Fire!

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Overview

- Considerations
  - Environment/Geometry
  - Human agents: Awareness, Behavior, Interaction
  - Fire
- Our “simple model” assumptions
- Key results
- Future directions

Considerations

Environment

- Size of room
- Obstacles in room (tables, cubicles, partitions)
- How many doors? Windows? Other exit possibilities? What story is the room on?
- Is there a telephone? Other means of communication to agents outside of the room?
- Is there a fire extinguisher? Sink? Blanket?

Geometry

- Location of obstacles (if any)
- Location of exit possibilities
- Location of external communication possibilities (if any)
- Location of fire extinguishing possibilities (if any)

Human agents I

- Awareness of the fire
- Awareness of escape route
  - Global full information vs. local information eg. presence of heavy smoke
- Awareness of (location of) external communication means
- Awareness of (location of) fire extinguisher
- Foresight/predictions about system state?

Human agents II

- Reaction behavior
  - Calm evacuator?
  - Panic-stricken evacuator?
  - Action to communicate externally?
  - Action to extinguish fire?
  - Confused? Other?
- Role of noise in the system
- Do agents change their behavior with time?

Human agents III

- Do agents interact with each other
  - Transmission of awareness-type information?
  - Coordinated action?
- If there is interaction, is this:
  - One-to-one sequential interaction along a network path?
  - One-to-many simultaneous interaction?
  - Only with spatially nearest neighbors?

Fire characteristics

- Location
- Extent
- Rate at which fire spreads
  - Constant? Time-varying?
- Rate at which fire is extinguished
  - Constant? Time-varying?

Our “simple model”

“Simple model” assumptions

- Environment/Geometry
  - Room is a rectangular grid of *varying* shape & size
  - Only 1 human agent/cell allowed
  - No obstacles
  - One door at mid-wall location, no other exits
  - No means of external communication
  - No fire extinguishing possibilities

Assumptions cont'd.

- Human agents
  - Initially randomly located on the rectangular grid
  - All agents have global full information about the environment/geometry at each time step
    - Location/extent of fire; location of door & other agents
  - No foresight
  - No knowledge transmission (since global info)
  - No coordinated action
  - No adaptation/mutation of basic agent type

Assumptions cont'd.

- Fire
  - Initiated at central *or* corner cell in square grid
  - Spreads at constant rate of 1 cell per time unit

In terms of the BARN*

Mutation/adaptation ——— **Network**

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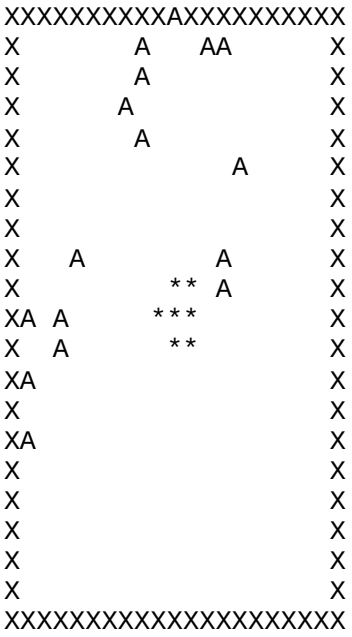
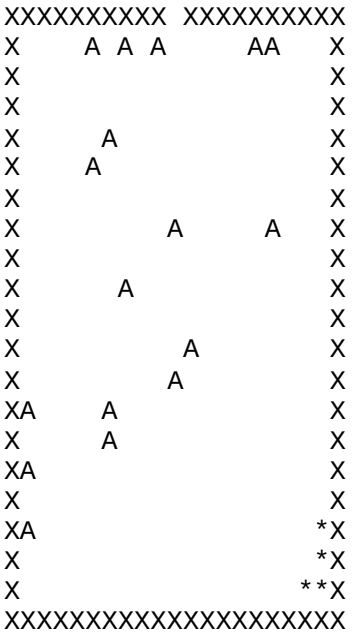
Interaction ——— *Diversity*

*) ref. Scott Page

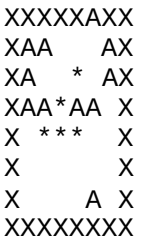
Implementation in Python I

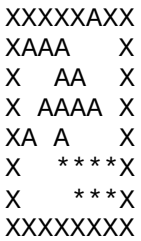




Python ASCII display for example runs with a large room, for (a) central and (b) corner fire locations

Implementation in Python II





Python ASCII display for example runs with a small room, for (a) central and (b) corner fire locations

Implementation in Python III

```
XXXXXXXXXX XXXXXXXXXX
XA A *********** A  X
XAA A*********   AA X
XXXXXXXXXXXXXXXXXXXX
```

```
XXXXXXXXXXAXXXXXXXXXX
X  AAAAAAA AA   ****X
X A  AA  A       ***X
XXXXXXXXXXXXXXXXXXXX
```

Python ASCII display for example runs with a long room, for (a) central and (b) corner fire locations

Implementation in Python IV

```
XXAX
X  X
XA X
XA X
X  X
XA X
X  X
X  X
X**X
X* X
X**X
X* X
X  X
X AX
X  X
X AX
XA X
XAAX
X AX
X  X
XXXX
```

```
XXAX
X  X
XA X
X  X
XA X
XA X
XA X
X  X
XA X
X  X
XA X
XA X
XA X
XA X
X  X
X *X
X**X
X**X
X**X
X**X
XXXX
```

Python ASCII display for example runs with a tall room, for (a) central and (b) corner fire locations

Path selection with global info

- Each agent performs a breadth first search (BFS) at *initial time* to find shortest path to exit around fire
- At a given time step, the breadth first search is *repeated* to find a *new* selected path, if fire encroaches on the current selected path

Scheduling

- Fire spreads at each time step; if it encroaches on an occupied cell, afflicted agents die
- Live agents (sequentially) *select* moves based on the location/extent of the fire and the current location of other agents
- Agents (sequentially) attempt pre-selected moves
- If multiple agents select same cell: one agent is chosen at random to move, and others wait

Double-buffered scheduling

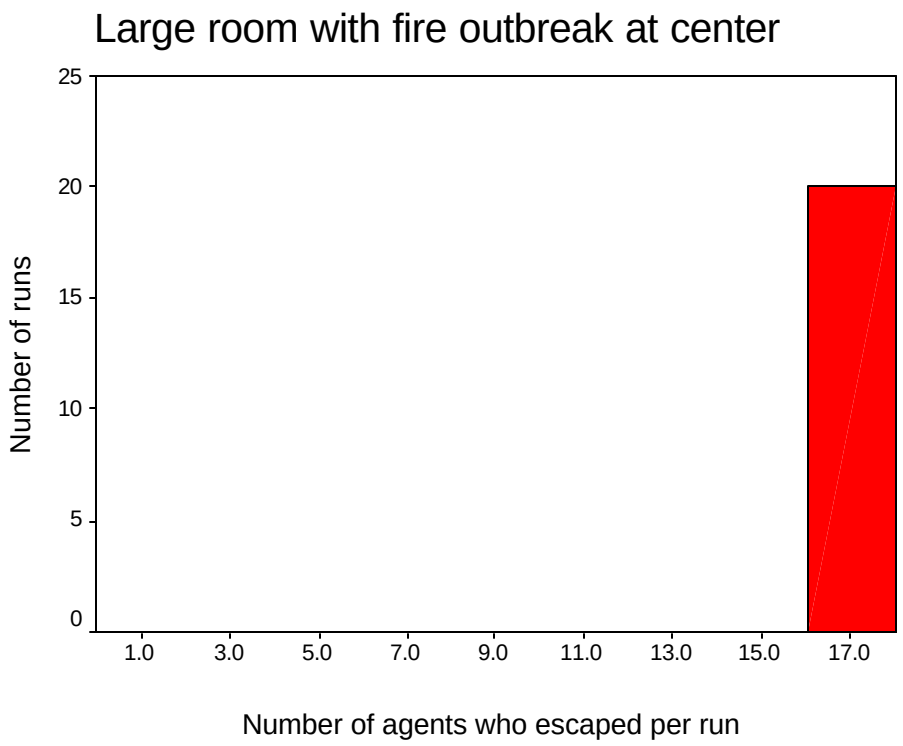
- Simulated effect of simultaneous movement alleviates the need for Monte Carlo runs over the order in which agents move

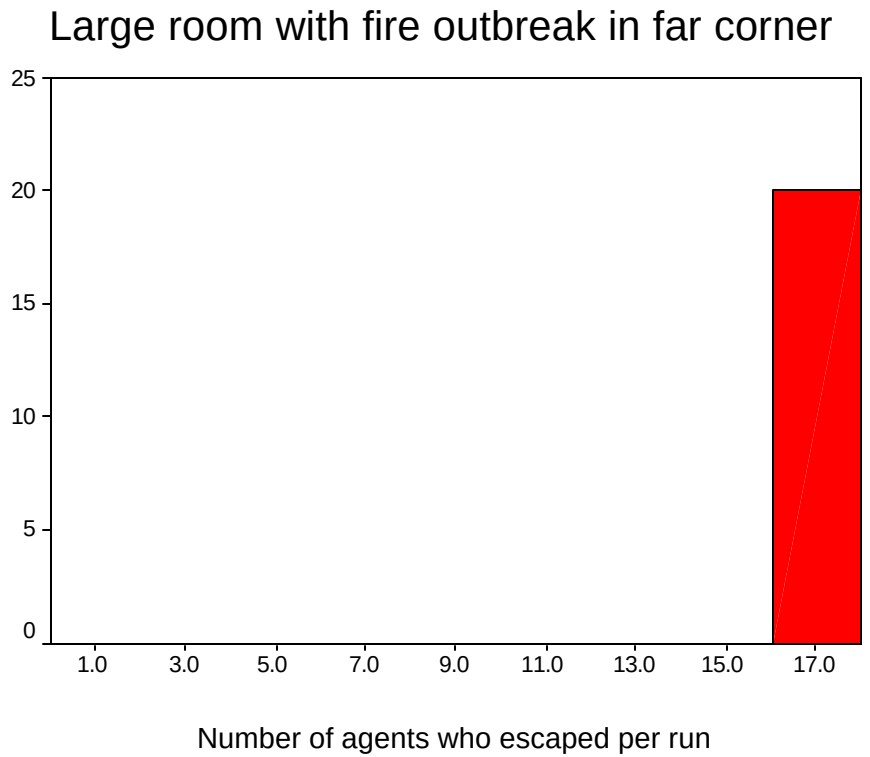
Question for the model

- What combination of room geometry and agent density yields more efficient evacuation with a central or far corner location of the fire?

Key results

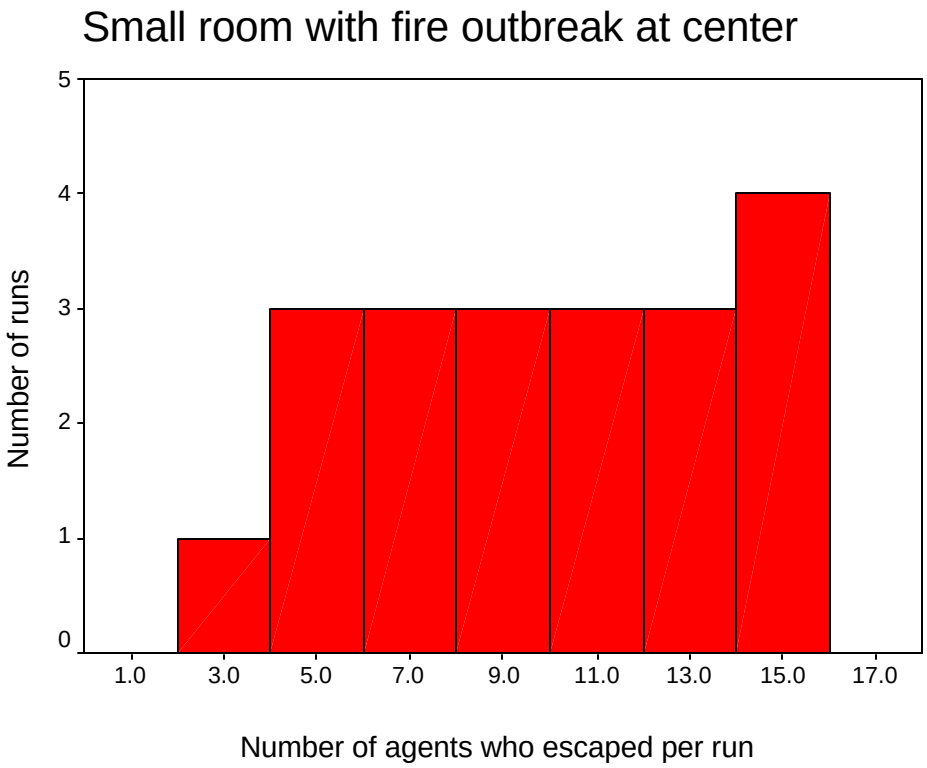
Large room

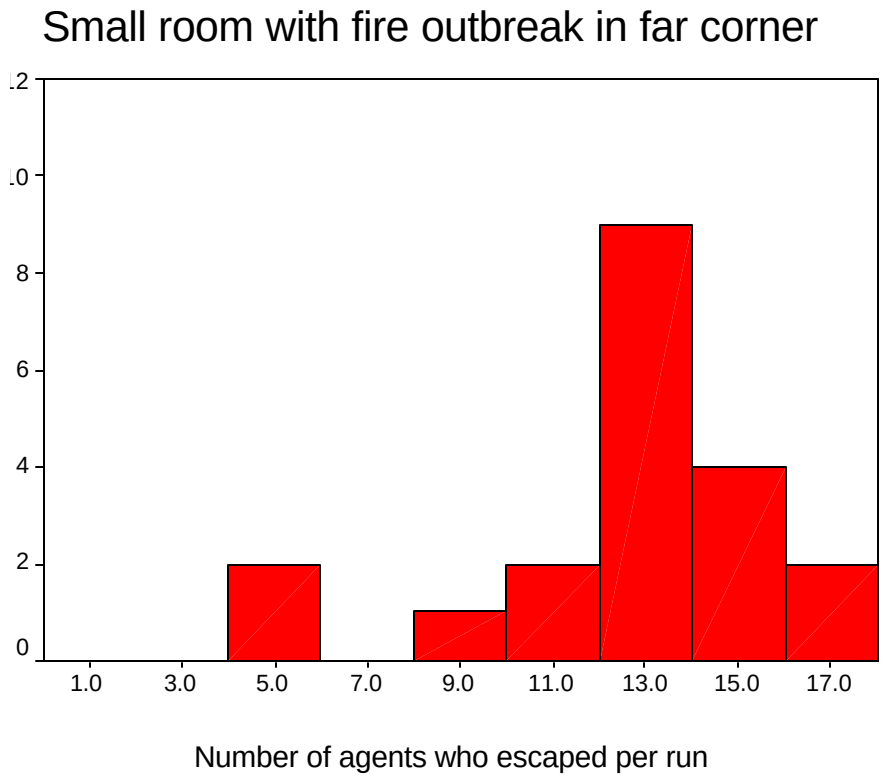




Cumulative histograms with 18 agents over 20 runs for (a) central and (b) corner fire locations

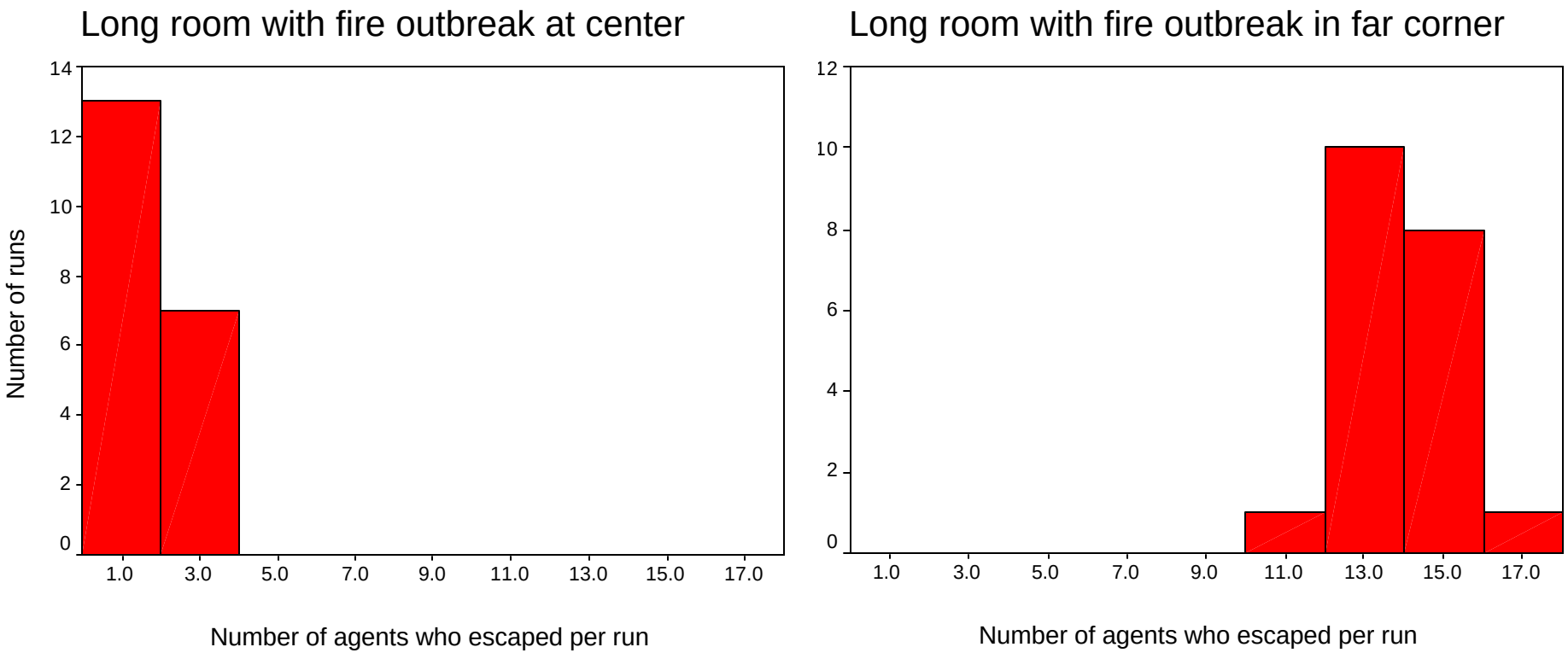
Small room





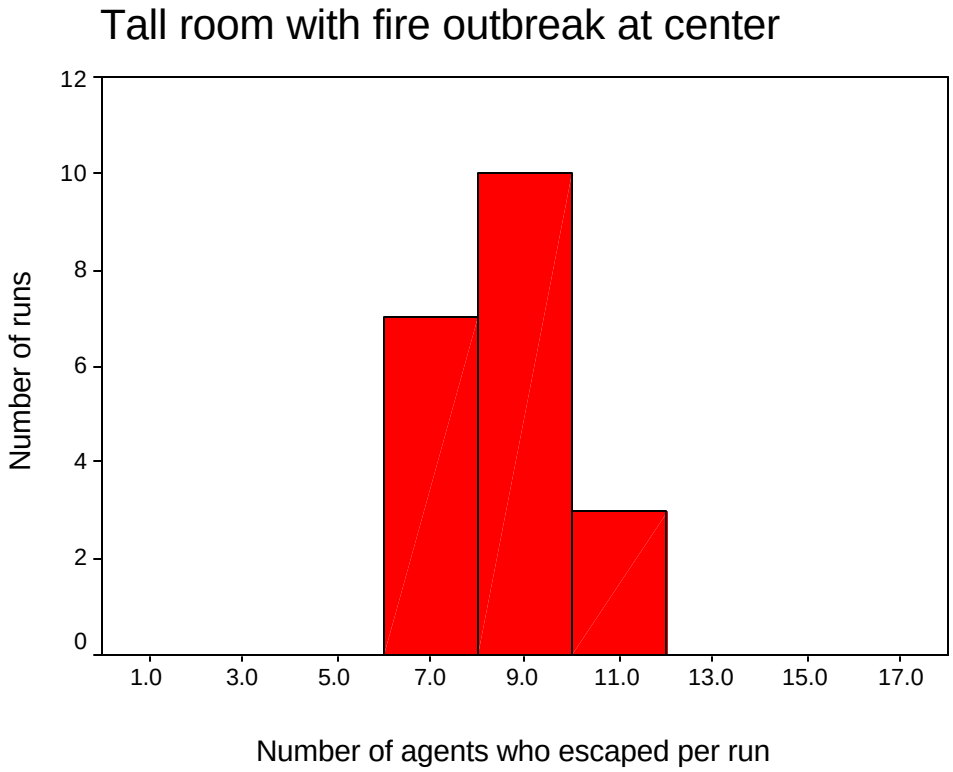
Cumulative histograms with 18 agents over 20 runs
for (a) central and (b) corner fire locations

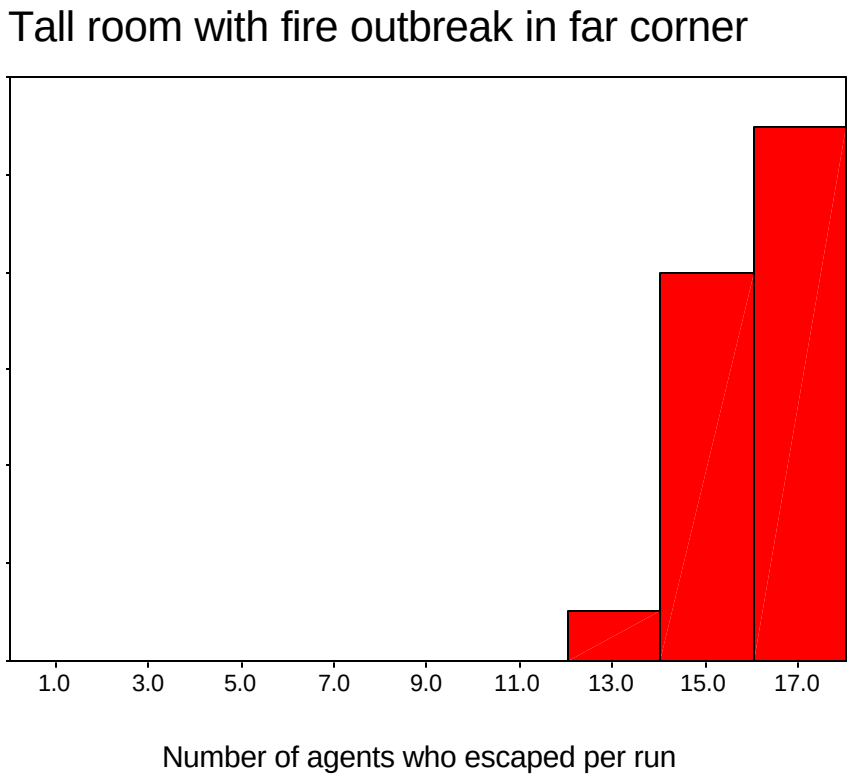
Long room



Cumulative histograms with 18 agents over 20 runs
for (a) central and (b) corner fire locations

Tall room





Cumulative histograms with 18 agents over 20 runs
for (a) central and (b) corner fire locations

Suggested extensions

Suggested extensions I

- Modify rules for behavioral agent types
- Vary extent and rate of spread of fire
- Allow mutation/adaptation of agent type
- Vary geometry, include obstacles, more exits

Suggested extensions II

- Include “heavy smoke”: with and without transmission of local environment info for various human agent networks
- Allow coordinated action for various human agent networks
- Include fire extinguishing possibilities and/or external communication possibilities

Other social science applications

- Traffic jam
- Any example where geometry and congestion impact flow rate