

# VAST CHALLENGE 2022

PATTERNS OF LIFE IN ENGAGEMENT, OHIO  
DATA VISUALIZATION

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# Challenge Overview

# The Problem

## Challenge Overview

### Urban Planning Challenge

- City of Engagement, Ohio
- Low knowledge of resident behavior
- Need data-driven insights

### Challenge Scope

- Map of urban area
- 15 months of data
- Diverse activity patterns

### Our Mission

- Analyze patterns of daily life
- Identify city characteristics
- Support infrastructure planning
- Improve quality of life

# The Dataset

## Challenge Overview

### Massive Urban Activity Data

- **Duration:** 15 months (March 2022 - May 2023)
- **Participants:** ~1,000 volunteer residents
- **Data Volume:** ~18GB of location and activity logs
- **Sampling Rate:** Every 5 minutes, 24/7

### Data Sources

- **Participant Status:** Location, activity mode, joviality
- **Buildings:** Venue types, locations, polygons
- **Travel Journal:** Trip origins, destinations, purposes
- and more...

**Challenge:** Transform raw data into actionable urban insights

# Research Questions

## Challenge Overview

1. **Question 1:** What are the distinct areas of the city?
2. **Question 2:** Where are the traffic bottlenecks?
3. **Question 3:** How do individual daily routines differ?
4. **Question 4:** How do patterns change over time?

# Our Solution

# Technology Stack

## Our Solution

### Frontend

- React + TypeScript + Vite
- D3.js for interactive visualizations

### Backend

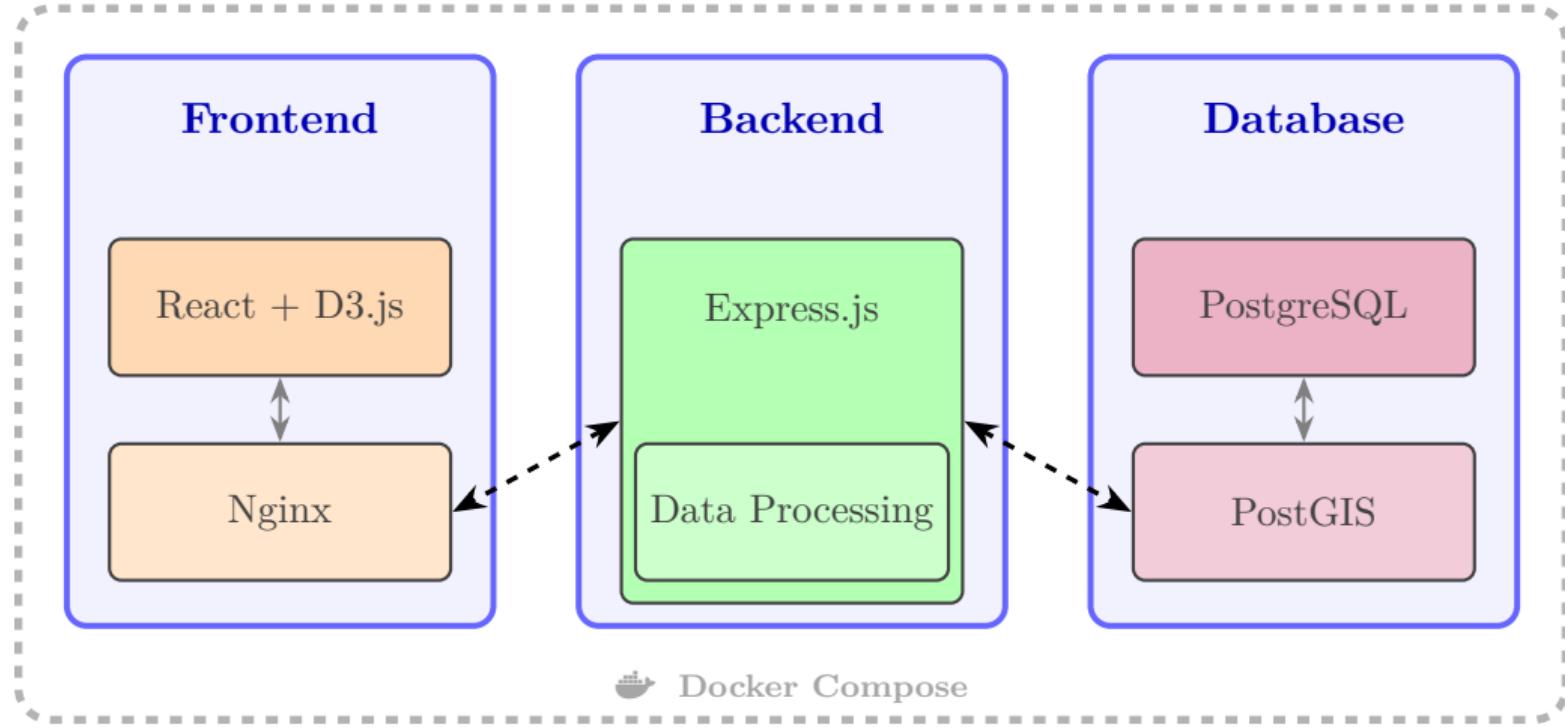
- Node.js + Express
- PostgreSQL with PostGIS

### Deployment

- Docker containerization for all services
- Nginx reverse proxy for API routing
- Optimized database with materialized views

# Architecture Overview

## Our Solution

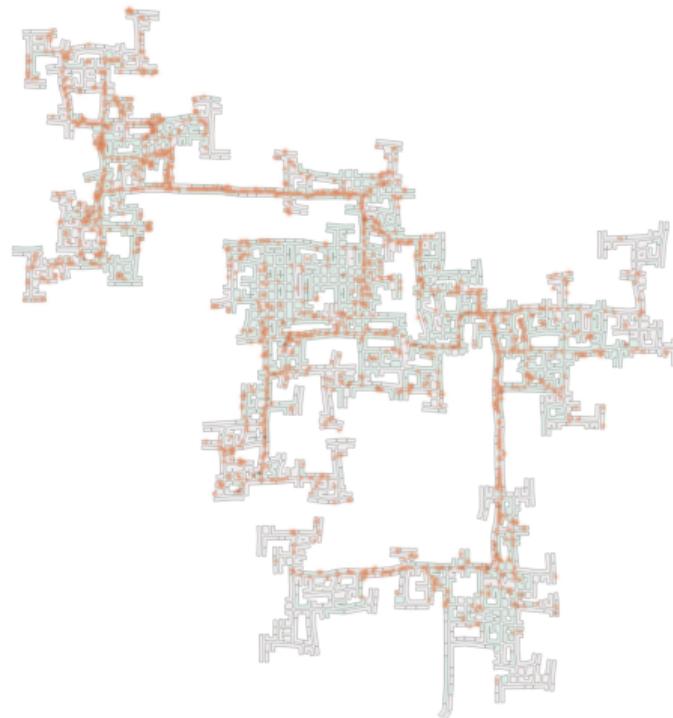


# Visualization Techniques

How can we identify  
activity hotspots  
across the city?

# Visualization 1: Spatial Heatmap

## Visualization Techniques



# Spatial Heatmap - Purpose & Features

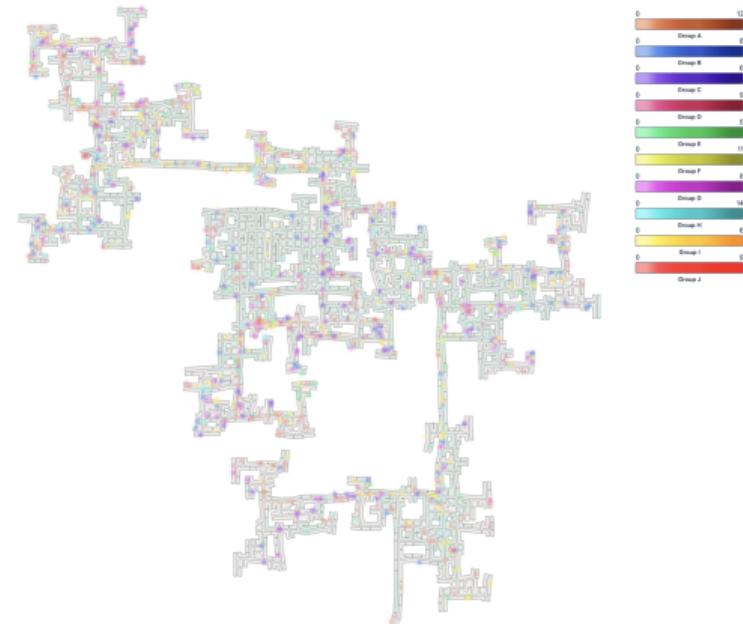
## Visualization Techniques

### Purpose

- Visualize activity density across the city
- Identify busy areas and hotspots
- Track temporal patterns

### Key Features

- Grid-based aggregation
- Time slider (hourly/daily/weekly)
- Interest Group filtering
- Building polygon overlay
- Interactive zoom and pan



# Spatial Heatmap - Evaluation

## Visualization Techniques

### Pros

- Intuitive geographic representation
- Reveals spatial patterns at a glance
- Flexible temporal exploration
- Supports multiple aggregation levels
- Combines well with building overlays
- Effective for identifying hotspots

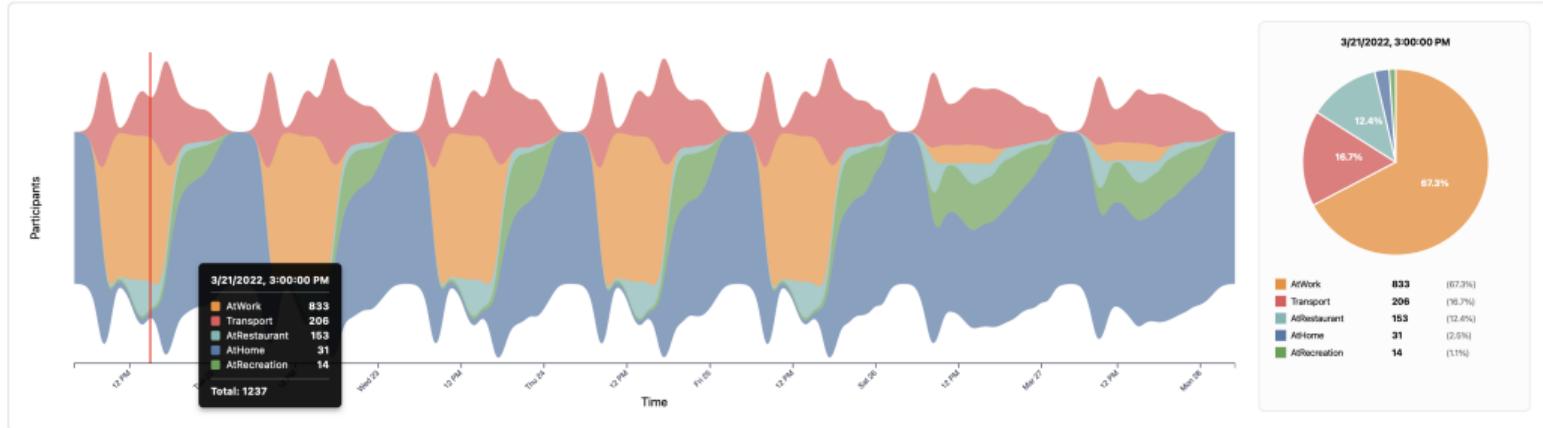
### Cons

- Grid resolution affects interpretation
- Can obscure individual movements
- Performance challenges with high granularity
- Requires spatial context to interpret
- May hide temporal variations within aggregates

# How do activity patterns evolve over time?

# Visualization 2: Activity Streamgraph

## Visualization Techniques



# Activity Streamgraph - Purpose & Features

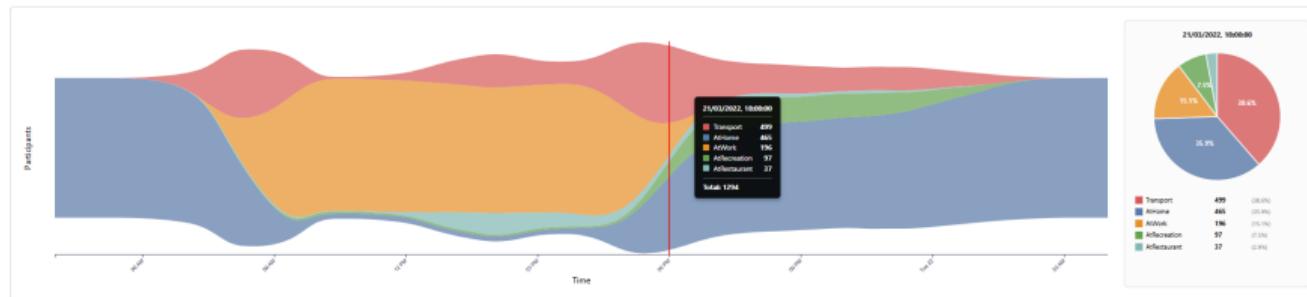
## Visualization Techniques

### Purpose

- Show activity percentage over time
- Reveal behavioral shifts
- Track participation trends

### Key Features

- Stacked area chart with smooth interpolation
- Multiple activity types (work, social, etc.)
- Temporal filtering capabilities
- Color-coded activity categories



# Activity Streamgraph - Evaluation

## Visualization Techniques

### Pros

- Shows composition and trends simultaneously
- Aesthetically appealing and engaging
- Reveals both macro and micro patterns
- Effective for time-series comparison
- Handles multiple categories elegantly

### Cons

- Difficult to read precise values
- Middle layers harder to interpret
- Can be overwhelming with too many categories
- Requires color differentiation
- Temporal aggregation may hide short-term spikes

How do individual  
daily routines differ?

# Visualization 3: Activity Calendar

## Visualization Techniques



# Activity Calendar - Purpose & Features

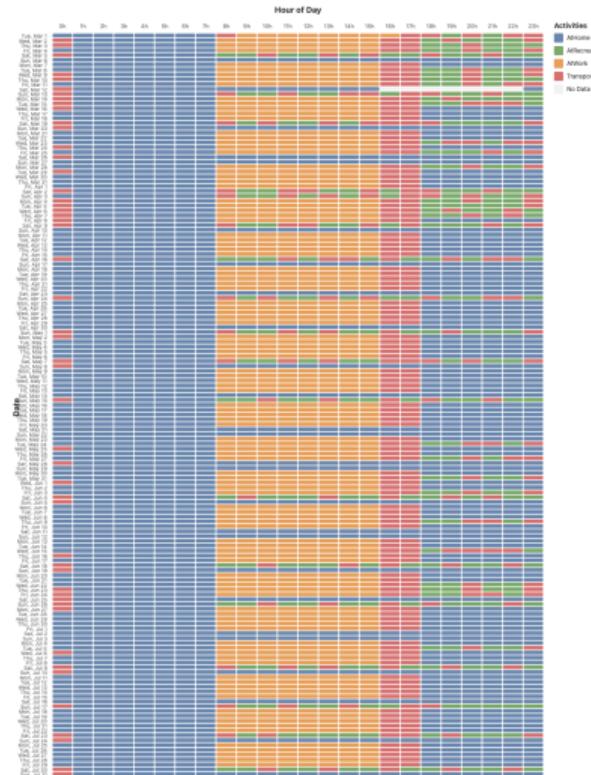
## Visualization Techniques

### Purpose

- Analyze individual daily routines
- Identify patterns and variations
- Compare participants side-by-side

### Key Features

- Days × Hours matrix
- Color-coded by activity type
- One month visible at a glance
- Scrollable timeline for full 15-month period



# Activity Calendar - Evaluation

## Visualization Techniques

### Pros

- Compact representation of long periods
- Patterns emerge naturally (work hours, weekends)
- Easy to spot anomalies and changes
- Effective for individual analysis
- Supports direct comparison
- Intuitive time-of-day interpretation

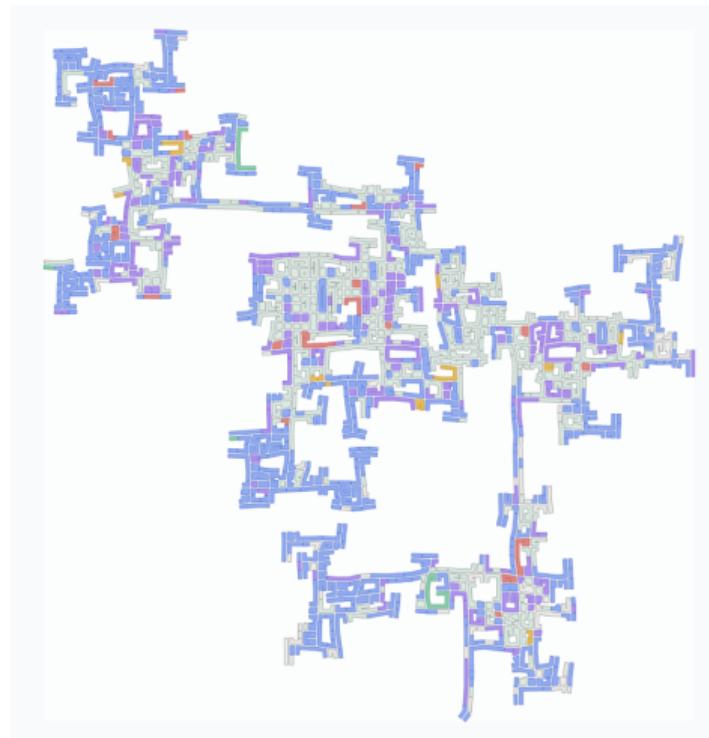
### Cons

- Limited to individual
- Requires significant screen space
- Can be cluttered with too many activity types
- Doesn't show spatial information
- Difficult to see population-level trends

How can we understand  
urban infrastructure context?

# Visualization 4: Building Polygons Overlay

Visualization Techniques



# Building Polygons - Purpose & Features

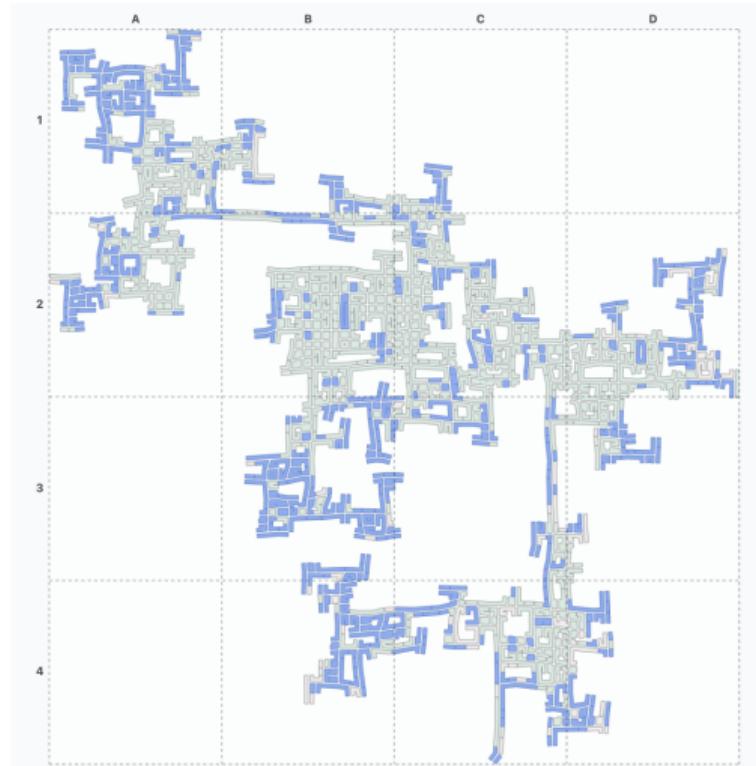
## Visualization Techniques

### Purpose

- Provide spatial context for activity patterns
- Link activities to physical infrastructure
- Identify functional zones

### Key Features

- Filter by building type
- Integrated with heatmap for layered context
- Color-coded by function



# Building Polygons - Evaluation

## Visualization Techniques

### Pros

- Connects activity to infrastructure
- Helps explain spatial patterns
- Supports urban planning decisions
- Reveals functional zoning
- Combines well with other visualizations

### Cons

- Can clutter the map
- Requires accurate building data
- May obscure underlying heatmap
- Static representation of dynamic spaces

# How can we compare individual lifestyles?

# Visualization 5: Participant Comparison

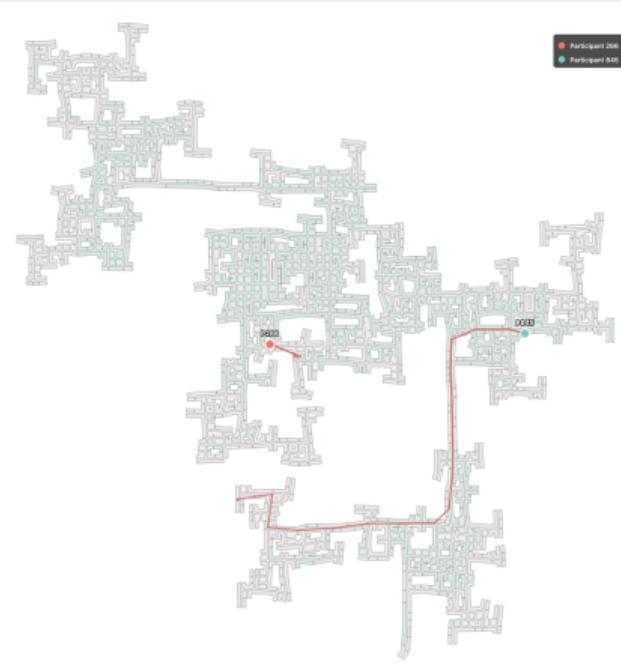
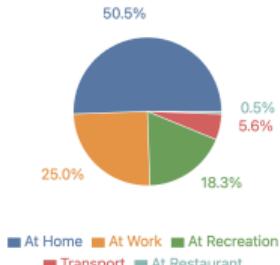
## Visualization Techniques

**Participant 266**

Age: 32 years Household: 3 people  
 Children: Yes Education: Graduate Degree  
 Interest Group: F Joviality: 97.3%

Distance Travelled:  
**158.75 units**

**Activity Distribution**

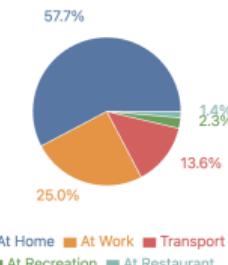


**Participant 845**

Age: 40 years Household: 2 people  
 Children: No Education: High School/College  
 Interest Group: G Joviality: 23.5%

Distance Travelled:  
**501.16 units**

**Activity Distribution**



# Participant Comparison - Purpose & Features

## Visualization Techniques

### Purpose

- Compare individual behavioral patterns
- Identify contrasting lifestyles
- Support hypothesis about proximity and well-being

### Key Features

- Daily travel distance
- Average joviality score
- Social activity percentage
- Work patterns
- Demographics

# Participant Comparison - Evaluation

## Visualization Techniques

### Pros

- Direct quantitative comparison
- Reveals individual differences
- Supports finding extreme cases
- Evidence-based storytelling

### Cons

- Limited to 2 participants at once
- Doesn't show population distribution
- Risk of cherry-picking examples
- Requires manual selection

# Data Aggregation Strategy

## Visualization Techniques

### Spatial Aggregation

- Grid-based binning (configurable cell size)
- GROUP BY FLOOR(lat/cell\_size), FLOOR(lng/cell\_size)
- Enables density calculation and hotspot identification

### Temporal Aggregation

- Hourly: Daily patterns and rush hours
- Daily/Weekly: Routine identification
- Monthly: Long-term trends

### Activity Mode Filtering

- Work, Home, Restaurant, Pub, Recreation, School, Shopping
- Supports focused analysis by activity type
- Reveals functional zones in the city

# Reflection

# Strengths & Limitations

Reflection

## Strengths

- Interactive exploration
- Multi-scale analysis
- Evidence-based insights
- Scalable architecture
- Accessible visualizations

## Future Enhancements

- Flow diagrams
- Speed heatmaps
- Predictive modeling
- Real-time integration

## Limitations

- Sample representativeness
- No causal analysis
- Performance constraints
- Learning curve

## Applicability

- Urban planning
- Transportation analysis
- Behavioral studies
- Decision support

## Key Takeaways

Reflection

1. PostGIS essential for spatial data
2. Iterative design reveals insights
3. Performance matters for 18GB datasets
4. Context drives interpretation
5. Visual analytics enables discovery

# Conclusion

# Summary: Challenge Accomplished

Conclusion

## Answered All Four Questions

1. **City Areas:** 3 distinct zones identified
2. **Bottlenecks:** 3 critical congestion points
3. **Routines:** 6× difference in commute impacts life
4. **Changes:** 10 temporal patterns documented

Delivered actionable urban planning insights  
through interactive visual analytics

# Thank You!

Questions?

Alberto Finardi   Tommaso Crippa   Tom Gave