate scraping

S4M: Implement strong privacy protection and produce quarterly reports of data access. Assess laws in markets Smart City is published to and adjust privacy protection accordingly.

Technical Risks

Risk Matrix		Impact				
		Very Low	Low	Medium	High	Very High
		1	2	3	4	5
Probability	Very High	5				
	High	4				T4R
	Medium	3			T3R T4M	
	Low	2		T2R T3M	T1R	
	Very Low	1	T2M	T1M		

Risks:

T1R: Software integration complexity - As we work to combine different forms of software and tools (mapping, artificial intelligence, community hub) the application architecture could become complex and bloated

T2R: Prediction/AI accuracy - Integrating AI needs to be reasonable with accurate results. There are risks with our models generating false information.

T3R: Data pipeline reliability and timeliness - With multiple data sources (crowdsourced reports, IoT sensors, public APIs), failures, delays, or schema changes can make information stale or incorrect

T4R: Performance and scalability - Heavy geospatial and time-series processing (routing, hotspot detection, forecasts) may slow response times during peak usage and degrade the user experience

Mitigation:

T1M: Software integration complexity - Start small and ensure systems are working before adding on. Clean coding and proper documentation. Taking actionable steps to prevent risk.

T2M: Prediction/AI accuracy - Implement information vetting through unit, integration and systems testing otherwise monitoring the results and having a check for those.

T3M: Data pipeline reliability and timeliness - Standardize input formats and validate on ingest. Add retries and backoff for flaky sources. Monitor data freshness and alert on staleness. Use last-known-good fallbacks when feeds fail.

T4M: Performance and scalability - Use spatial/time indexing and caching for frequent queries. Pre-aggregate common views. Load test and autoscale the service. Set clear latency goals and optimize slow endpoints.

Smart City vs. The Competition

Feature	Smart City	Navigation Apps (Google maps, Citymapper)	City Platforms (IBM, Siemens, Microsoft)	Community Apps (Nextdoor, SeeClickFix)	Sector Specific Apps (HealthEngine, School Apps)
Multisector Coverage	✓	✗	✓	✗	✗
Dynamic Queue	✓	✓	✓	✗	✗
Community Forum	✓	✗	✗	✓	✗
Privacy-First Design	✓	✗	✗	✗	✗

Development Tools - Tech Stack

- Development: Visual Studio Code
- APIs: Google's Places Aggregate API, OpenStreetMaps API
- Frameworks: React Native, Expo
- Libraries: Gifted Chat (UI), react-native-maps (Google maps implementation), react-native-geolocation-service (User Location)
- Languages: JavaScript (Frontend), Java (Backend)
- Website: HTML, CSS, GitHub Pages
- Version Control: git through GitHub
- Database: Firebase

User Roles

User Roles

- Daily commuters using Smart Routing and live traffic updates
- Event-goers avoiding crowds with Alternative Destinations
- Community reporters sharing updates through Crowdsourced Data
- Local connectors engaging in the Community Forum

City Official

- Uses Dashboard and Analytics to monitor city activity
- Receives Alerts when areas become crowded
- Reviews Trend Reports to plan for future improvements
- Responds quickly to resident reports and real-time data

Business Owner

- Tracks visitor activity using Business Insights
- Posts live wait times to inform customers
- Monitors nearby business traffic trends
- Uses Reward Integration to engage with the community

User Stories

As a Resident, I want to...

1. Use a forum to report issues like potholes or overcrowded businesses so that I can alert neighbors and officials quickly.
2. Confidence-rated alerts for overcrowded areas I travel through frequently so that I can adjust my plans in time.
3. Access to alternate routes in the app's navigation so that I can avoid congested corridors.
4. Suggestions for alternative businesses that are less crowded but similar to my original destination so that I can save time without sacrificing what I need.
5. View my user profile so that I can see statistics and activity related to my usage.
6. Earn rewards and unlock priority queue access when I follow suggested alternate routes so that I can stay incentivized to reduce congestion.

As a City Official, I want...

1. Population density analytics so that I can plan infrastructure upgrades and manage resources effectively.
2. To gather user feedback so that I can coordinate urban planning efforts with residents' input.
3. A central information hub so that I can manage all relevant information in one location.
4. Automated alerts when crowding exceeds safety thresholds in specific zones so that I can deploy responses promptly.
5. To view real-time community forum reports with location data so that I can verify issues and prioritize action.
6. Access to historical crowding trend data across different periods so that I can analyze patterns and plan ahead.

User Stories

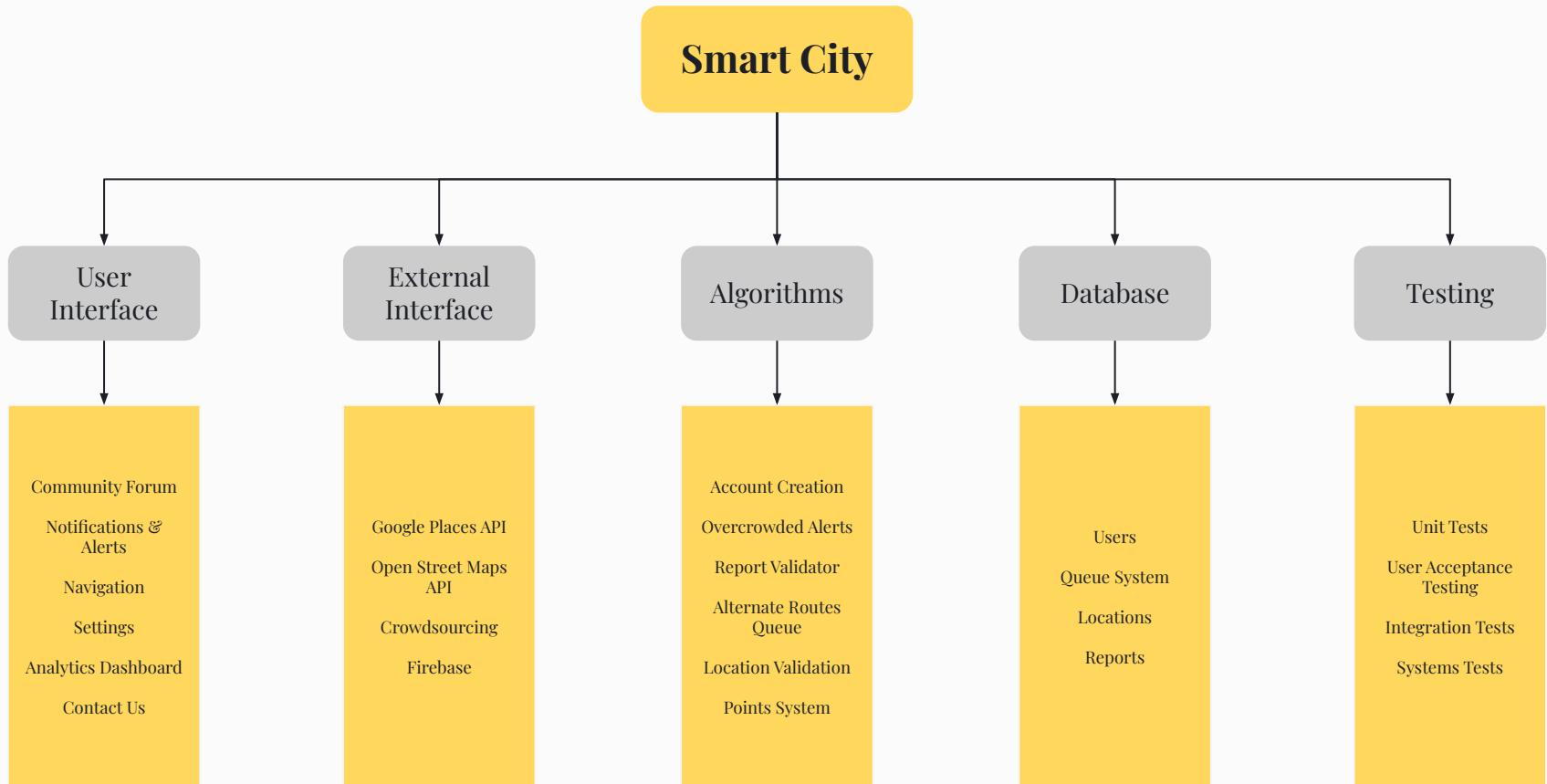
As a Business Owner, I want...

1. Foot traffic analytics for my store's location so that I can adjust operating hours and marketing strategies.
2. To offer parking options near my business so that customers can access my store without being deterred while searching for parking.
3. To interact with residents through a community forum so that I can get input and grow my business.
4. To post real-time wait estimates for my business so that customers can choose the best time to visit.
5. Demographic insights about visitors to my area so that I can target promotions effectively.
6. Comparative foot traffic analytics versus nearby competitors so that I can benchmark performance.

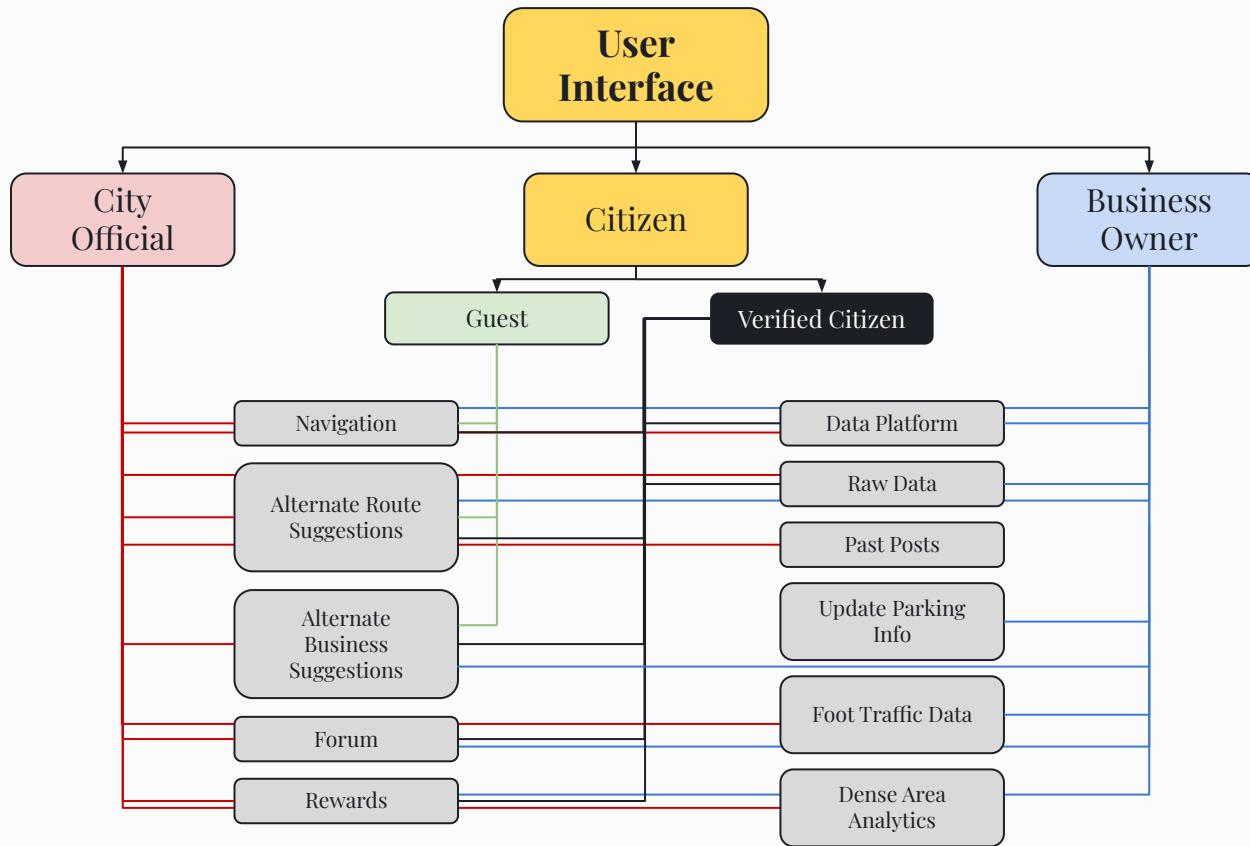
Feature Table

Features Table						
Category	Features	Admin	Residents	Guests	City Officials	Business Owners
Account Management	Login/Authentication	✓	✓		✓	✓
	Account Creation/Deletion	✓	✓	✓	✓	✓
	Manage Account Access/Permissions	✓				
User Application	Access Community Forum	✓	✓		✓	✓
	Access Dynamic Queue System for Navigation	✓	✓	✓	✓	✓
	Alerts and Notifications		✓		✓	✓
	Add Parking locations					✓
Data Platform	Central Information Hub	✓			✓	
	Data Analytics and Insights				✓	✓
	Visualize Data				✓	✓
	Data Anonymity	✓	✓	✓	✓	✓

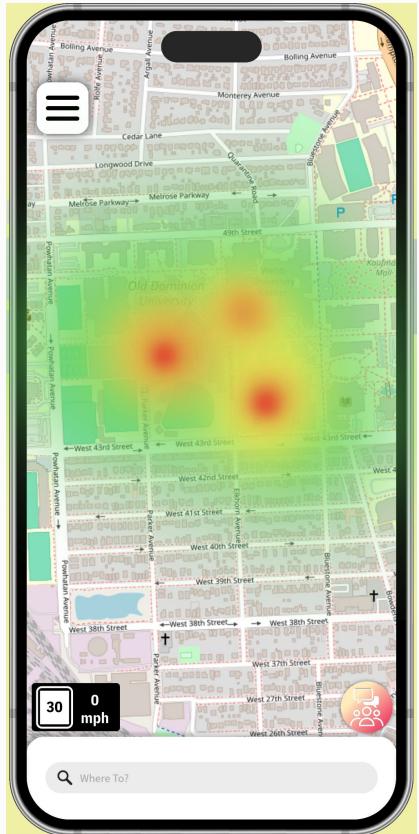
Work Breakdown Structure Overview



WBS - User Interface



UI Mockup



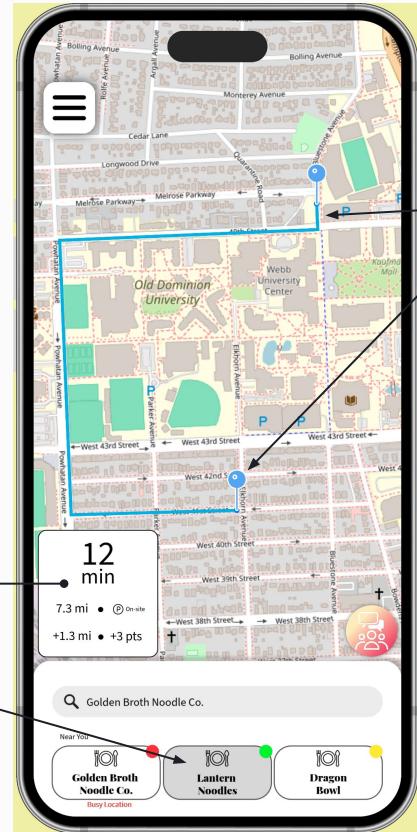
Busy
Indicator

Swipe
Up



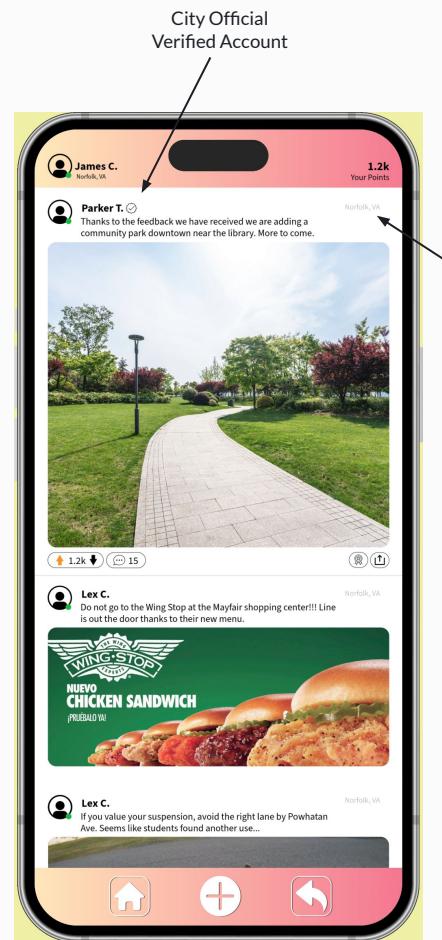
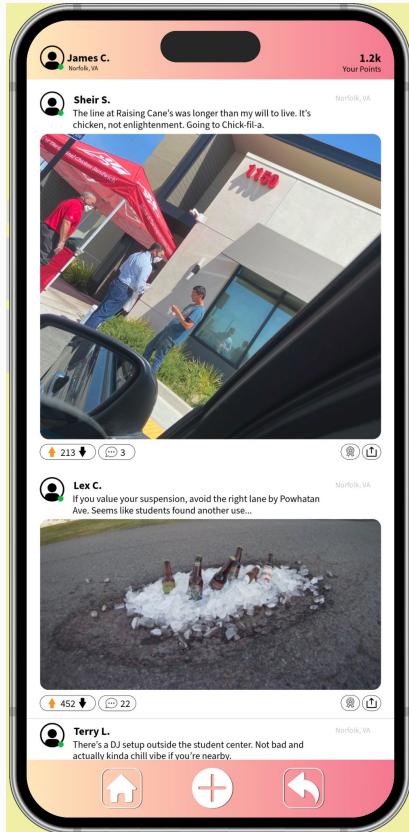
Shows Info
for New
Option VS
Original Search

Clicks
Better
Option

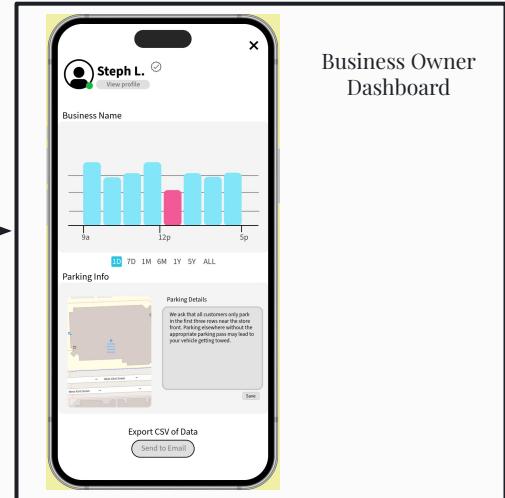
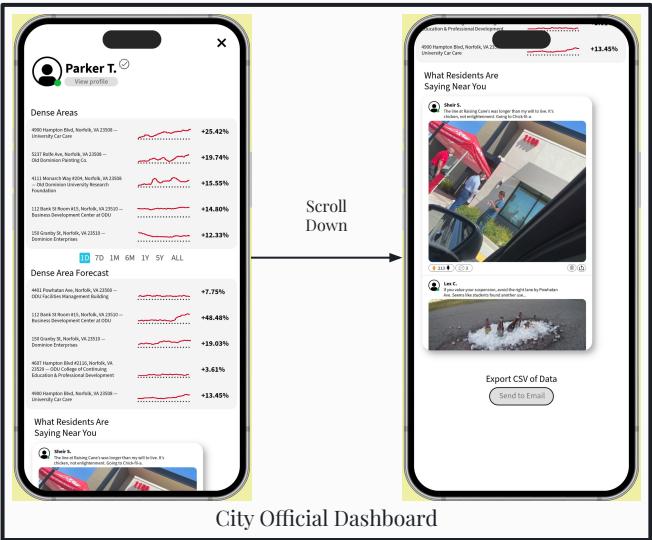
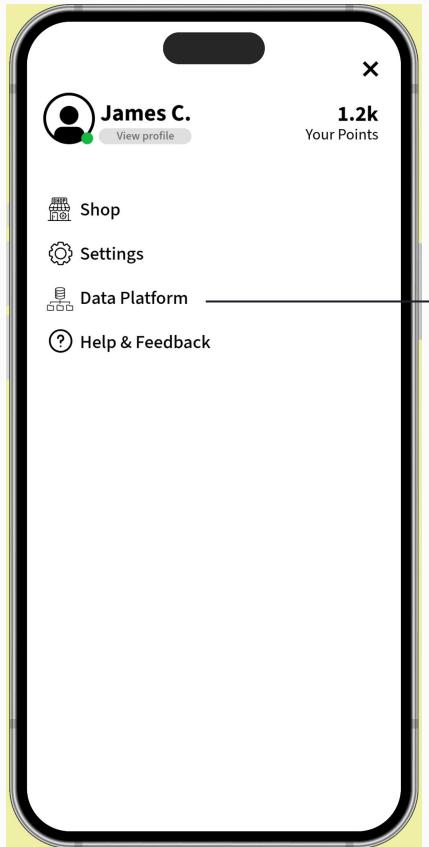


New Route
from Queue

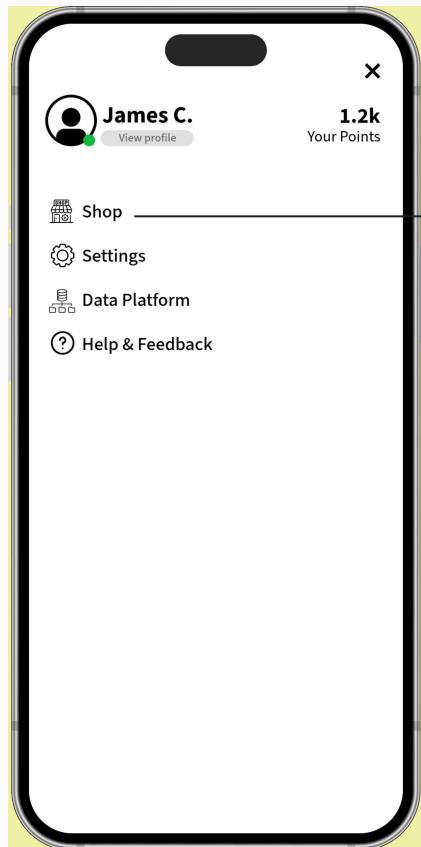
UI Mockup



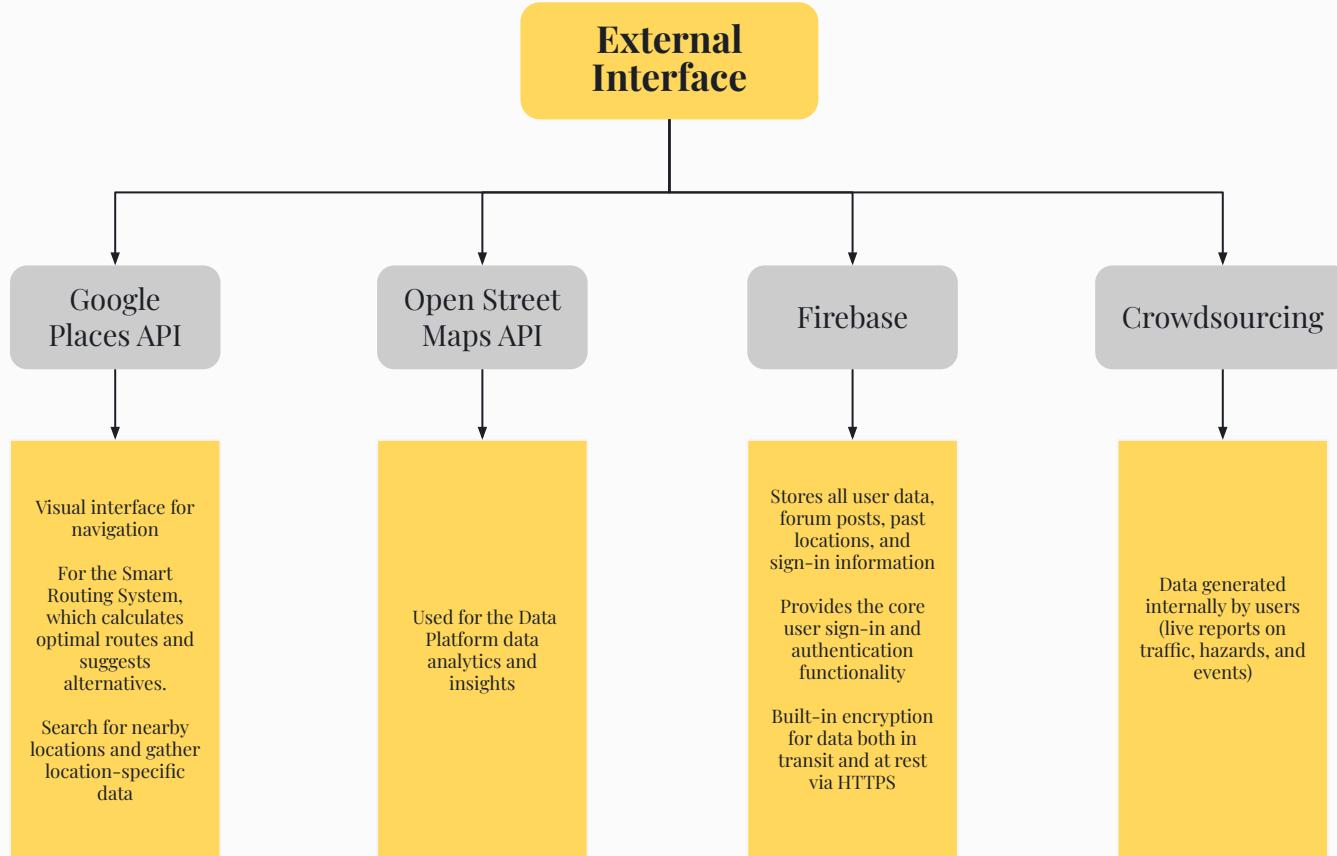
UI Mockup



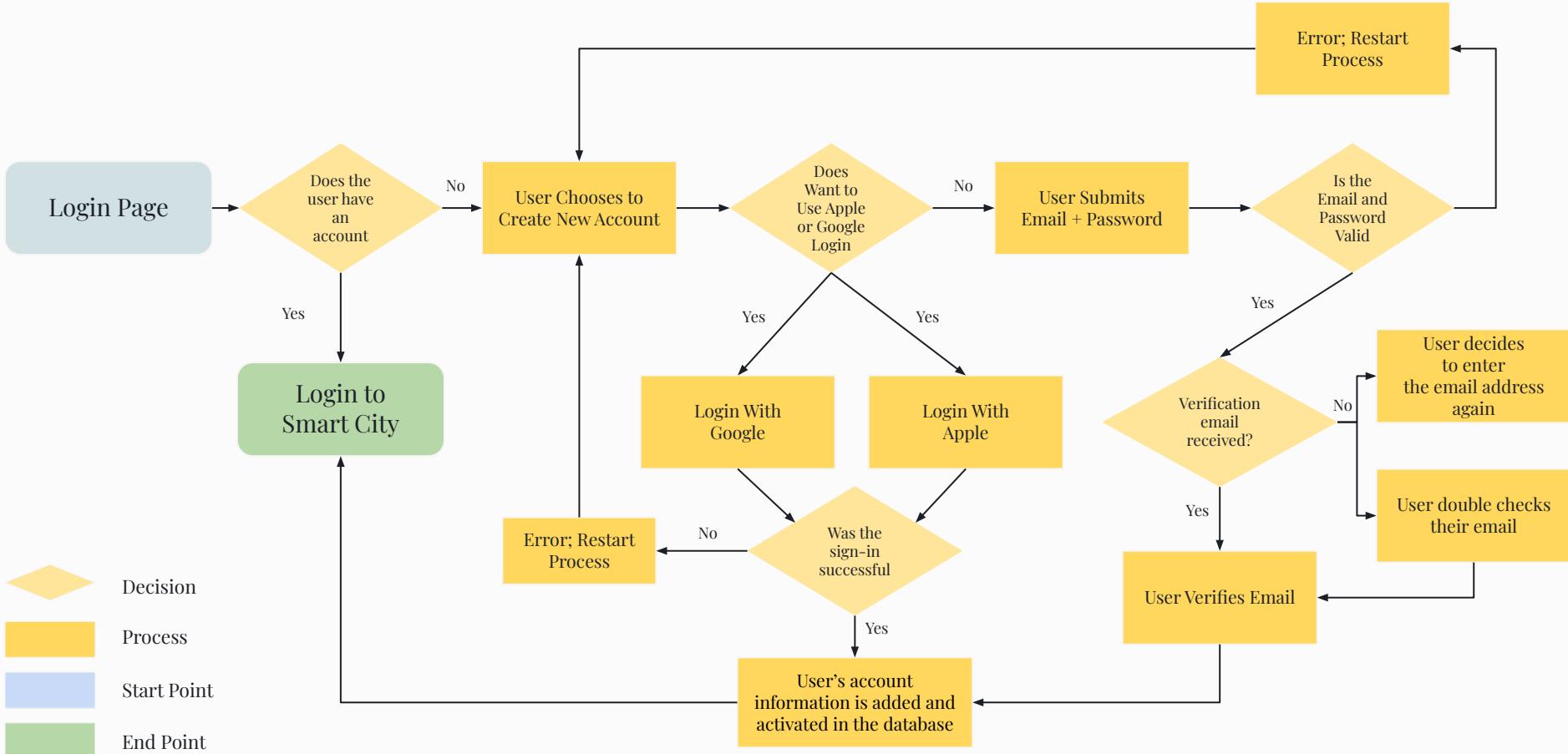
UI Mockup



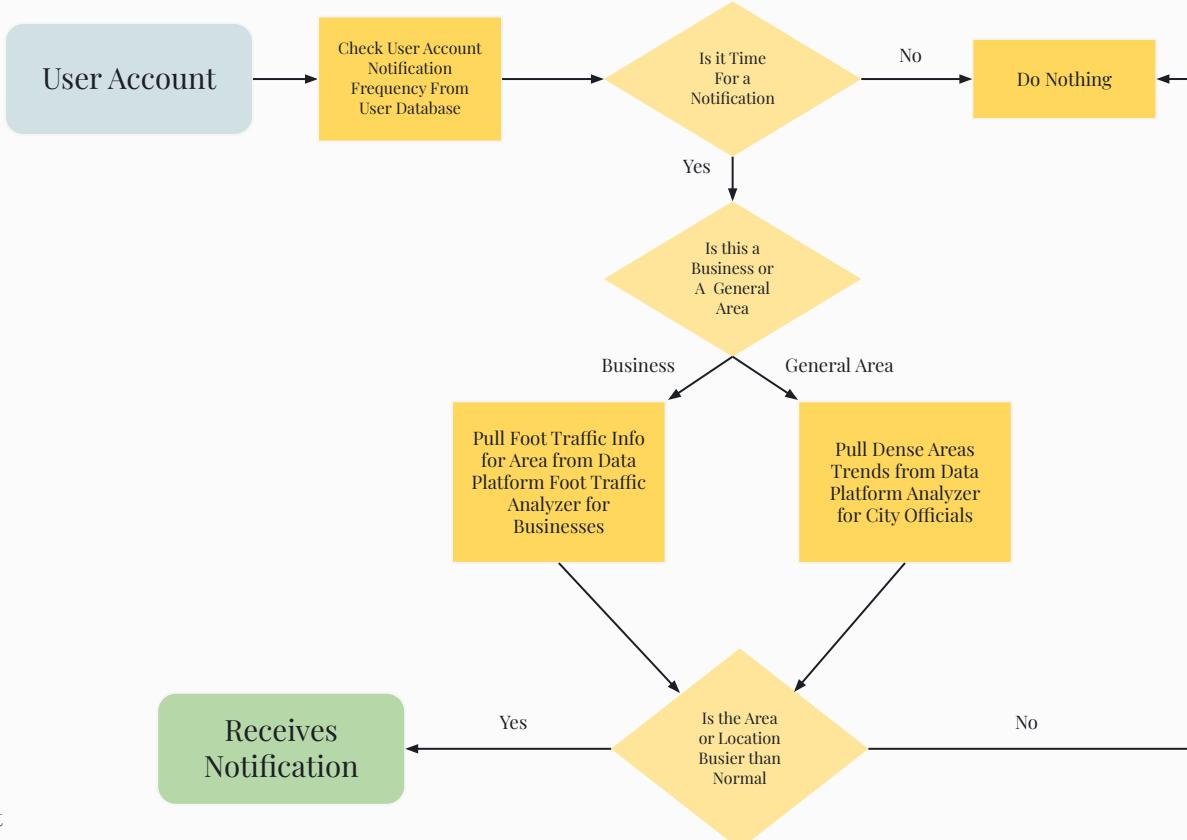
WBS - External Interface



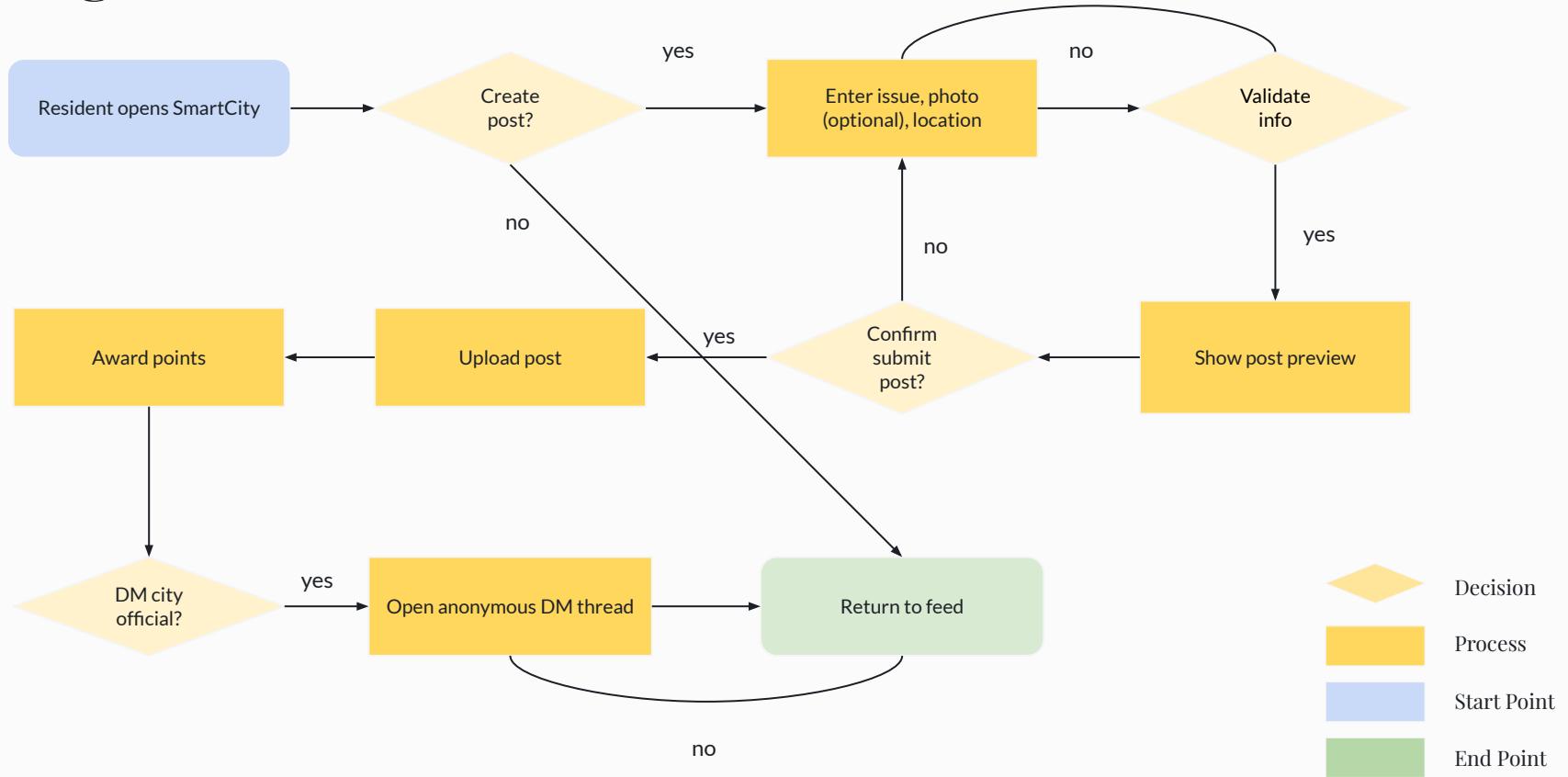
Algorithms - Account Creation



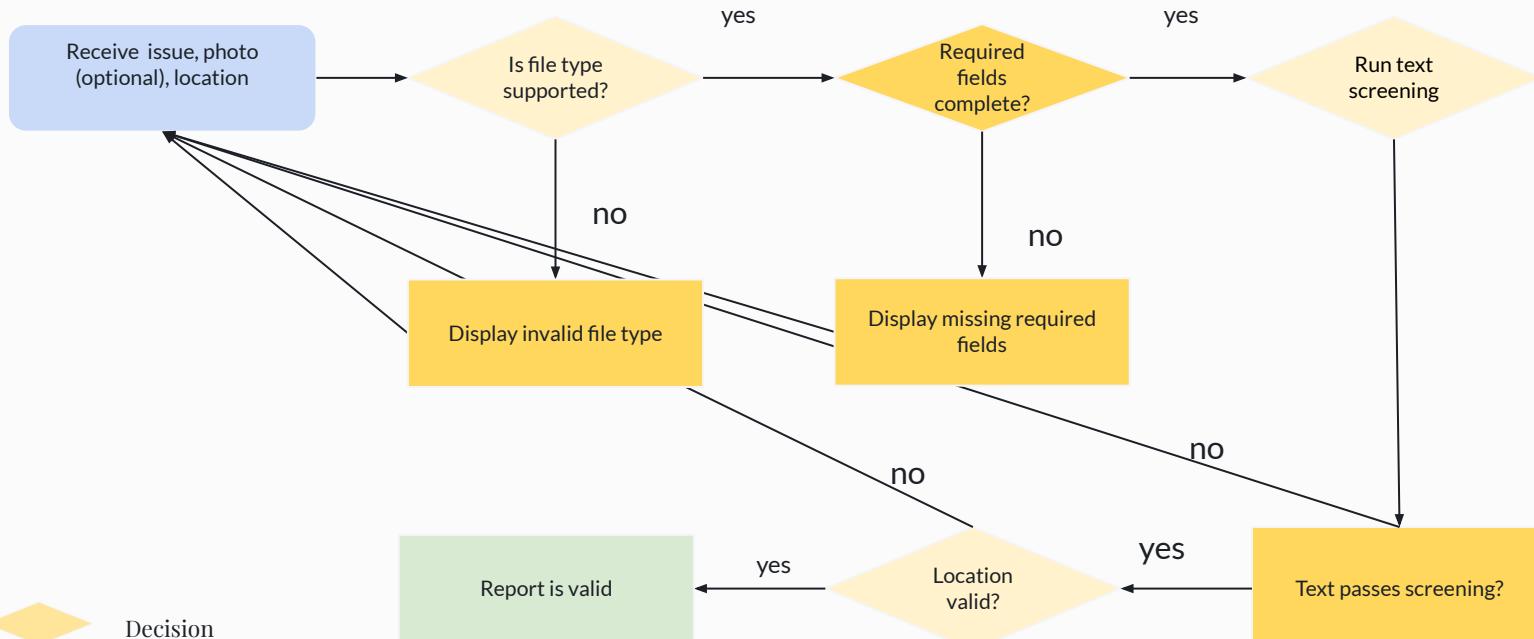
Algorithms - Overcrowded Alerts



Algorithms - Forum



Algorithms - Report Validator



Decision



Process



Start Point

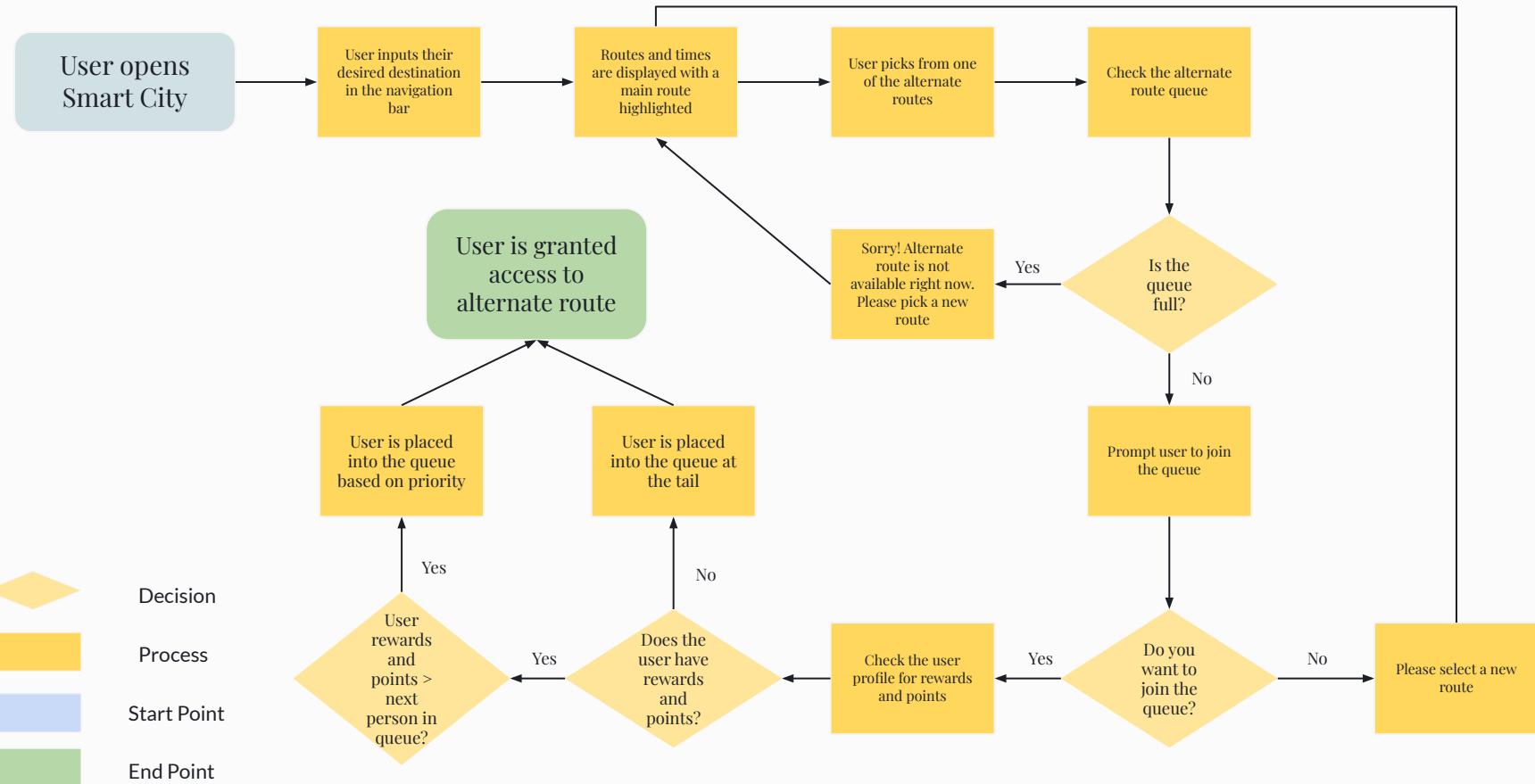


End Point

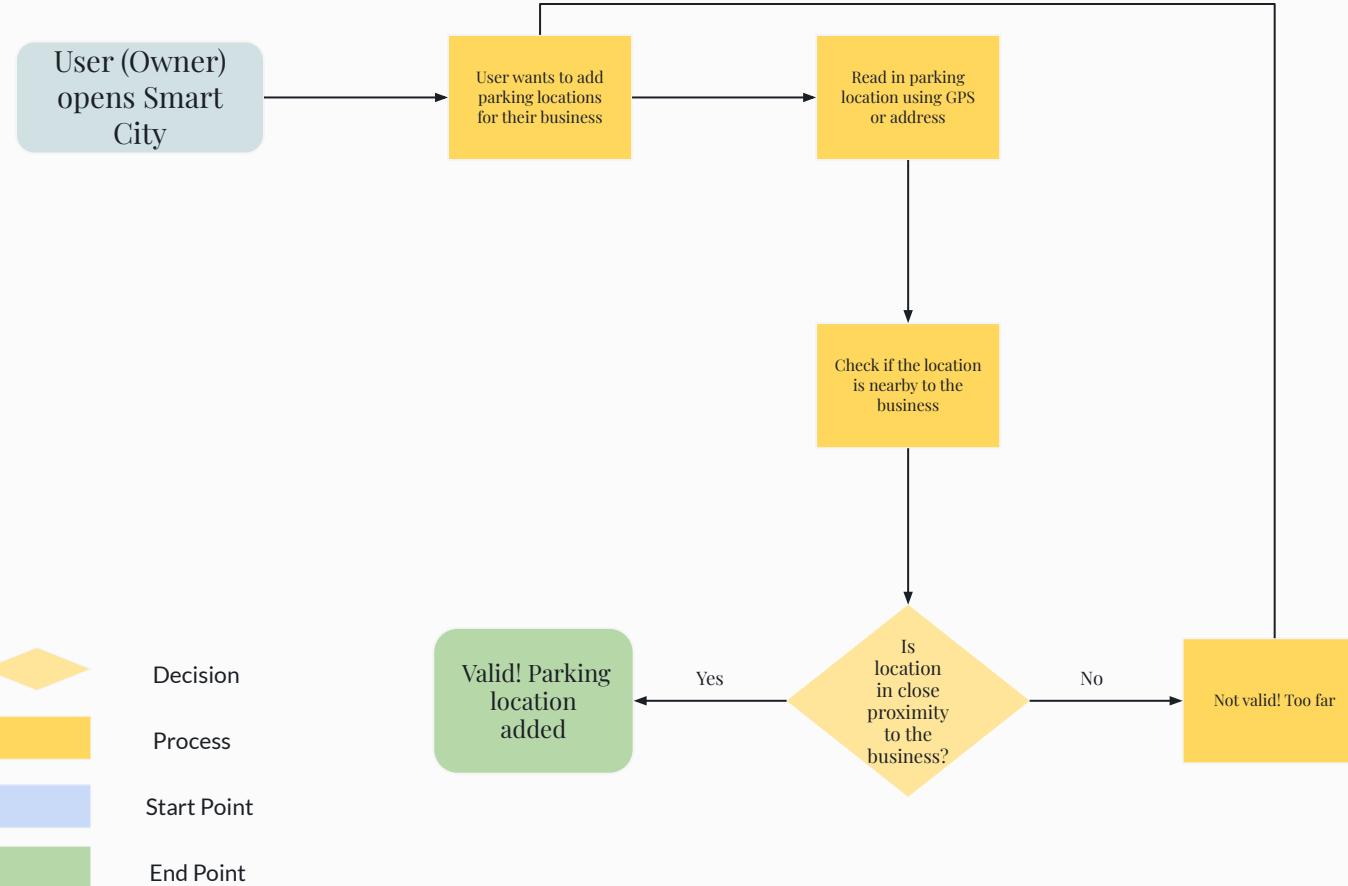
Braess' Paradox

- Braess' paradox refers to an observation between traffic congestion and more lanes. It is observed that when you are adding a new lane to an existing network of roads that traffic can become congested.
- When we are trying to route users to a new route we run into this problem were all the users will flood to the new suggested route causing further traffic congestion and not fixing the problem.
- What does Smart City propose? A dynamic queue system!
- By using a dynamic queue system in combination with Google's "Google Maps Places API", we can offer alternative routes to users and have them enter the queue. If the queue is not filled then they can enter the alternative route and go on their way. If the queue is filled then they cannot have access to that route at the moment.
- This feature can be tied into our reward system. Based on user profile and contributions we can assign a priority to the queue therefore incentivizing users to engage with the app and make their cities easier to navigate!

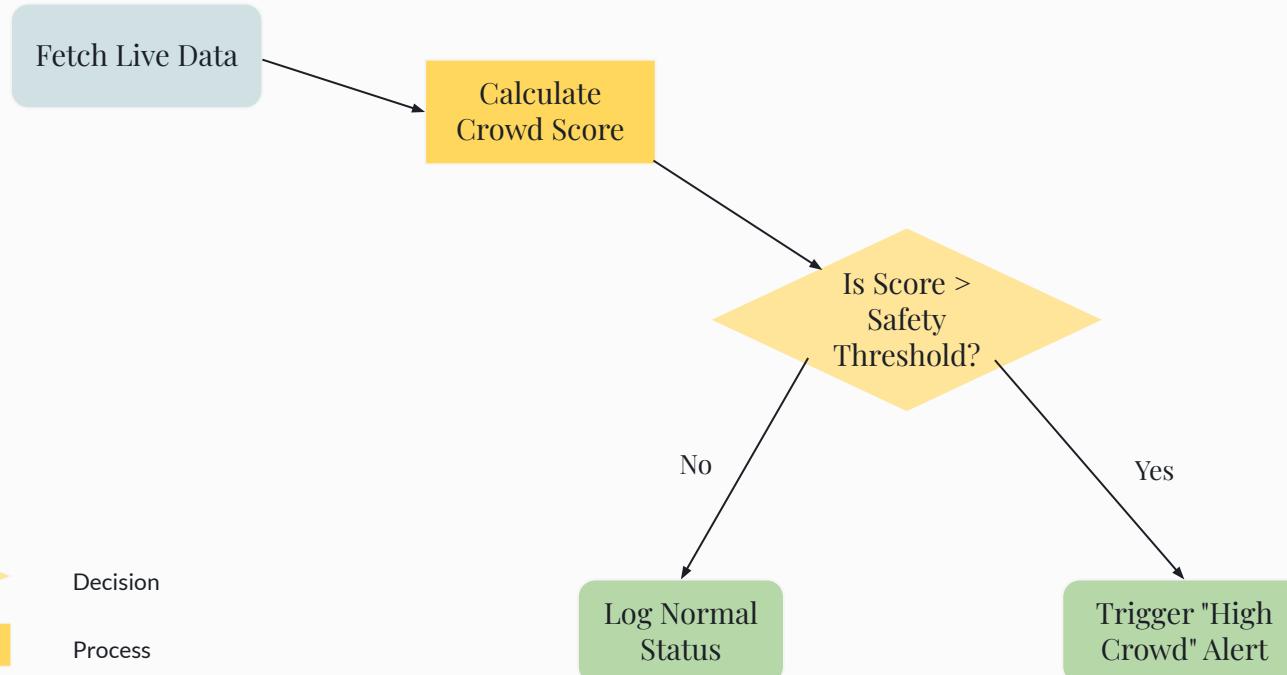
Algorithms - Alternate Routes Queue



Algorithms - Location Validation



Algorithms - Data Platform Logic (Resident)



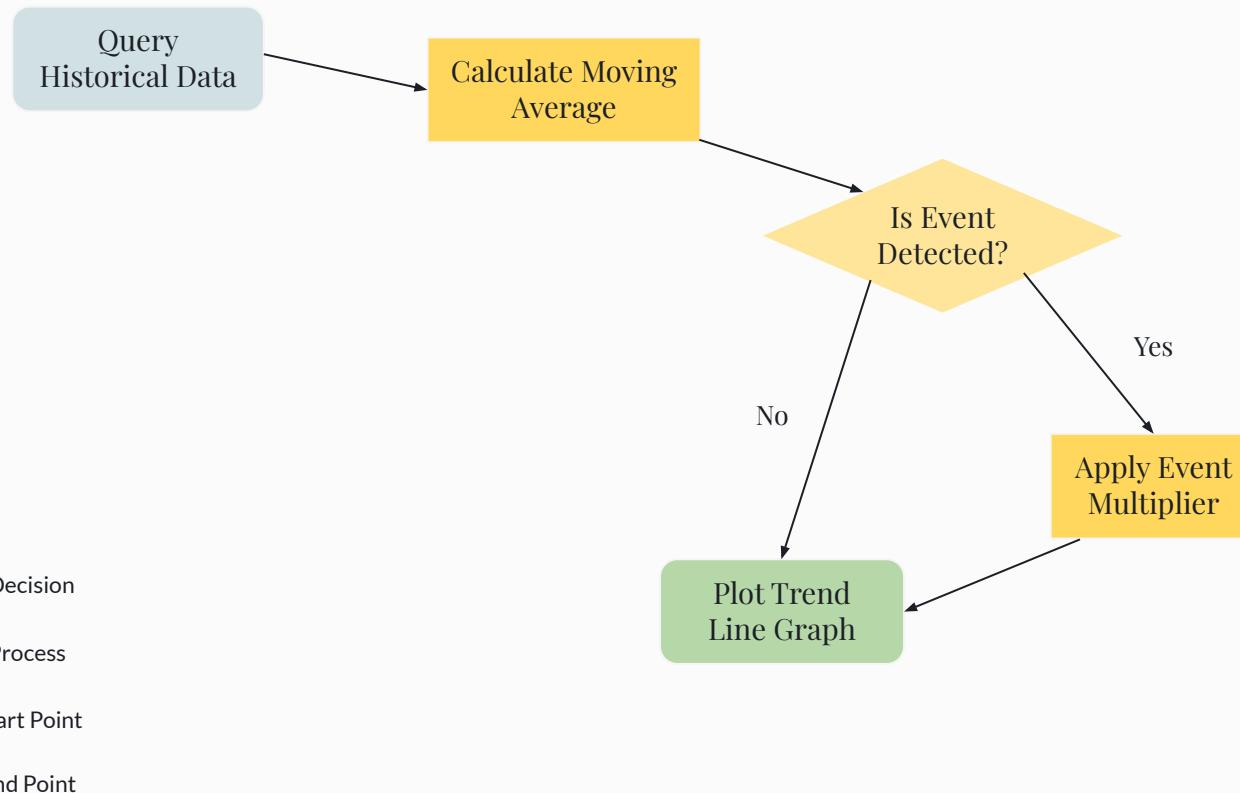
Decision

Process

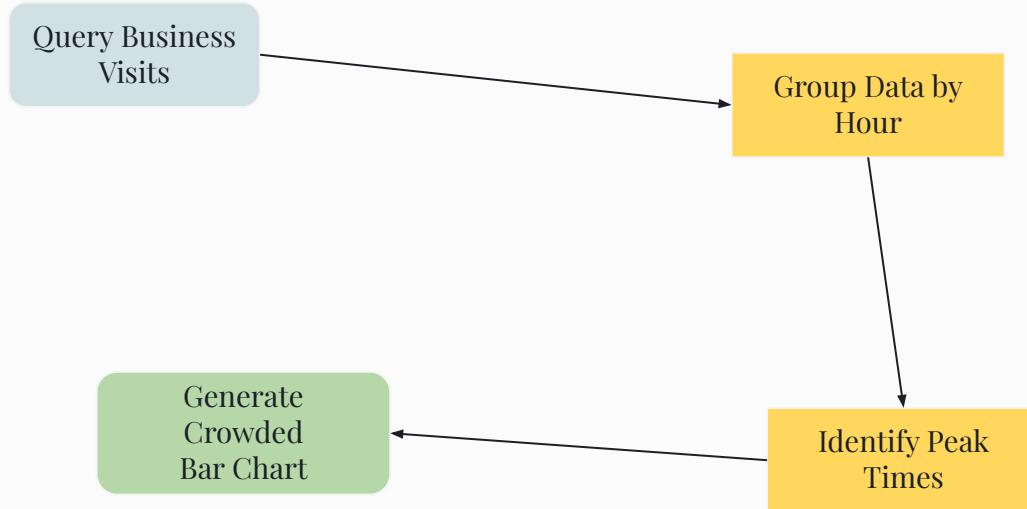
Start Point

End Point

Algorithms - Data Platform Logic (City Official)



Algorithms - Data Platform Logic (Business Owner)



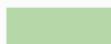
Decision



Process

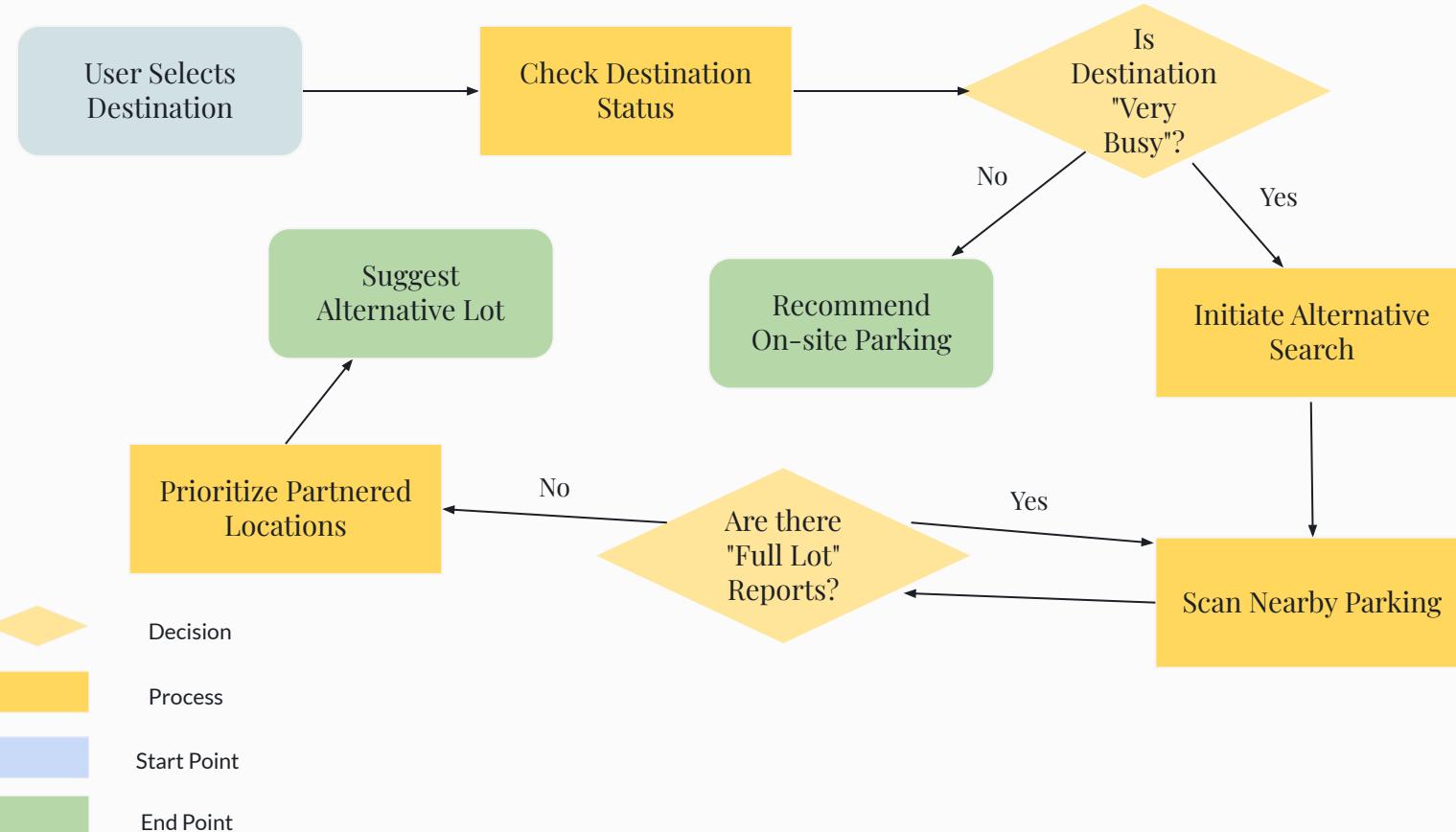


Start Point

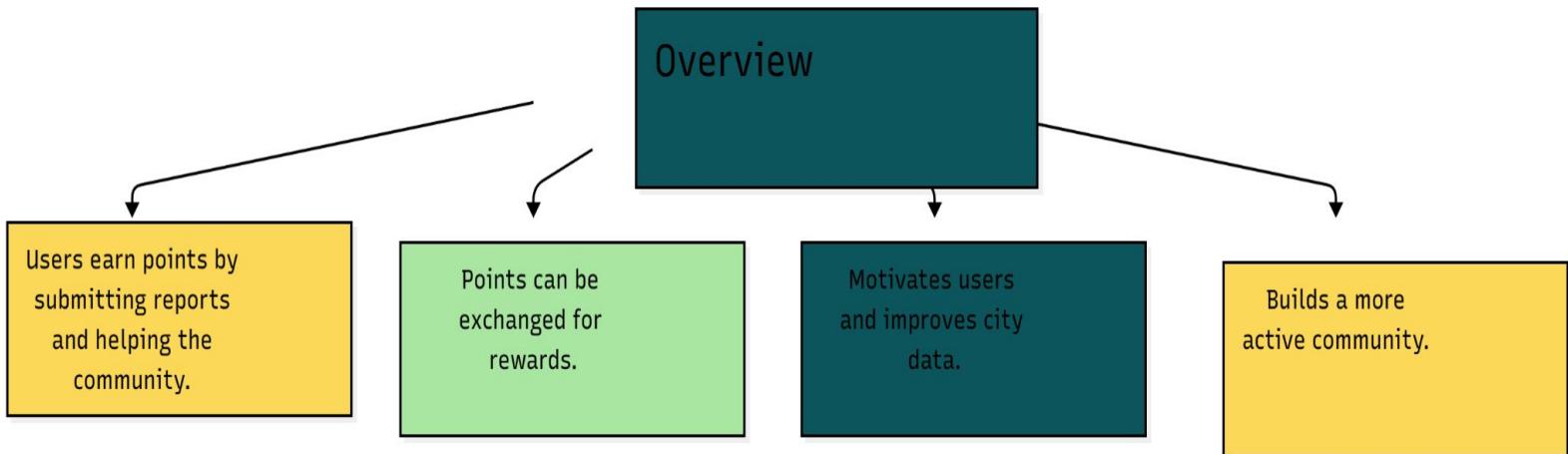


End Point

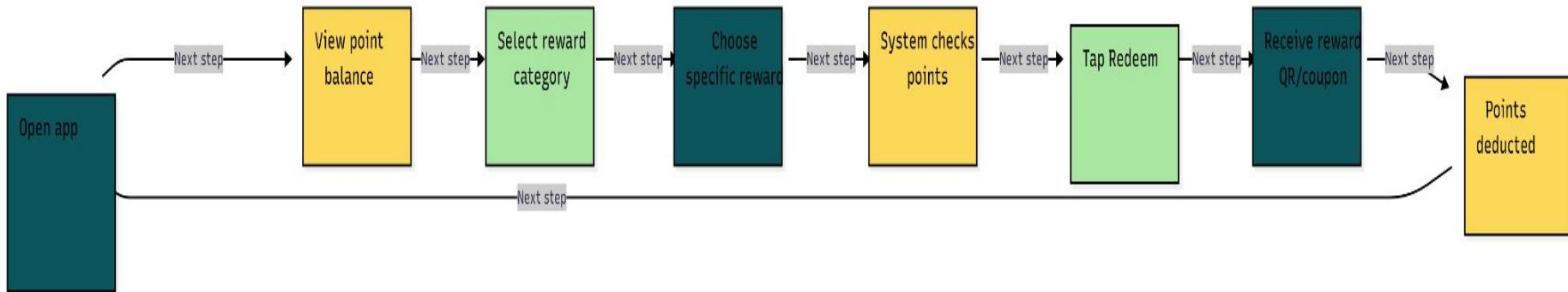
Algorithms - Parking Availability



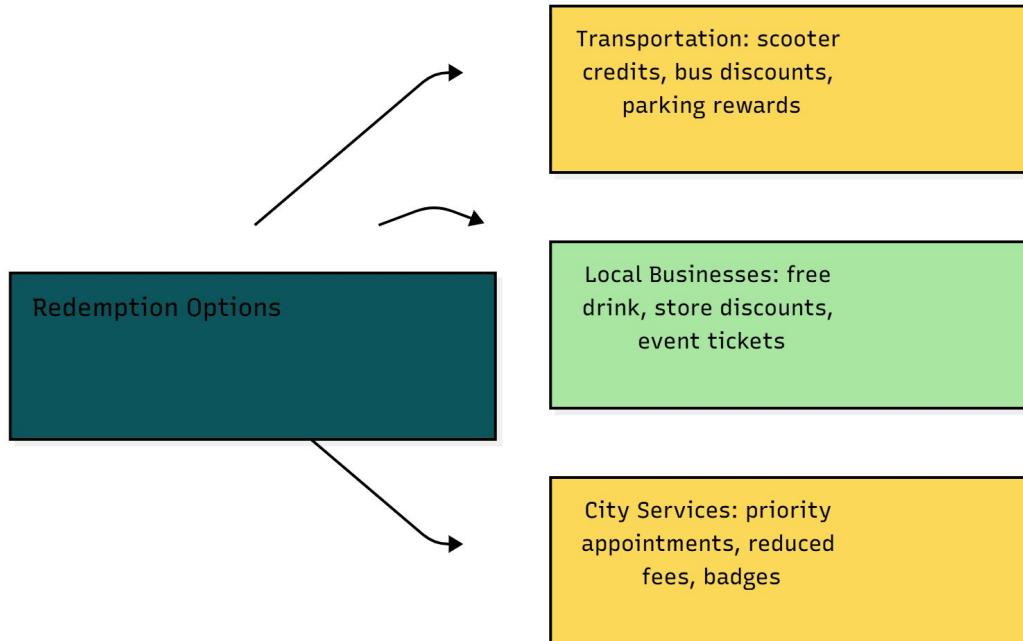
Overview



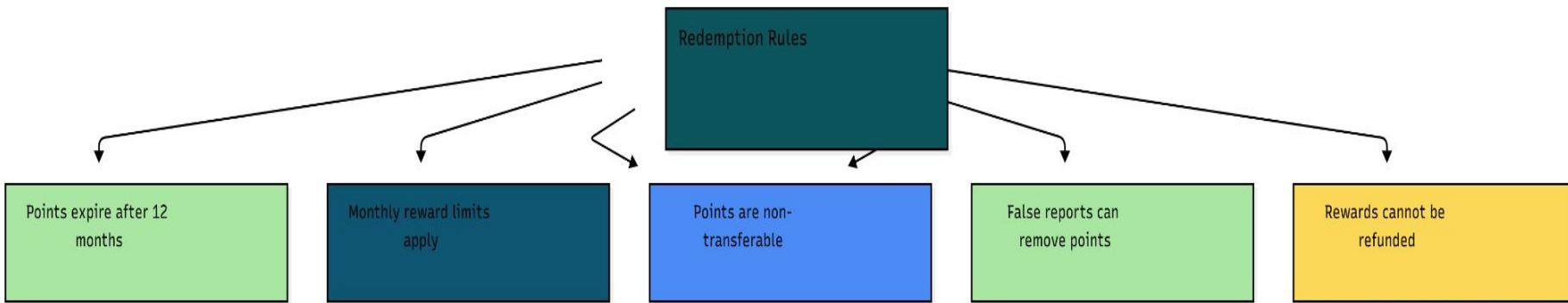
Redemption Flow



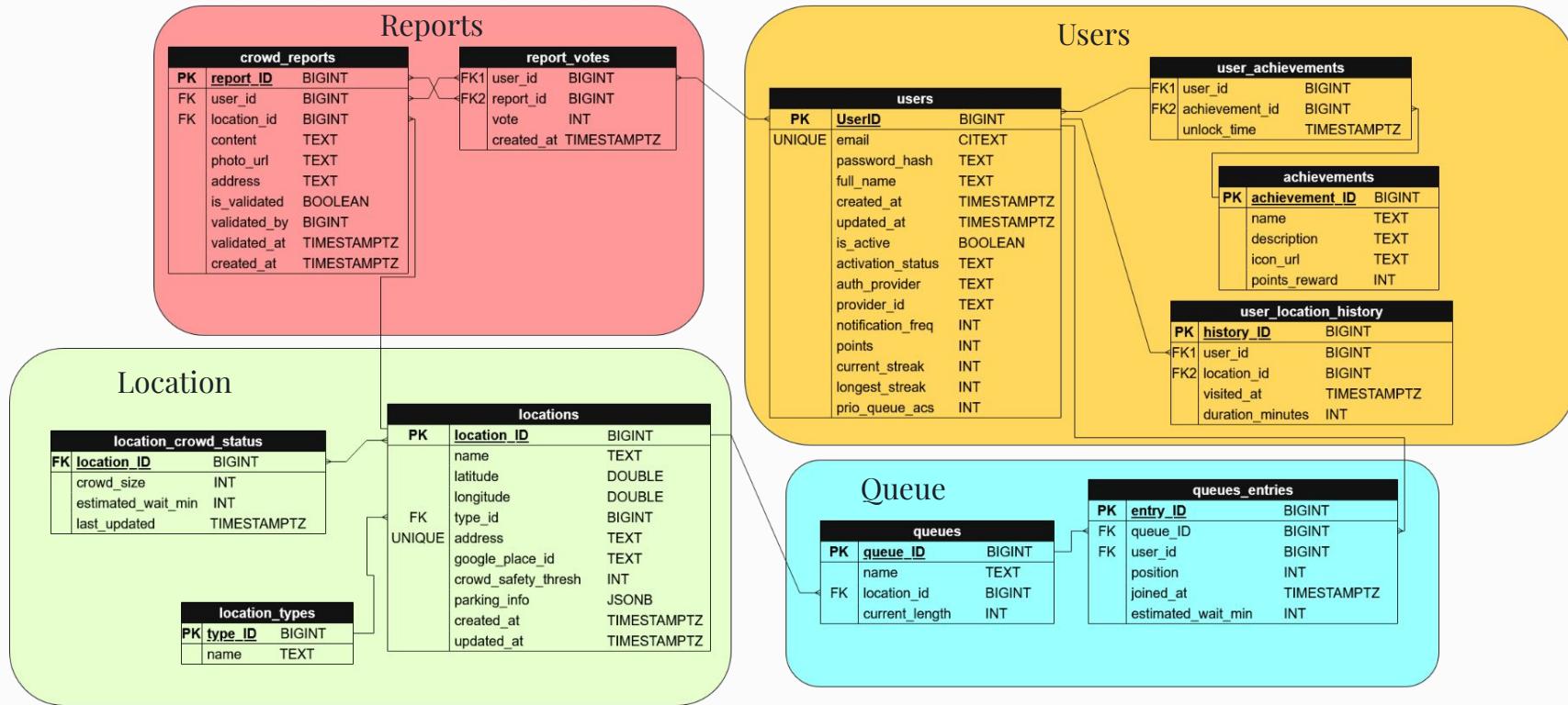
Redemption Options



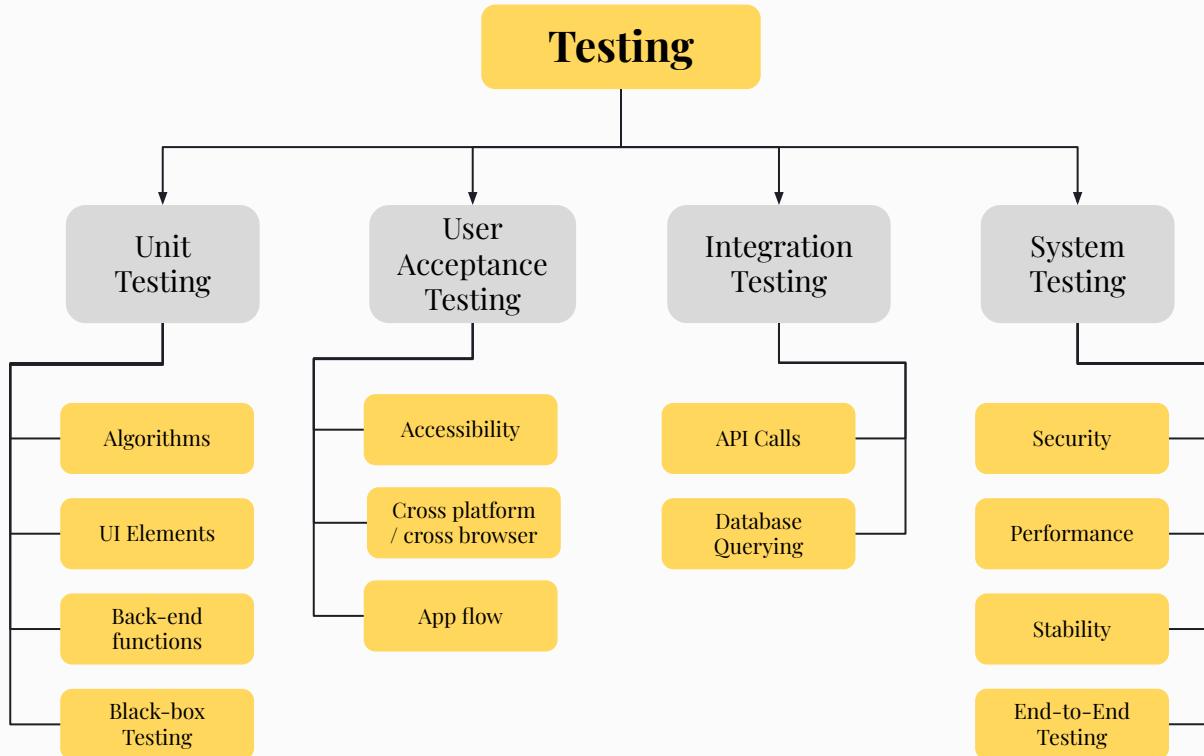
Redemption Rules



Database Schema



WBS - Testing





Sprints 0 - 3

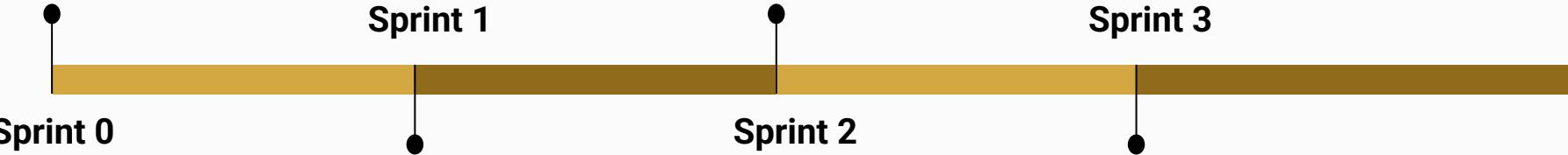
Framework Setup

- Setup GitHub repository
- Setup API routing
- Setup React Native

Data Platform

- Connect to Google Places API and enable heat map view
- Build backend support for community reports & feedback
- Start user profile data

Sprint 1



Sprint 0

Core Prototype

- Build Front end UI
- Implement community forum screen
- Integrate Google Maps API
- Mock data for notifications and analytics dashboard

Sprint 2

Sprint 3

Features

- Build population density analyzer
- Build foot traffic analyzer

Sprints 3 - 6



Feature Expansion

- Integrate alternate Dynamic Routing System
- Display alternate business recommendations
- Implement user incentive



Finalization

- Finalize Smart City
- Finish debugging
- Publish/demo Smart City

System Testing

- Run full unit, integration and system tests
- Debug if necessary



Any questions?
Ask away!

Glossary (Part 1)

IoT (Internet of Things) — systems that combine sensing, computing, communication, and actuation to connect physical/cyber objects

API (Application Programming Interface) — a set of features and rules that lets software interact with other software (a “contract” between programs)

Crowdsourced Data — information gathered from a large group of people through digital platforms and user contributions

Privacy-First Design — building systems so that, by design and by default, only the personal data necessary for a purpose are processed

Community Forum — a location-based platform within the app where residents share updates, report local issues, and engage in discussions about their neighborhoods

Glossary (Part 2)

Open Data — data anyone can freely use, re-use, and redistribute, with at most attribution/share-alike requirements

Predictive AI — using data, statistical algorithms, and ML to estimate the likelihood of future outcomes

Anomaly Detection — identifying data patterns that deviate from expected behavior

Access Control — controls that enforce authorized access to information and system resources in line with policy

Citizen Feedback Loop — a two-way process where institutions act on and report back about citizen input to sustain engagement and trust

References (Part 1)

- [1] Joyce, H. (2025, March 26). Urban overcrowding: A major driver of pollution crises. ShunWaste.
<https://shunwaste.com/article/how-is-overcrowding-in-cities-causing-more-pollution>
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