



# Multi-Agent Simulation of Disaster Response

Daniel Massaguer, Vidhya Balasubramanian, Sharad Mehrotra,  
Nalini Venkatasubramanian

AAMAS'06, ATDM Workshop



# Motivation: Testing IT in emergency response

- Efficacy of emergency response plays a key role in the consequences of the disaster
- Information technology (IT) can improve efficacy by delivering the right information to the right people at the right time
- Need for testing IT in the context of emergency response
  - Drills: realistic settings but expensive
  - Simulation: cheaper, but lacks realism and validation



# DrillSim: A testbed

- DrillSim *simulates* a crisis response activity (e.g, evacuation)
- DrillSim allows testing IT solutions in the context of the *simulated* response activity
  - Plug-and-Play capabilities
- Translates IT metrics to response metrics
  - E.g., Bandwidth usage, time, accuracy to casualties, response time, risks taken



# DrillSim: An augmented reality simulator

- DrillSim can simulate a crisis response activity
  - DrillSim can also be synchronized with an on-going drill:
    - Simulated drill augments an on-going drill adding
      - Simulated people
      - Simulated communications infrastructure
      - Simulated sensing infrastructure
- *Lowers cost of a real drill, adds flexibility*



# DrillSim: An augmented reality simulator

- DrillSim can simulate a crisis response activity
- DrillSim can also be synchronized with an on-going drill:
  - Simulated drill augments an on-going drill adding
    - Simulated people
    - Simulated communications infrastructure
    - Simulated sensing infrastructure
  - ***Lowers cost of a real drill, adds flexibility***
  - On-going drill augments simulated drill
    - Real people
    - Real communications infrastructure
    - Real sensing infrastructure
  - ***Adds realism, allows for calibration of the simulated entities***



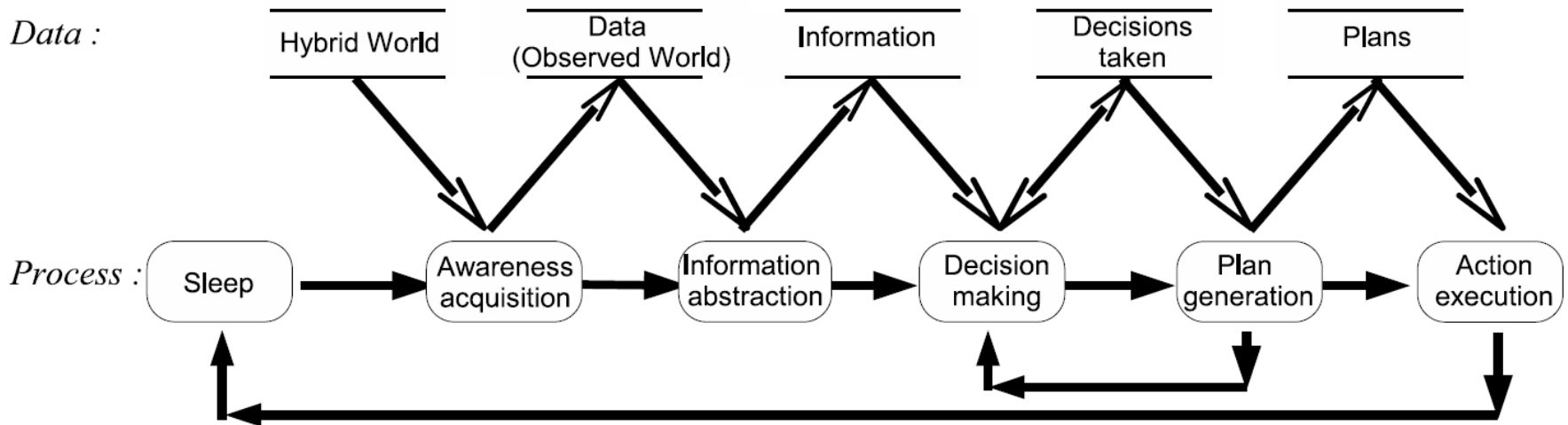
# DrillSim: A Multi-Agent Simulator

- **One agent** simulates **one person**
- Multiple **roles**:
  - Evacuee
  - Floor warden
  - Building coordinator
  - Zone captain
  - Etc.
- Individual **profiles** (physical and cognitive abilities)
- Relationship between agents -> social networks.
- Agents involved in information flow
  - Collect information via their own *sensors* (e.g., eyes), or the devices they carry (e.g., PDA)
  - Analyze information (i.e., assimilate information, make decisions)
  - Share and disseminate information via their own communication *devices* (e.g., speech) or the devices they carry (e.g., PDA)



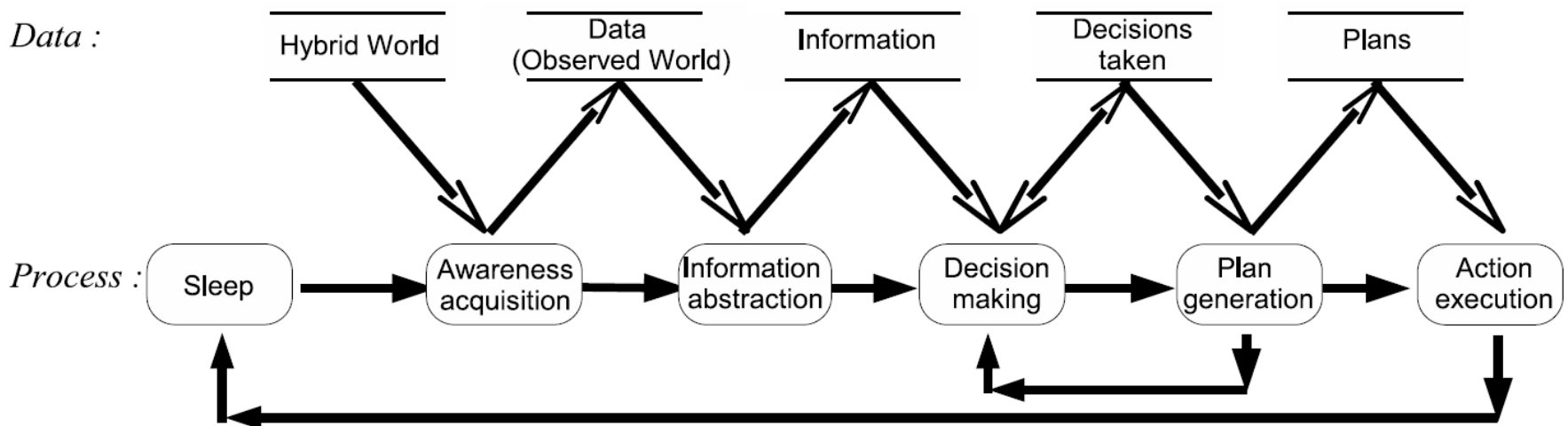
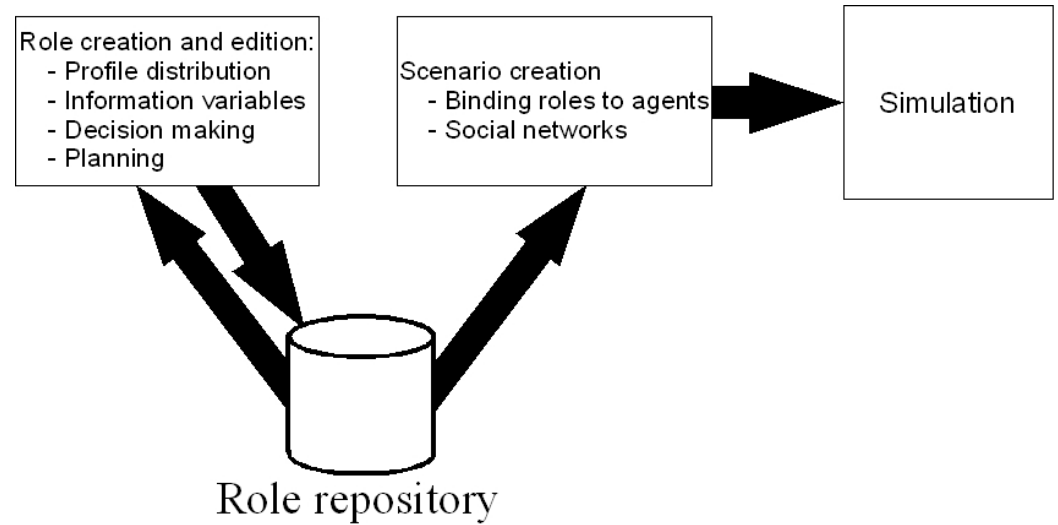
# DrillSim Agent Model

- Information processing
- Clear interfaces between stages



# Agent Role Editing

- A scenario is created by binding roles and profiles to agents
- An agent roles is an instantiation of each information processing step

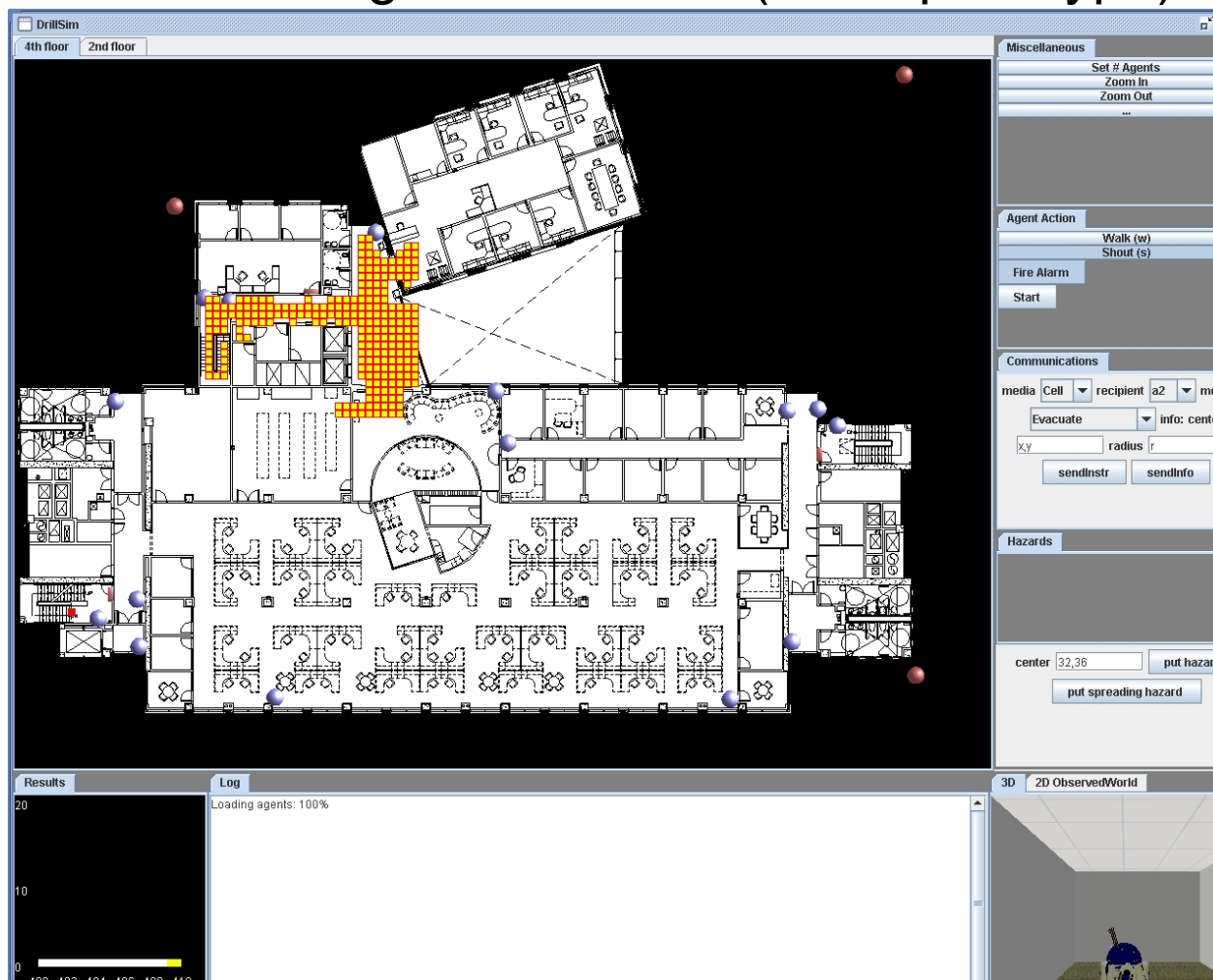




Come see the demo:  
Thursday May 11th, 12:05 - 13:25

# Synthetic Humans in Emergency Response Drills

demonstrating DrillSim v0.2 (basic prototype)





<http://www.ics.uci.edu/~projects/drillsim>

## Multi-Agent Simulation of Disaster Response

Daniel Massaguer, Vidhya Balasubramanian,  
Sharad Mehrotra, and Nalini Venkatasubramanian

Donald Bren School of Information and Computer Science

University of California, Irvine

Irvine, CA 92697, USA

{dmassagu, vbalasub, sharad, nalini} [at] ics.uci.edu

AAMAS'06 : ATDM workshop, Monday May 8th, 2006, Hakodate,  
Hokkaido, Japan



# EXTRA SLIDES

## Multi-Agent Simulation of Disaster Response

Daniel Massaguer, Vidhya Balasubramanian,  
Sharad Mehrotra, and Nalini Venkatasubramanian

Donald Bren School of Information and Computer Science

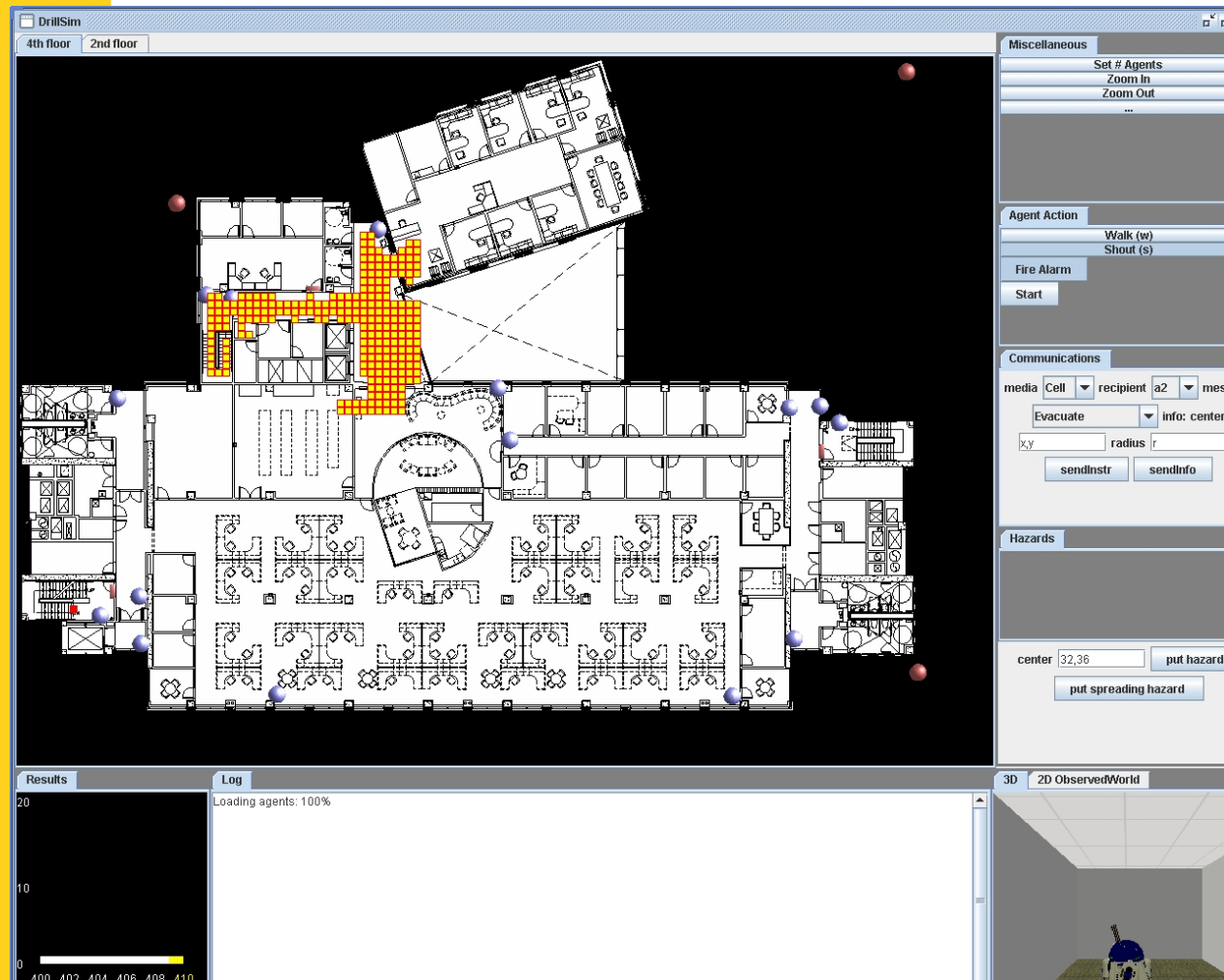
University of California, Irvine

Irvine, CA 92697, USA

{dmassagu, vbalasub, sharad, nalini} [at] ics.uci.edu

AAMAS'06 : ATDM workshop, Monday May 8th, 2006, Hakodate,  
Hokkaido, Japan

# DrillSim v0.2 – basic prototype

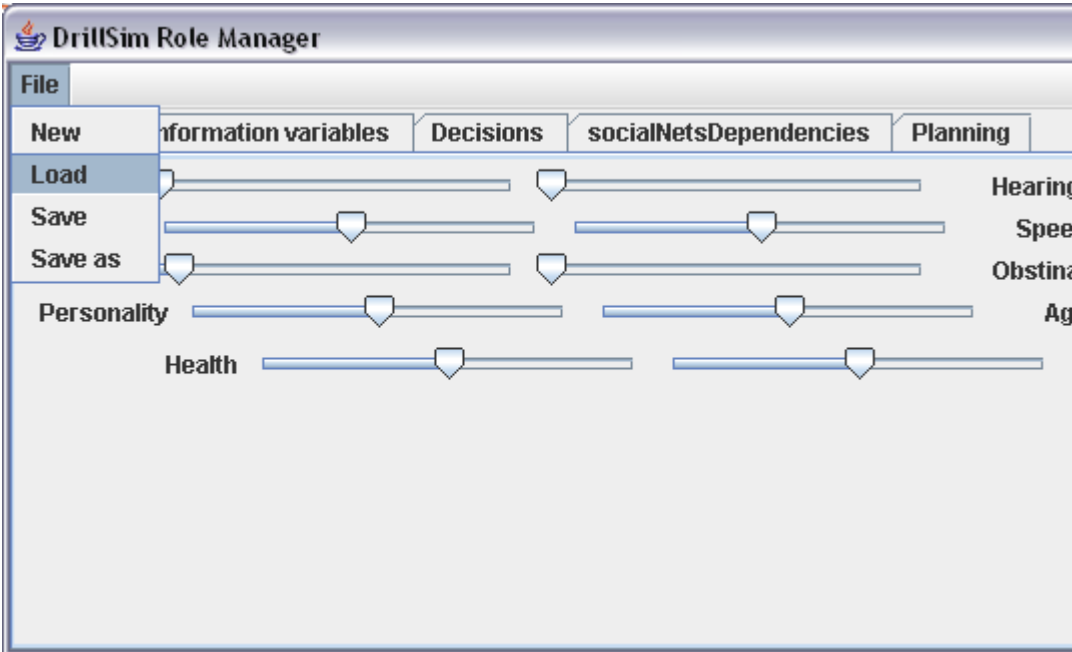


- Response activity: evacuation
- 4<sup>th</sup> floor Cal(IT)2
- Grid representation
- A\* algorithm + obstacle avoidance
- Stochastic decision making based on ANN
- Evacuee and floor-warden roles
- 2D/3D interface
- Human can control an agent
- Human can communicate with agents
- Simplified crisis model (spreading fire)
- Response metric: number of people in building vs time



# Current status

- Achieved:
  - Role management



```

<?xml version="1.0" encoding="UTF-8"?>
<Role id="OfficeBuildingEvacuee">
  <profile>
    <visual>
      <mean>5.0</mean>
      <variance>0.5</variance>
    </visual>
    <hearing>
      [...]
    </profile>

    <informationVariables>
      <var id="ROOM_FULL"></var>
      <var id="KNOW_ABOUT_HAZARD"></var>
      [...]
    </informationVariables>

    <decisionMaking>
      <decision id="KNOW_ABOUT_HAZARD">
        <NN_weights>
          <w dst="EXIT">1.0</w>
        </NN_weights>
      </decision>
      <decision id="TOLD2EVAC">
        [...]
      </decision>
    </decisionMaking>

    <planners>
      <var id="evacuate"></var>
      <var id="exitFloor"></var>
      <var id="Default"></var>
    </planners>

    <socialNetsDependencies>
      <var id="trust"></var>
      <var id="waitFor"></var>

```



# DrillSim v2.0 : where we are going

- Campus-wide evacuation
- Plug-and-play architecture: integration with MetaSim
- Scalable architecture (  $O(100,000)$  agents)
- Integration with real world and real activities
- Realistic models for crisis, agent behavior, and initial scenario generator.
- Calibration of agent models



# DrillSim: a *plug-and-play* system

- Plug models that drive simulation such as
  - human behavior,
  - spatio-temporal models (e.g., geography, class schedules)
  - crisis models,
  - response activity,
  - response plans.
- Plug IT solutions.
  - Response activity projected as information flow
    - Information is
      - Collected
      - Analyzed
      - Shared
      - Disseminated
    - IT solutions can be plugged at any of these points