Optimization of Multimodal Evacuation of Large-Scale Transportation Networks

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Emergency Evacuation

- **The Context:**
  - Natural or man-made disasters in large cities

- **The Problem:**
  - Sudden sheer demand (people)
  - Limited supply (infrastructure capacity)
  - Chaos

- **The Solution:**
  - Control demand: evacuation scheduling and destination choice
  - Control supply: routing, signals, ATMS
Multi-dimensional Problem

Objective 1
Minimize network clearance time

Objective 2
Minimize total evacuation time

Objective 3
Maximize number of evacuees reaching safety

Contra-flow

Scheduling

Destination Assignment Optimization

Signals
Framework for Optimization of Multimodal Evacuation
Time Structures and Objectives

- Explicit Representation for Loading and Evacuation Curves and Network Clearance Time

- Multiple objectives:
  - Min Travel Time
  - Min Waiting Time
Demand Estimation Model by **Mode, Time, Space**

6:00 AM

9:00 AM

Noon

Automobile
Evacuation of City of Toronto

- Population: 2.37 M
- Area: 628 km²
Network Representations

Transit Network:
- 1320 bus
- 4 metro lines

Roadway Network:
- Roads: 3,610 km
- No of Nodes: 3,393
- No of Links: 7,480
- No of Zones: 463
Evacuation of Toronto

**Optimal Plan**
- Avg Evacuation Time = 2 Hrs
- Network Clearance Time = 9 Hrs
- Avg Stop Time = 0.5 Hrs

**Do Nothing**
- Avg Evacuation Time = 7 Hrs
- Network Clearance Time = 30 Hrs
- Avg Stop Time = 6 Hrs
High Performance Computing (HPC) for Parallel Distributed GA Optimization

Almost Linear Speedup
Detailed Routing Plan and Schedule for Transit

Where People Are Located

Where Buses Are

Visit 2270

Visit 1268
Conclusions

- Essential to estimate demand by mode and time of the day
- Essential to consider waiting time at origins
- Essential to consider the readily available transit systems capacity
- **Automobile Evacuation in Toronto:**
  - Average automobile evacuation time **2 hours (vs 8 hrs)**
  - Network Clearance Time **8 hrs (vs 30 hrs)**
  - Average Stop time **0.5 hrs (vs 6 hrs)**
  - Average In-Vehicle Travel Time **1 hr (vs 7 hrs)**
- **Transit Shuttling in Toronto:**
  - Average transit evacuation time **2.5 hrs**
  - Transit network clearance time **4 hrs**
- **High Performance Cluster Computing Time** **1.2 hrs (vs 3+ days)**
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