

# Conceptual Model of a Self-Organizing Traffic Management Hazard Response System

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# Outline

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- Self-Organizing Traffic Management System
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- Implementation
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# Introduction

- Recent natural disasters and terrorist attacks have sparked renewed interest in developing effective policies and strategies for evacuating densely populated areas
- Lack of analytical tools for dealing with such evacuations

# Introduction

But currently...

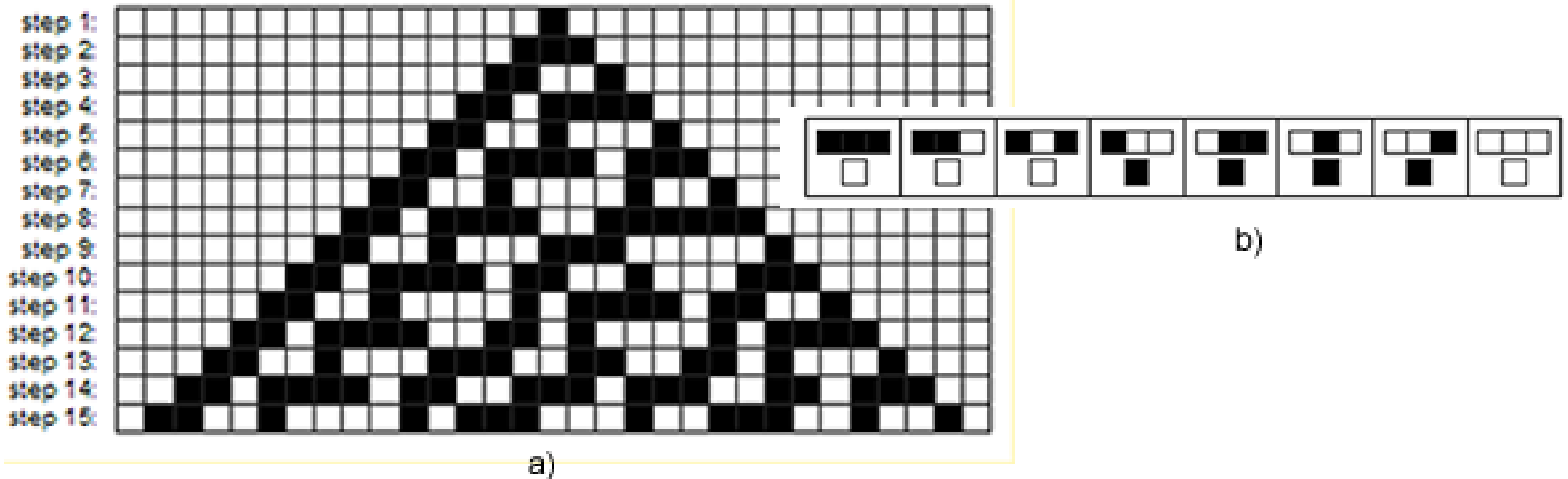
- Progress in information technology and transportation science allows faithful simulations and testing of various what-if scenarios
- Cellular automata and evolutionary computation provide tools for designing effective traffic management strategies

# Background: Cellular Automata

- One of the simplest mathematical representations of complex systems
- Useful idealizations of the dynamical behavior of various systems
- Models for complex systems and processes consisting of a *large number* of *identical, simple, locally interacting* components
- Discrete dynamical system simulators used to study pattern formation and *self-organization* processes

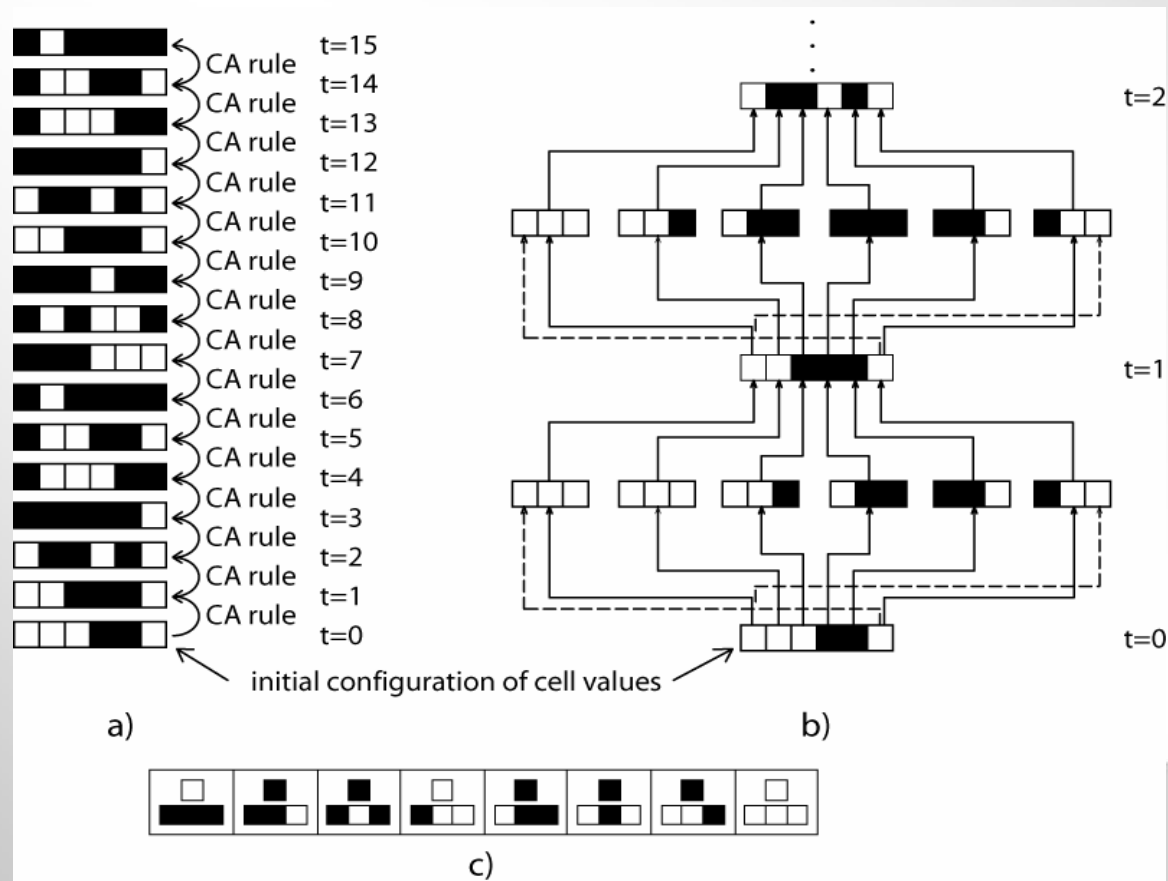
# Background: Cellular Automata

## Simplest 1D Cellular Automata



# Background: Cellular Automata

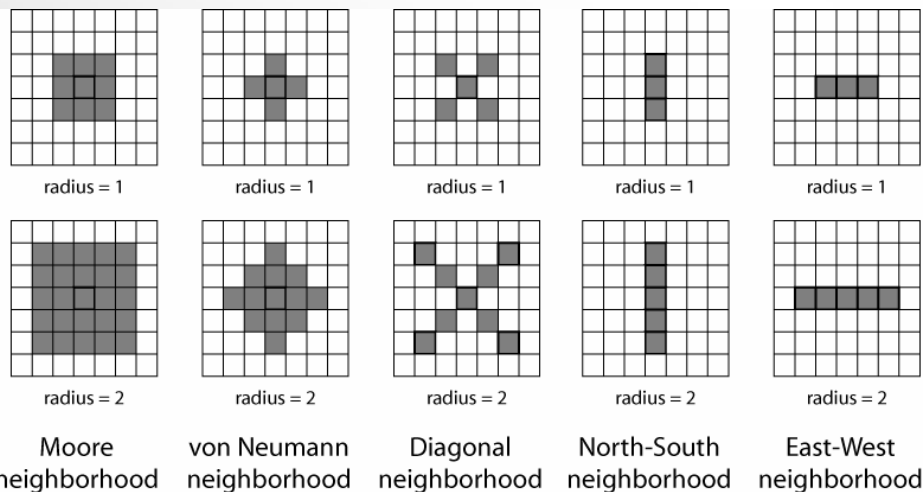
## 1D Cellular Automata: Mechanism



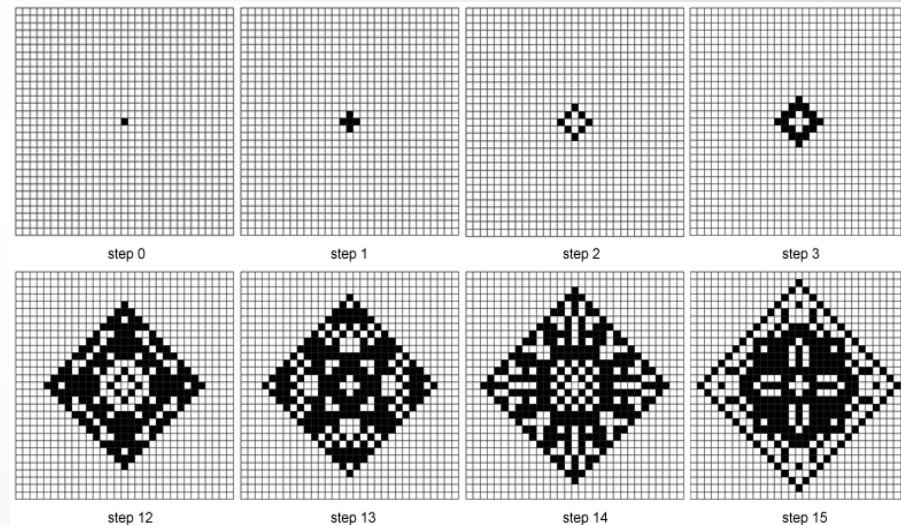
# Background: Cellular Automata

## 2D Cellular Automata

### Neighborhoods



### Iteration



# Background: Evolutionary Algorithms

- Use a population of individuals
- Individuals are points in search space
- Individuals are evaluated for their “fitness”
- Population dynamics:
  - New individuals (samples) are created from existing high fitness parents using operators like:
    - Crossover
    - Mutation
  - Existing low fitness individuals are deleted

# Self-Organizing Traffic Management System

## Assumptions and Hypotheses:

- A typical transportation network can be understood as a complex system with many entities and actors, all pursuing their own somewhat limited objectives and acting with variable and limited information inputs.
- All of the actors in the system have actions they can take that are perceived to improve their own performance, or to advance their assigned operational objectives, and they often make decisions with little or no knowledge of the impacts of their decision on the performance of the overall system.

# Self-Organizing Traffic Management System

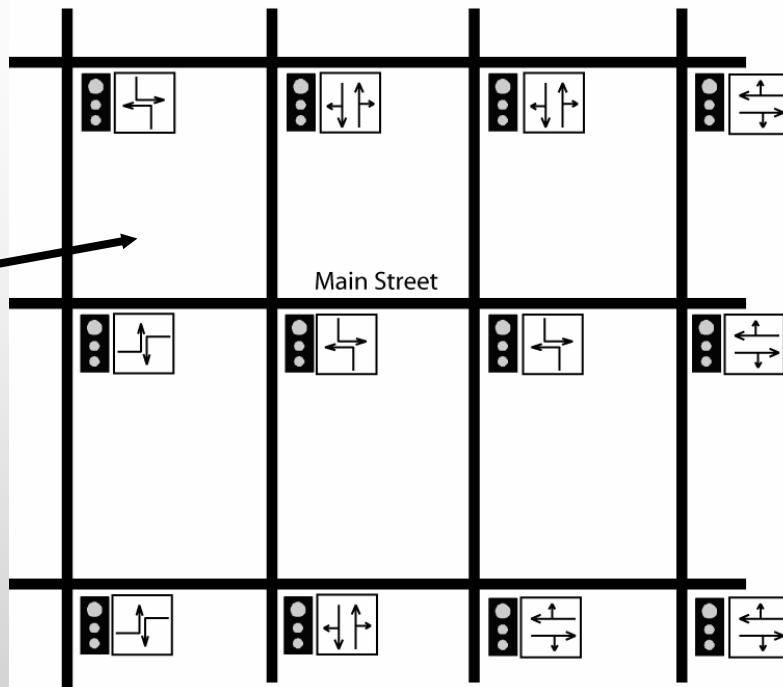
## Assumptions and Hypotheses:

- The *emergent behavior* of the system and its subsystems is of great interest for finding effective technology and policy approaches to improving performance.
- *Systems operating in crisis mode exhibit self-organizing behavior*, so finding optimal operational strategies involves understanding and capitalizing on this attribute

# Self-Organizing Traffic Management System

## Conceptual Model:

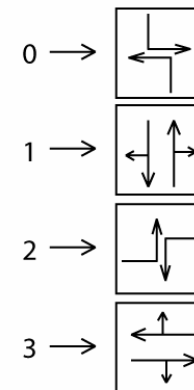
Simple model of an urban area to be evacuated



Traffic signal system representation

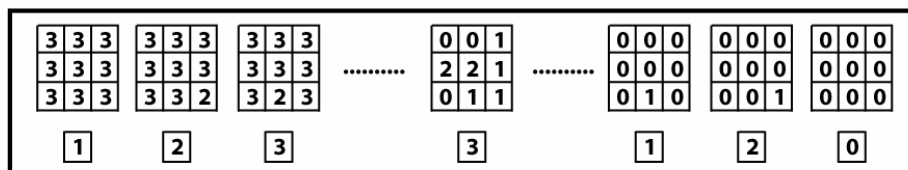
0	1	1	3
2	0	0	3
2	1	3	3

b)



c)

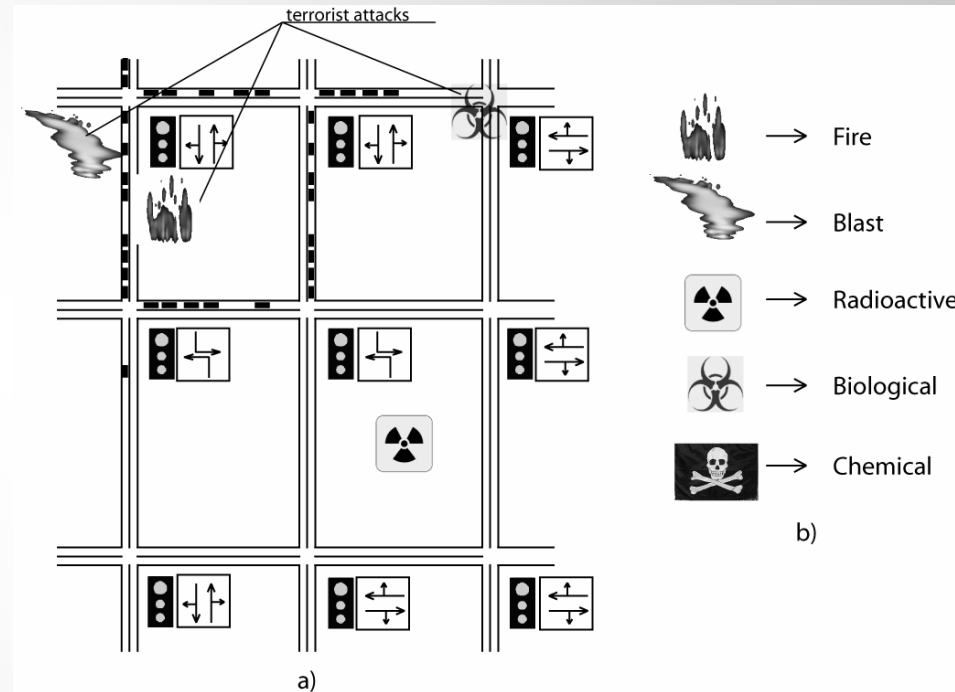
2D cellular automaton updating the traffic signal system



d)

# Self-Organizing Traffic Management System

- Cellular automata models of the traffic control system can be employed to determine evacuation strategies following terrorist attacks in a given urban area
- The input for each evacuation scenario simulation consists of:
  - a configuration of vehicles (pedestrians will be introduced in later versions) in the urban area under consideration
  - a specific CA model of a traffic control system to be evaluated, and
  - pre-determined terrorist threat situation, i.e., locations and types of terrorist attacks

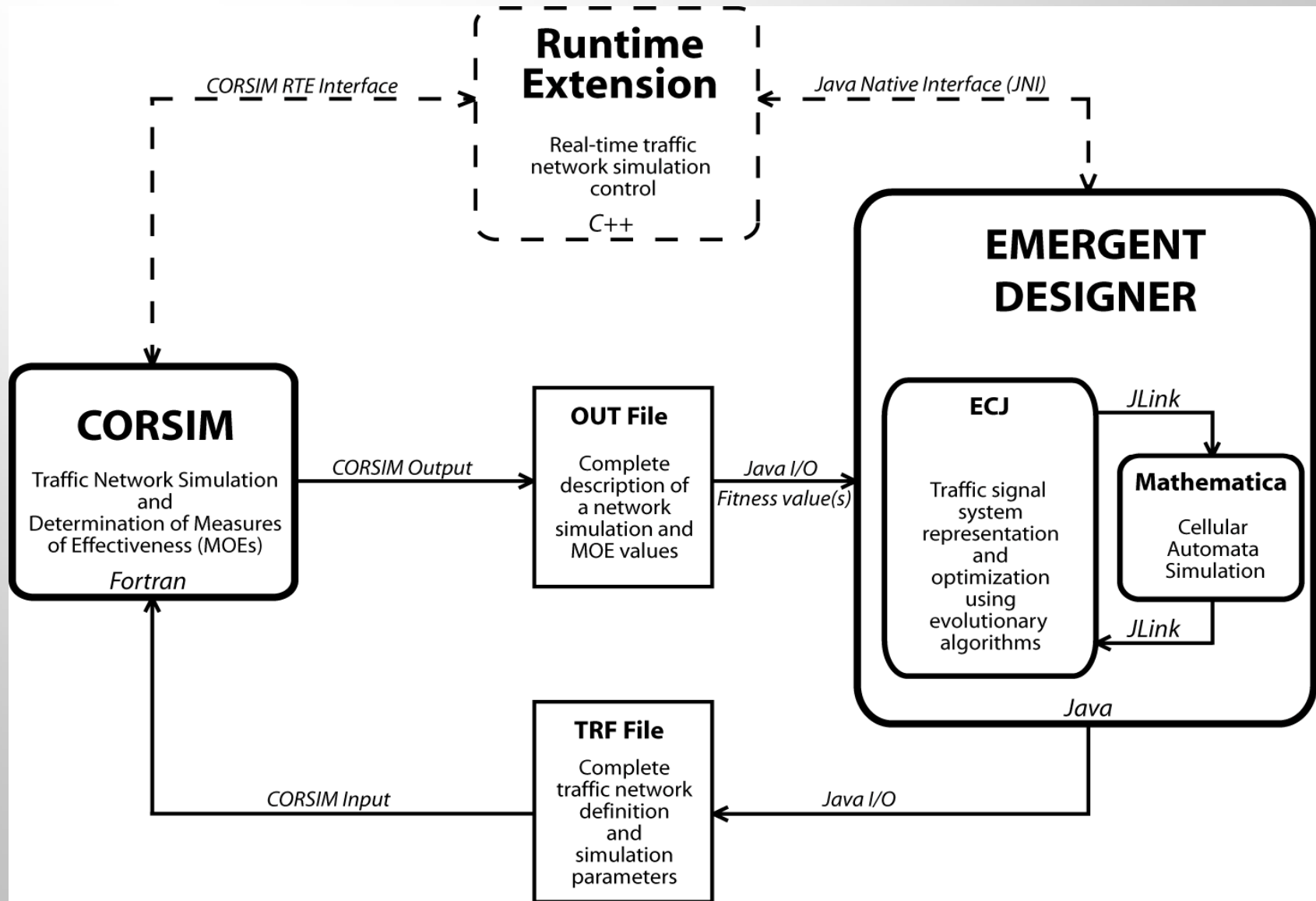


# Self-Organizing Traffic Management System

## Conceptual Model Assumptions:

- Traffic signal state durations (phase lengths) are fixed and constant. A traffic phase length is an integral multiple of the model's fixed time step, and cycle times are a product of the modeling results. The length of the time step is a modeling variable.
- Vehicles move only in marked lanes (i.e., not on the shoulders, sidewalks, or off-road areas), in the normal direction (i.e., not in opposing lanes, even if they are empty).
- The initial locations, destinations and travel paths of individual vehicles are given and constant, which determine the turning movement demand at individual intersections.

# Implementation: System Architecture





# Initial Conclusions

- Only a conceptual model presented
- Initial architecture of the system defined and implemented
- A simple demo version of the system presented - fine-tuning of the system required