CONTEXT-AWARE GEOGRAPHIC INFORMATION SYSTEMS FOR REAL-TIME SECURITY EVENT FORECASTING

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OUTLINE

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2. Background
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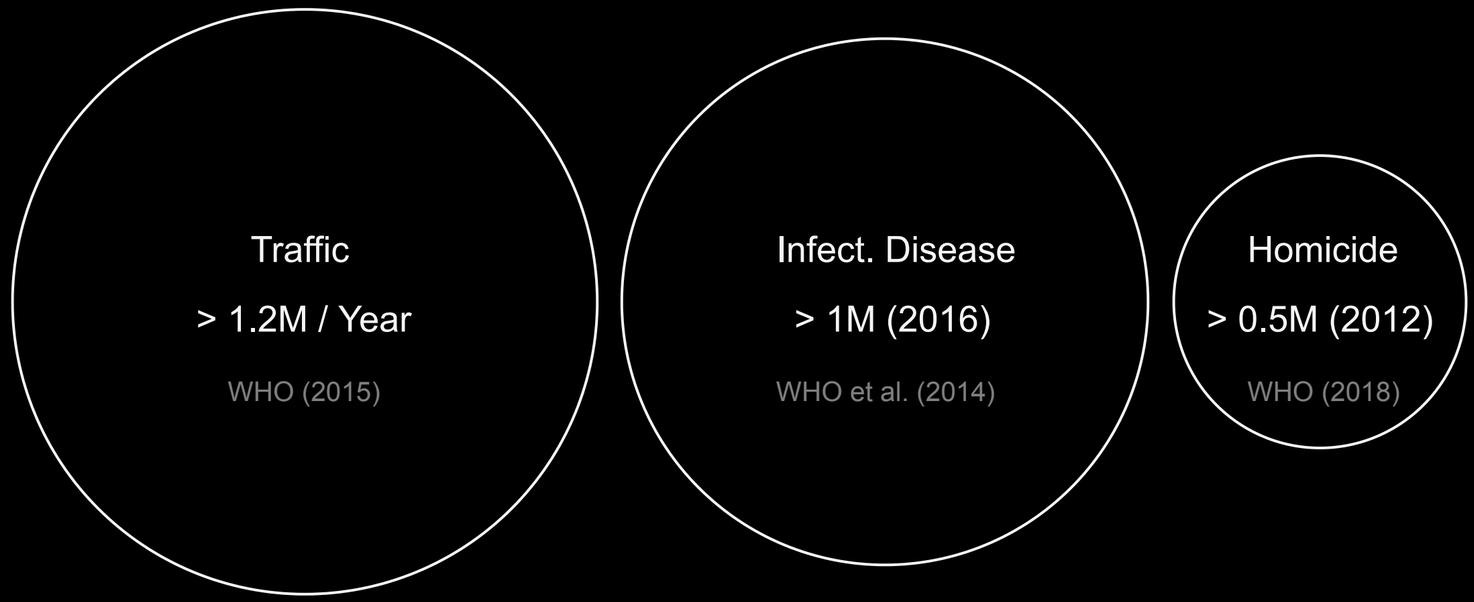
1. INTRODUCTION

OVER 40 MILLION DEATHS PER YEAR



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SECURITY EVENTS

- Disrupt society and daily life
- Economic burden
- Loss of life

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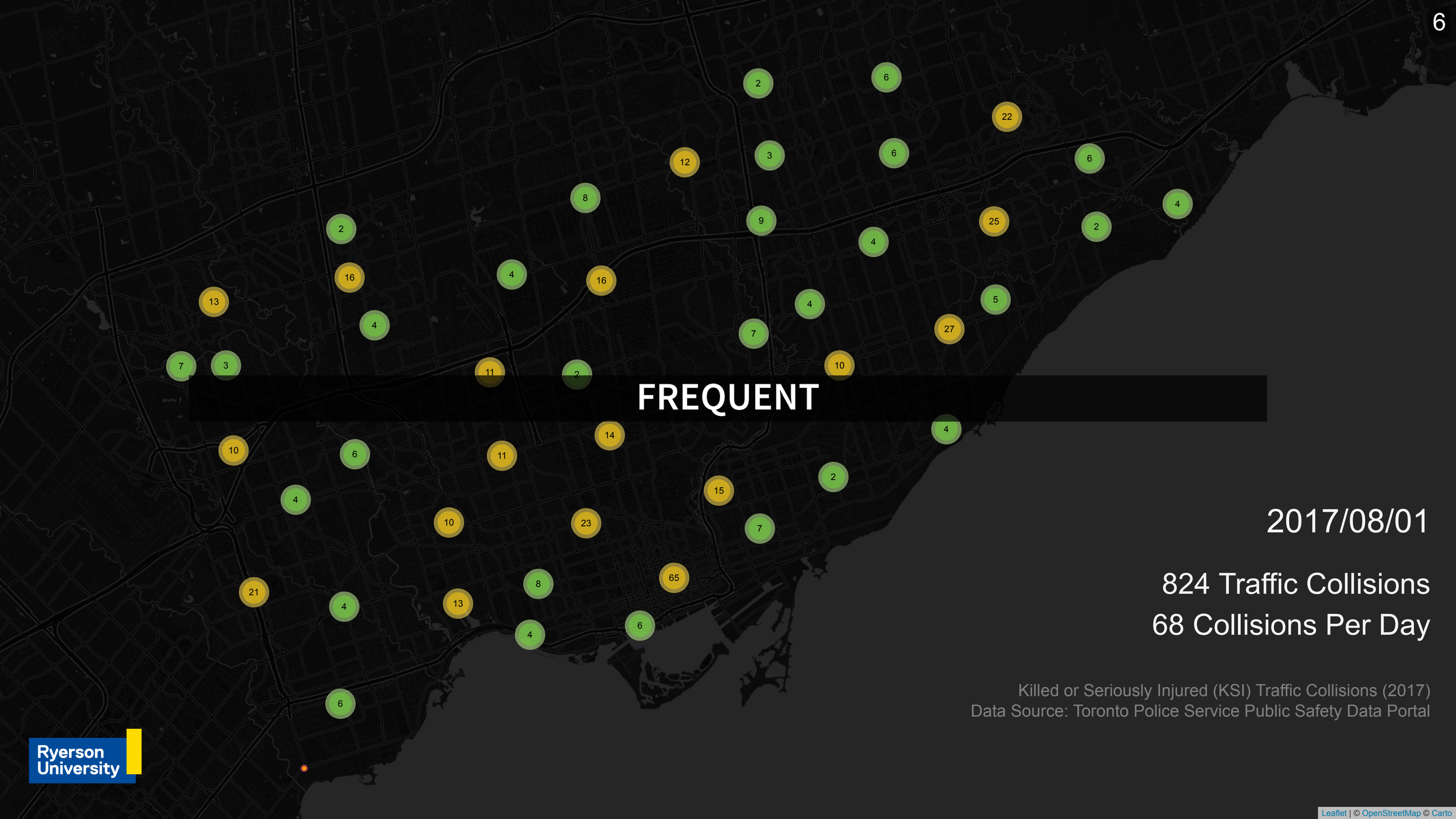
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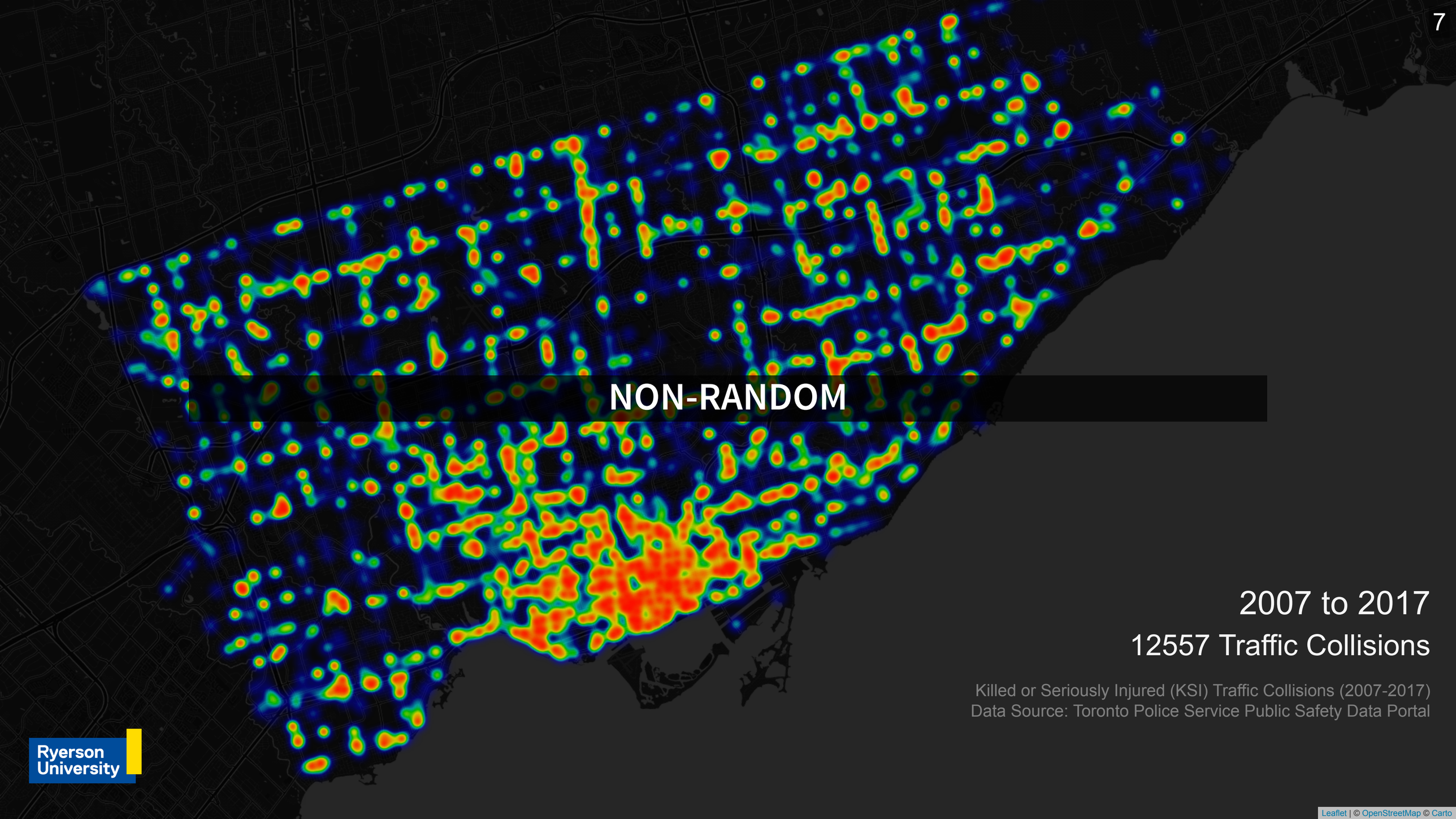
2017/08/01
824 Traffic Collisions
68 Collisions Per Day
Killed or Seriously Injured (KSI) Traffic Collisions (2017)
Data Source: Toronto Police Service Public Safety Data Portal
Leaflet | © OpenStreetMap © Carto



2007 to 2017

12557 Traffic Collisions

Killed or Seriously Injured (KSI) Traffic Collisions (2007-2017)
Data Source: Toronto Police Service Public Safety Data Portal

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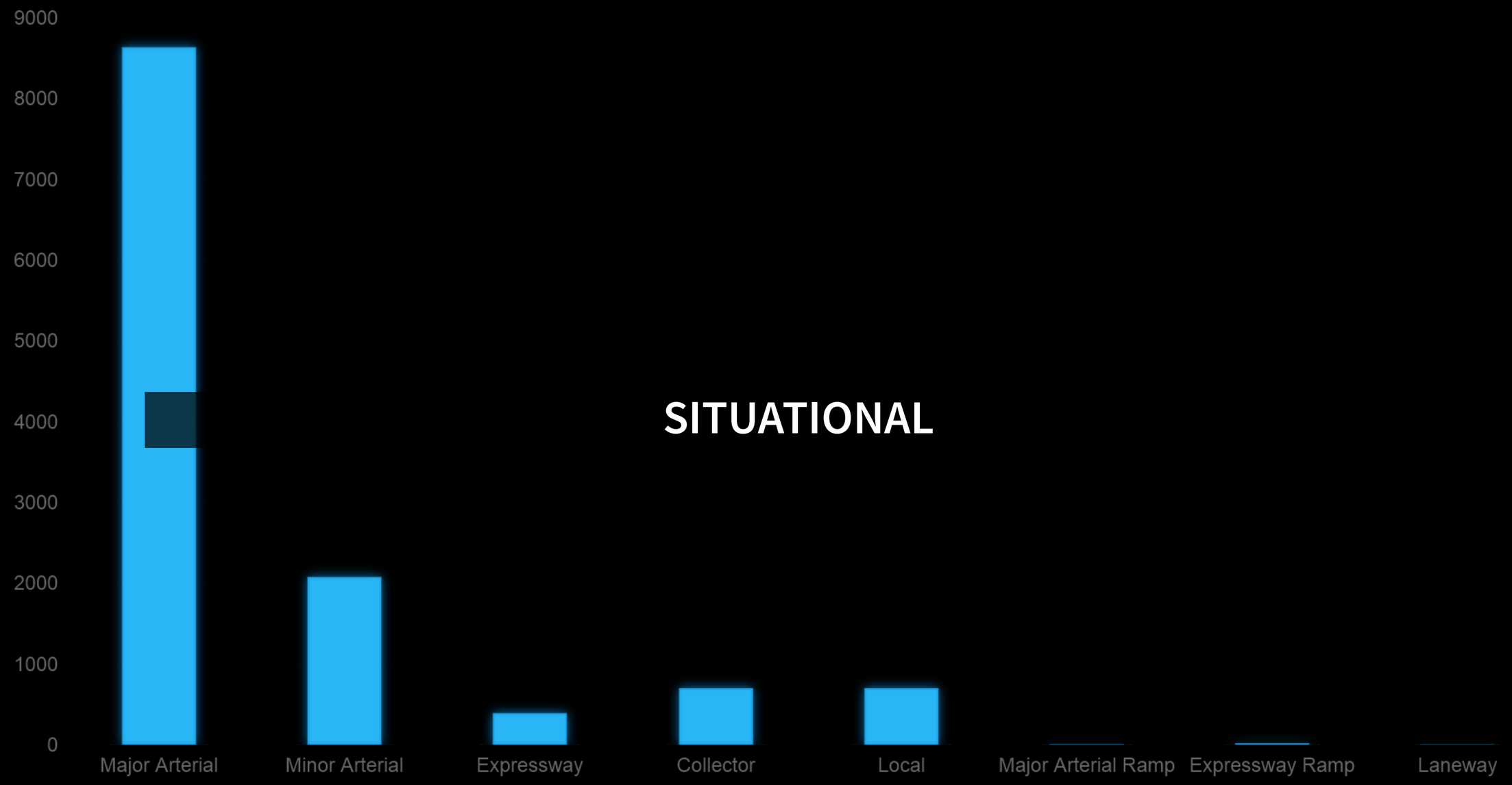

SITUATIONAL

Killed or Seriously Injured (KSI) Traffic Collisions (2007-2017) from Toronto Police Service Public Safety Data Portal

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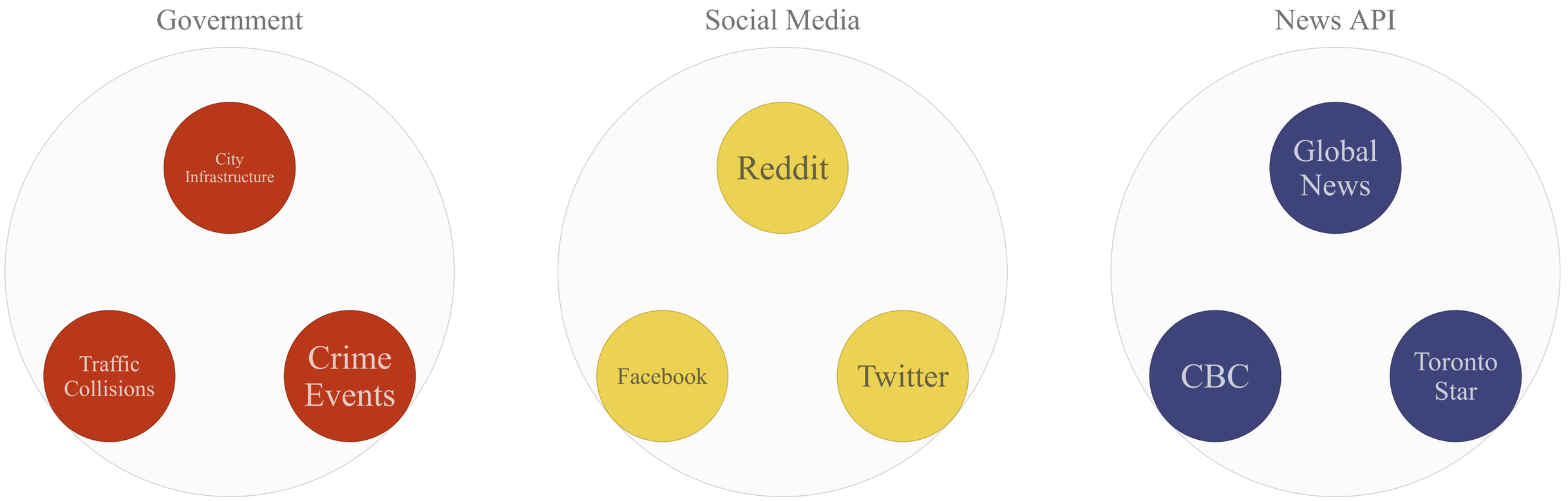
FORECASTING SECURITY EVENTS

CONTEXT

- Situation surrounding event
- What event and when will it occur?
- How probable is the event given the context?

CONTEXTUAL DATA



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GEOGRAPHIC INFORMATION SYSTEMS (GIS)

- Set of hardware and software
- Store, manage, and present spatial data
- Information extraction from data

CONTEXT-AWARE GIS

- Enable GIS to use contextual data
- Adapt and react to context
- Improve security event forecasts

RESEARCH OBJECTIVES

1. Develop methods/models for context-aware GIS
2. Conduct experiments with context-aware GIS

OBJECTIVE 1 COMPONENTS

1. **Data Source**: contextual data extraction
2. **Database**: store and query 1.
3. **Data**: process and manipulate 2.
4. **Model**: forecast security events using 3.
5. **Visualization**: present outputs of 4.

OBJECTIVE 2 CRITERIA

1. **Relevant**: involves security event forecasting
2. **Practical**: uses non-artificial data
3. **Measurable**: uses qualitative or quantitative forecasting model assessments
4. **Reproducible**: results can be produced again given the same data

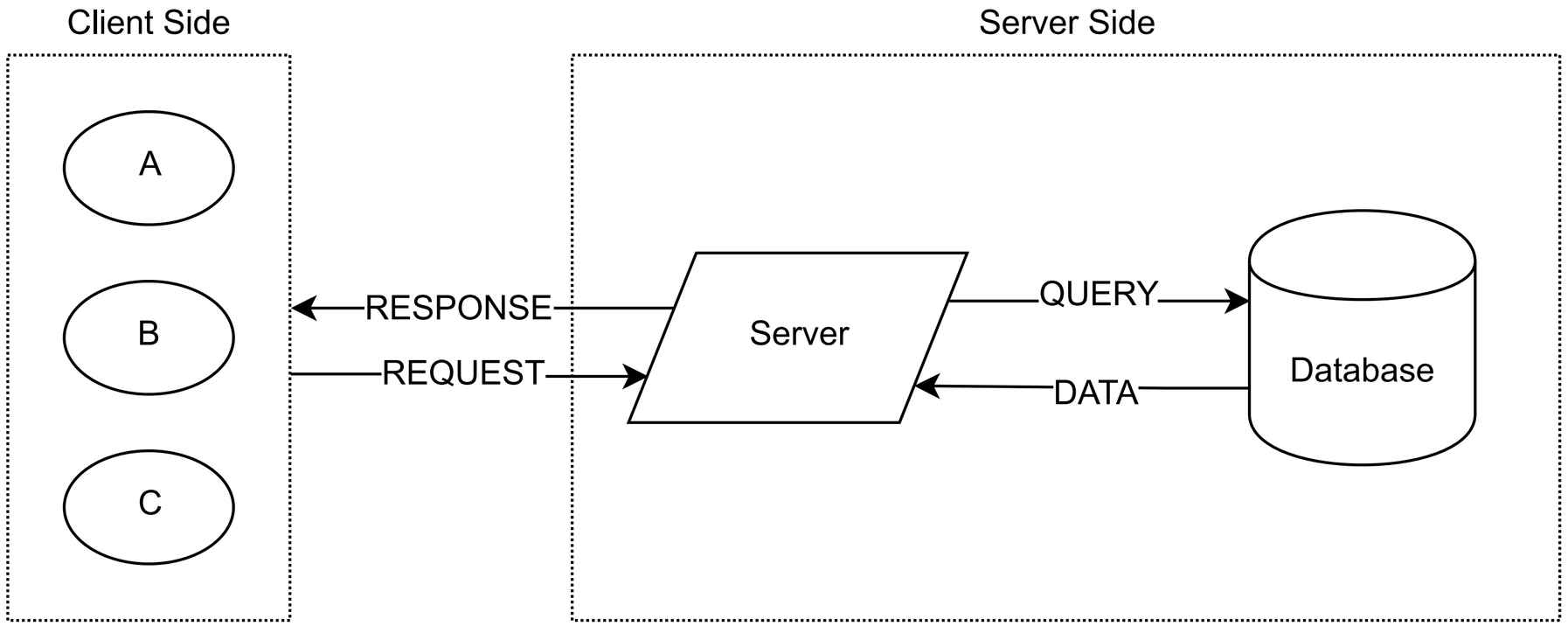
CONTRIBUTIONS

1. Conceptual framework for context-aware GIS
2. Software framework for context-aware GIS
3. Software architecture for context-aware GIS
4. Methods for forecasting security events

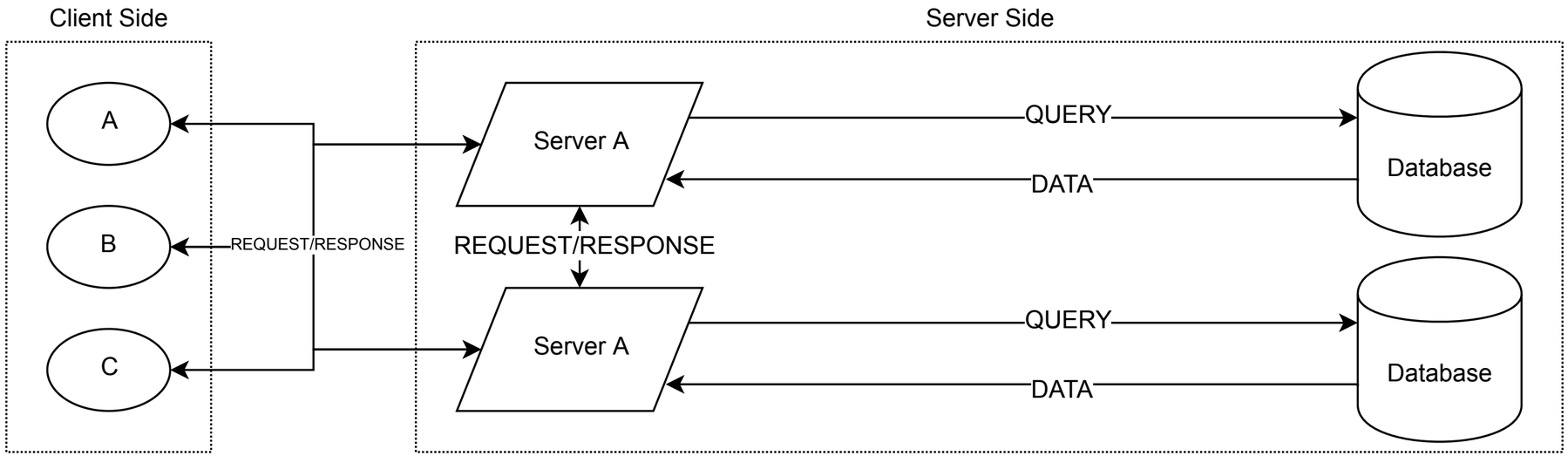
2. BACKGROUND

WEB GIS AND ARCHITECTURES

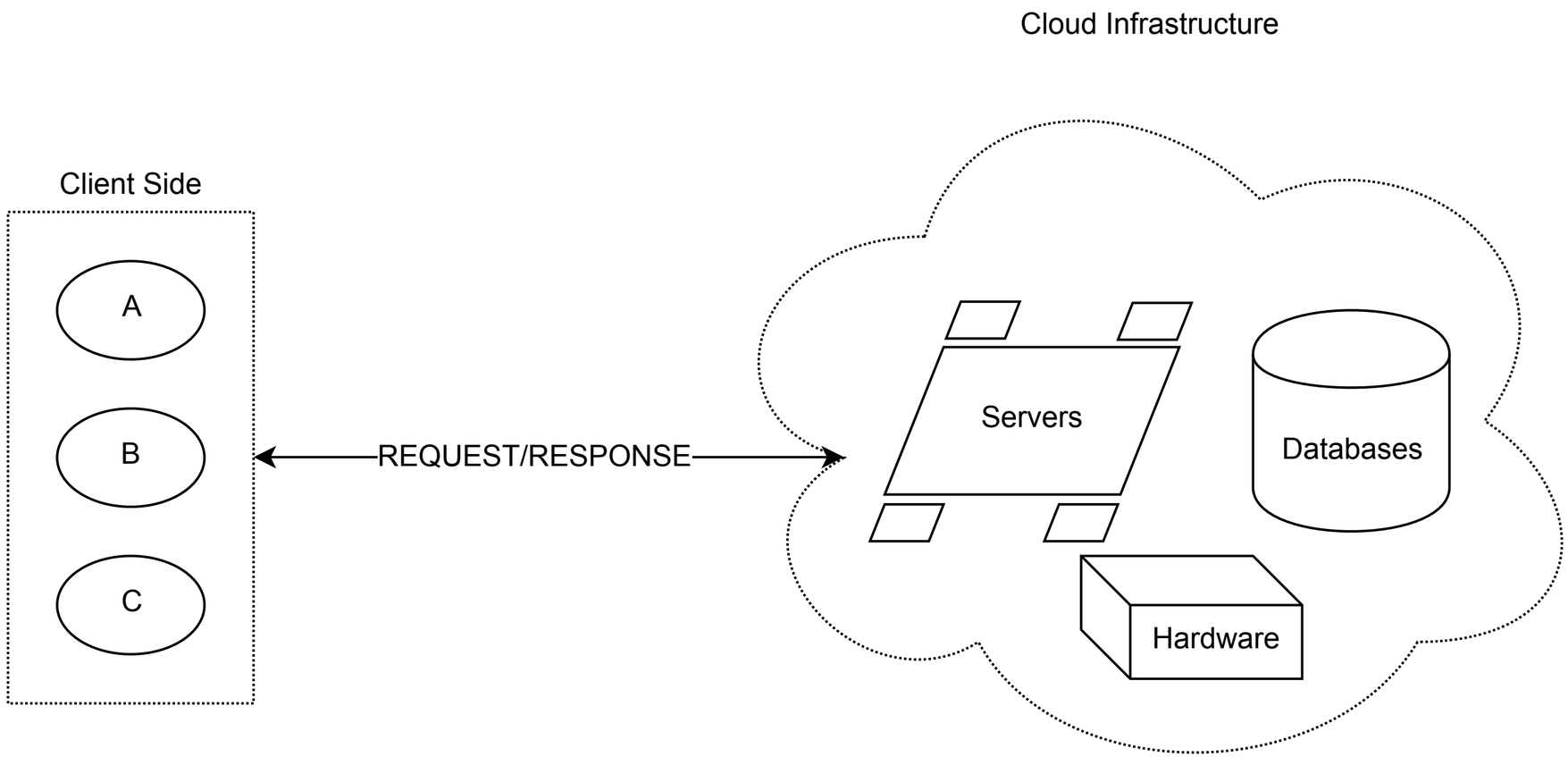
CLIENT SERVER



SERVICE-ORIENTED



CLOUD-BASED


Cloud Infrastructure
Client Side
A
B
C
REQUEST/RESPONSE
Servers
Databases
Hardware

CONTEXT-AWARE SYSTEMS

"A system is context-aware if it uses context to provide relevant information and or services to the user, where relevancy depends on the user's task."

Ref: Dey (2001)

NATURAL LANGUAGE PROCESSING (NLP)

- Extracting useful data from text
- Structure contextual data
- N-grams, word distributions

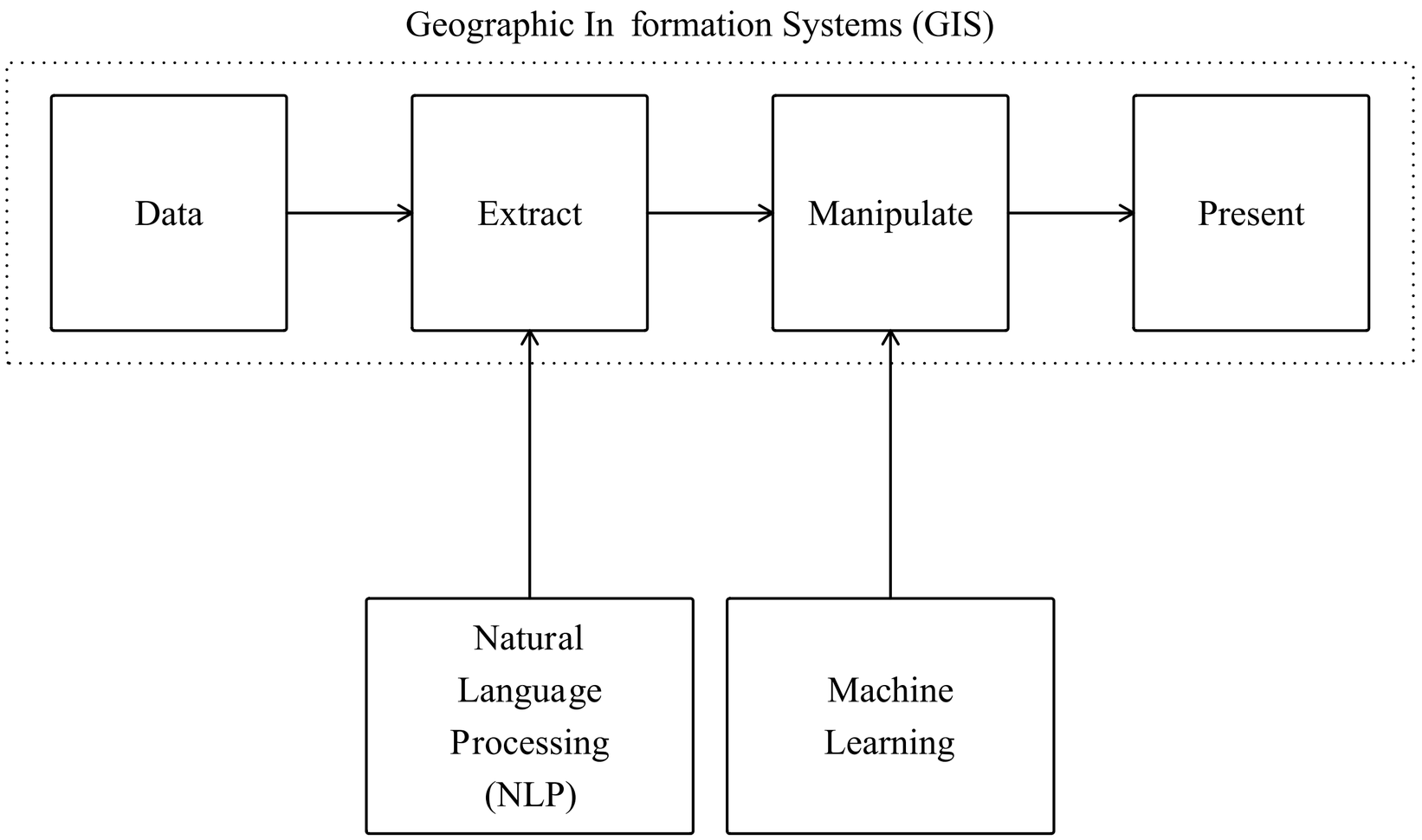
MACHINE LEARNING

- Discover and apply patterns from data
- **Supervised**: predict from known values
- **Clustering**: grouping similar data
- **Incremental Learning**: continuous model updates

PROBLEM STATEMENT

- **Real-time GIS**: large continuous spatial data
- **Event-driven Architecture**: react to events
- **Context-aware GIS**: react and adapt to context

CONTEXT-AWARE GIS INTEGRATION



3. METHODS

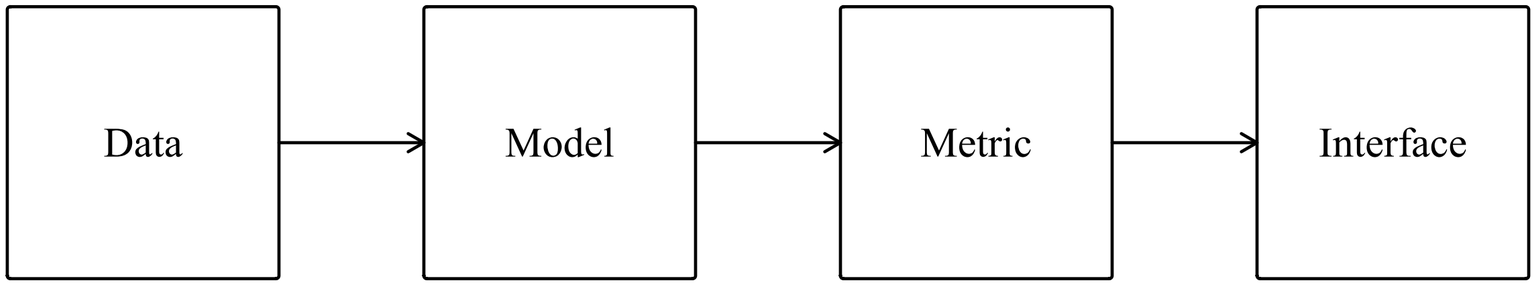
SOFTWARE FRAMEWORKS

- Produce applications in a standardized way
- Component interaction
- Reusable, consistent, comparable

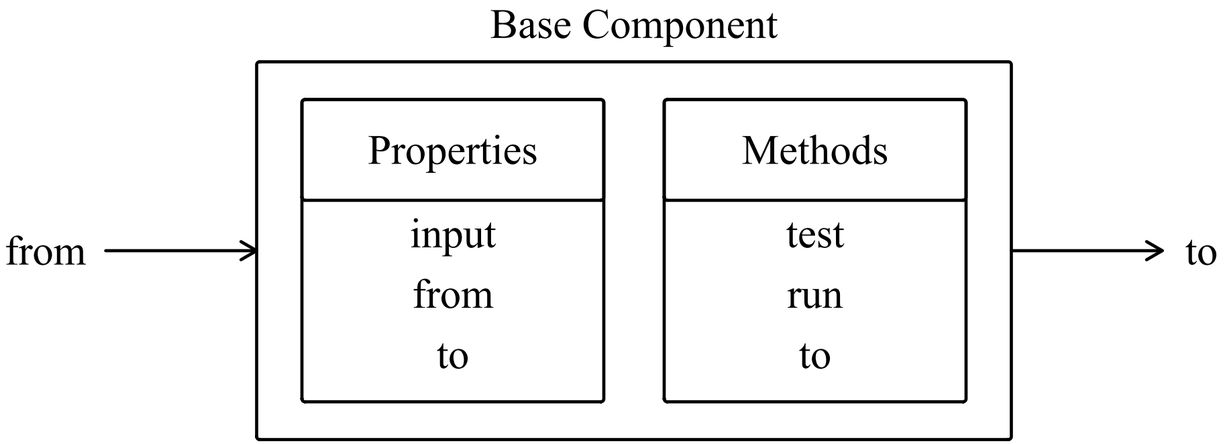
SOFTWARE DEVELOPMENT

- Object-oriented programming
- Test-driven approach
- Prototyping

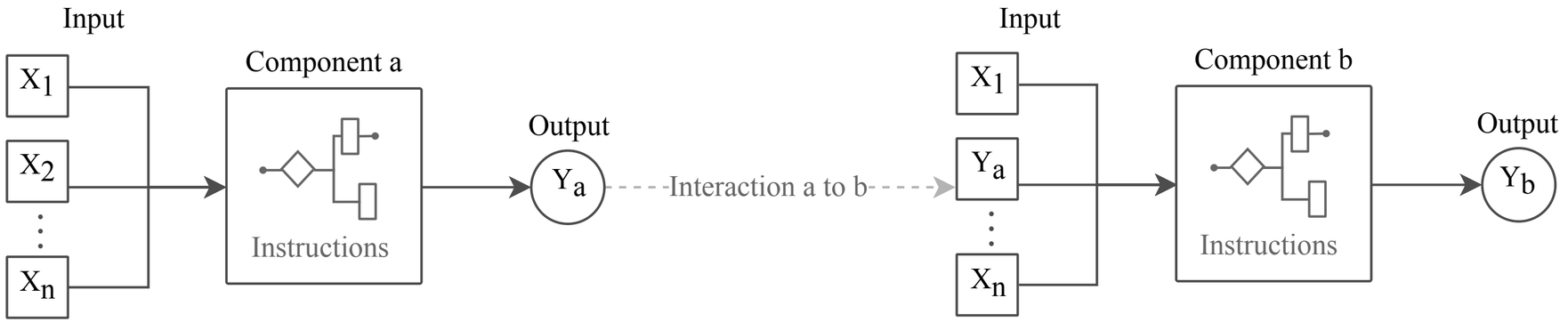
SOFTWARE COMPONENTS



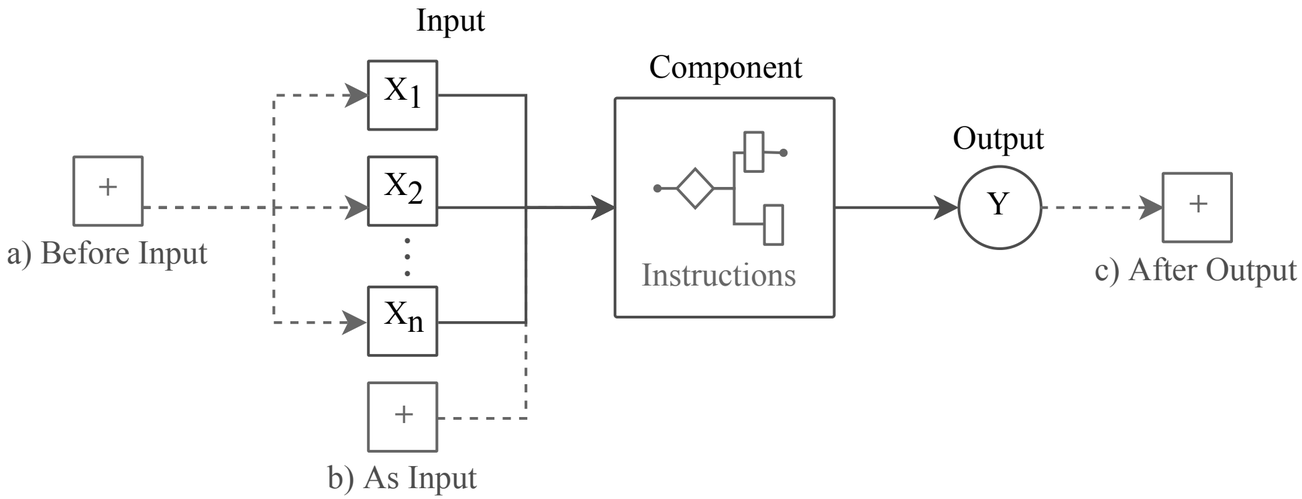
BASE COMPONENT



COMPONENT INTERACTION



COMPONENT EXTENSION



DATA COMPONENT

- Extract, store, process data
- Location, time, and numbers
- NLP methods for text

NLP WORD DISTRIBUTION

Given `a a b c c d`:

word	count
a	2
b	1
c	2
d	1

MODEL COMPONENT

- Statistics and machine learning
- **Supervised classification**: linear regression, naive bayes, decision trees
- **Clustering**: k-means, mixture models
- **Incremental Learning**: neural networks

METRIC COMPONENT

Metric	Description
Accuracy	Proportion of correct values
Precision	Correct values using model categories
Recall	Correct values using actual categories
F1 Score	Accuracy using precision and recall
RMSE	Scaled diff. of actual and model values

INTERFACE COMPONENT

- Map
- Dashboard

freeboard

LOAD FREEBOARD

SAVE FREEBOARD

ADD PANE

DATASOURCES

Name	Last Updated
wanderdrone	12:09:11 PM

ADD

INFORMATION

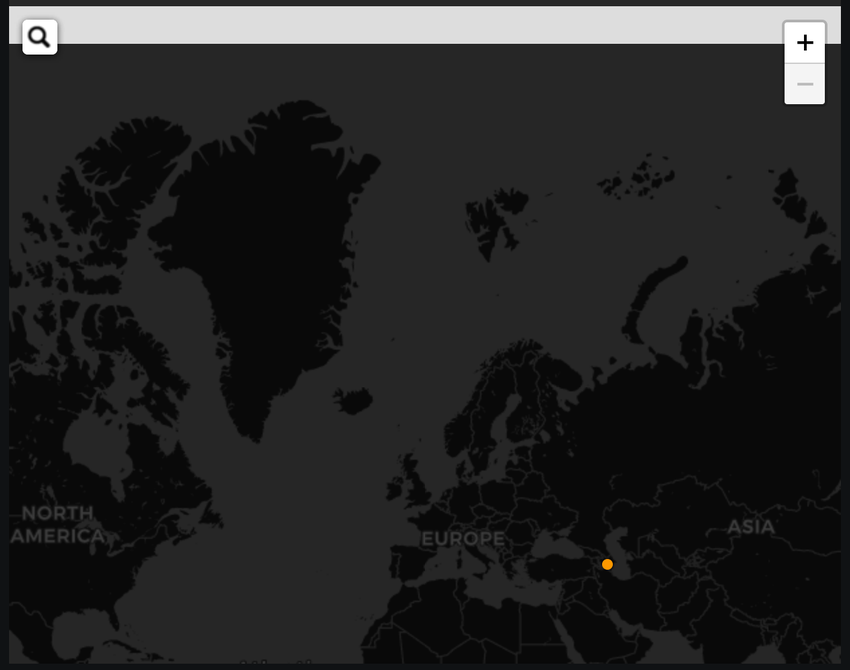
Dashboard: Freeboard
Plugin: freeboard-leaflet-realtime
Author: Richard Wen

POSITION

Longitude
52.575 degrees

Latitude
37.660 degrees

DEMO



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POTENTIAL EXPERIMENTS

1. Traffic Collision Forecasting
2. Crime Event Forecasting
3. Health Symptom Monitoring and Forecasting

TRAFFIC COLLISION AND CRIME EVENT FORECASTING

- Data: social media, open data, government
- Methods: NLP, supervised learning
- Outcomes: web app and models for forecasts

HEALTH SYMPTOM MONITORING AND FORECASTING

- Data: social media, open data, government
- Methods: NLP, supervised learning, clustering
- Outcomes: web app and models for monitoring and forecasts

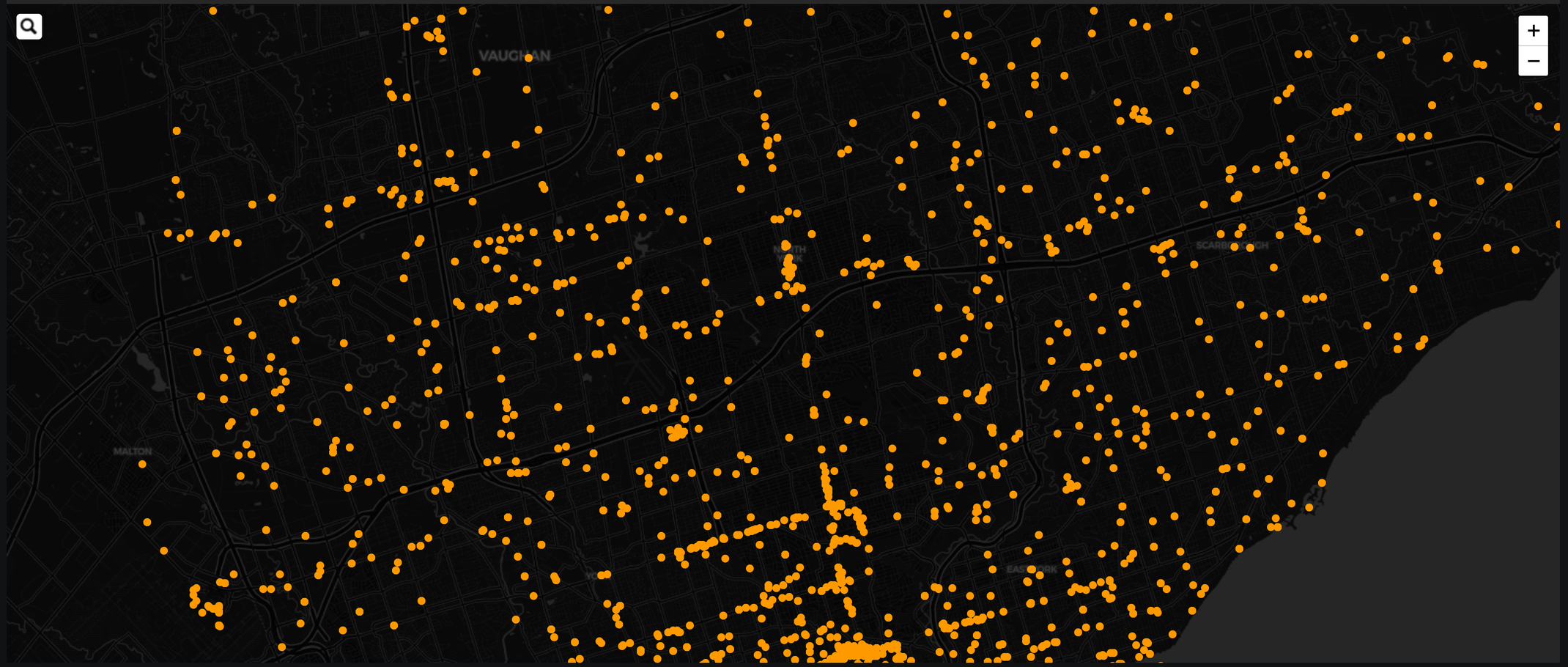
4. PRELIMINARY RESULTS

SOFTWARE

- Developed Node.js packages for Twitter data, MongoDB, and PostgreSQL
- Explored potential software for framework components
- Hbase, GeoMesa, scikit-learn, Apache Kafka, D3.js

INFORMATION	TOTAL	GEO-LOCATED	GEO-LOCATED / TOTAL	MAP LIMIT
Date 8/28/2018 Time 12:09:45 PM	tweets	tweets	tweets	Current 10000 Max

TWEETS IN TORONTO, ON



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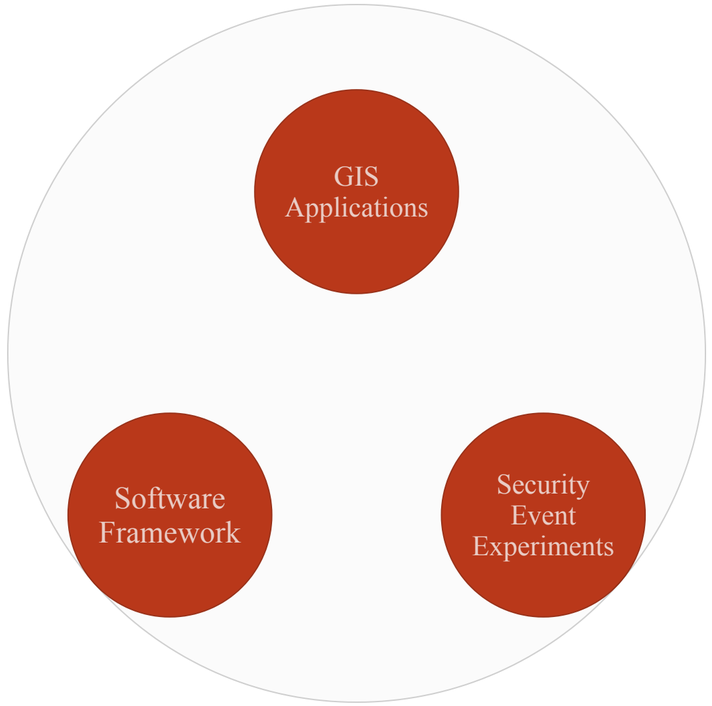
5. CONCLUSION

- Context-aware GIS framework and architecture
- Experiments of context-aware GIS
- Methods for forecasting and monitoring security events

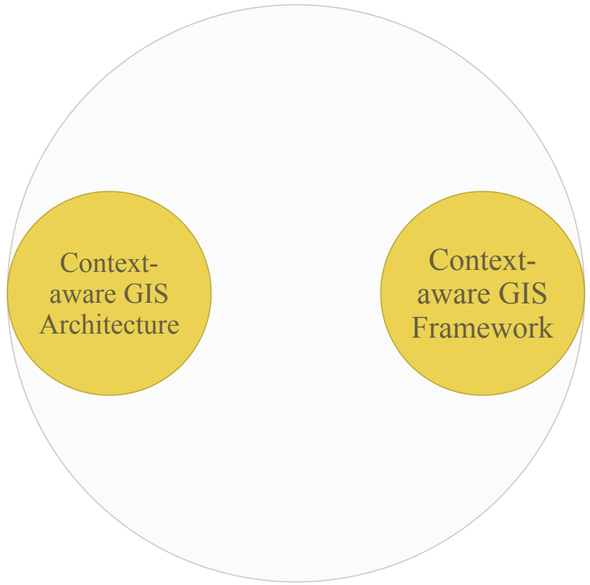
SUMMARY

Practical



Methodological

Conceptual



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