

Patterns in Modeling: A Case Study on Applying Techniques from Pattern-Oriented Modeling and Design Patterns to Simulation Design

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Patterns in Modeling

- Patterns in Modeling
 - Pattern-Oriented Modeling
 - Model development and refinement strategy
 - Systematic approach for reproducing observed natural patterns in simulations
 - Design Patterns
 - Software engineering techniques can provide extensibility without sacrificing performance
 - Object-oriented nature is good fit for agent-based models

Patterns in Modeling

- WIPER: Multi-agent system for emergency response
 - Agent-Based Model of human activity
 - Movement and behavior model for crisis scenarios
 - Output is location and cell phone activity
 - Simulation is one aspect of WIPER

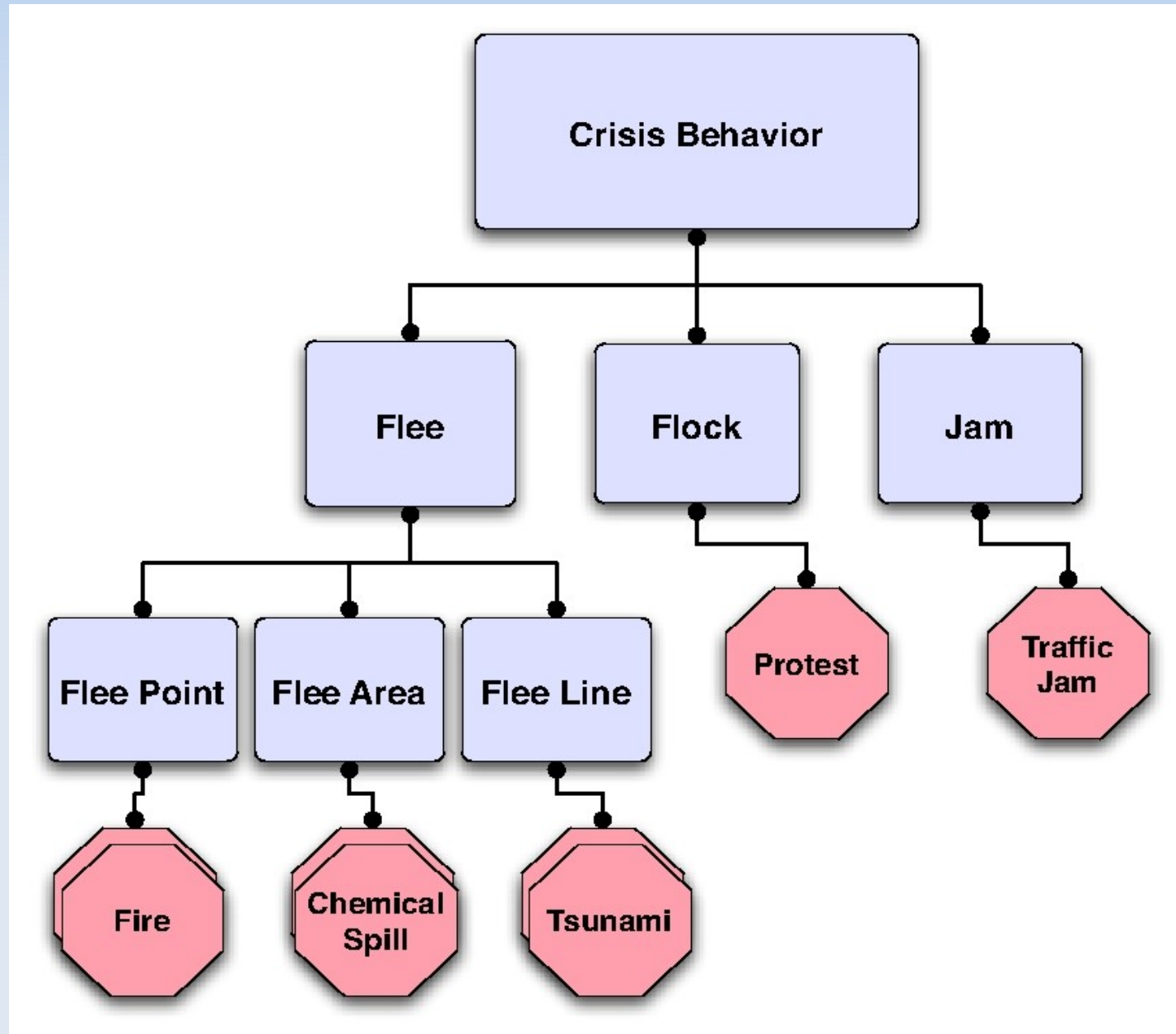
Patterns in Modeling

- Pattern-Oriented Modeling
 - Collect data and identify patterns
 - Determine parameter values
 - Compare observed patterns to predicted patterns
 - Observe “secondary” information from model
 - Repeat the cycle to refine model (Wiegand, et al, 2003)

Patterns in Modeling

- Observed patterns
 - How people call in response to a crisis
 - How people move
 - flock
 - flee
 - jam
 - move and return

Patterns in Modeling



Patterns in Modeling

- Parameters
 - Call frequency
 - Movement speed
 - Movement direction
- Comparison between observed and predicted patterns
 - Remove models and reduce parameter ranges when patterns do not emerge
 - Patterns must not be reproducible by arbitrary parameters

Patterns in Modeling

- Secondary information?
 - Nothing of note with limited implemented patterns and lacking environmental aspects
- Repeating the cycle
 - More patterns to be added
 - More environmental aspects to be added
 - Will likely yield “secondary” information
 - pedestrian clustering

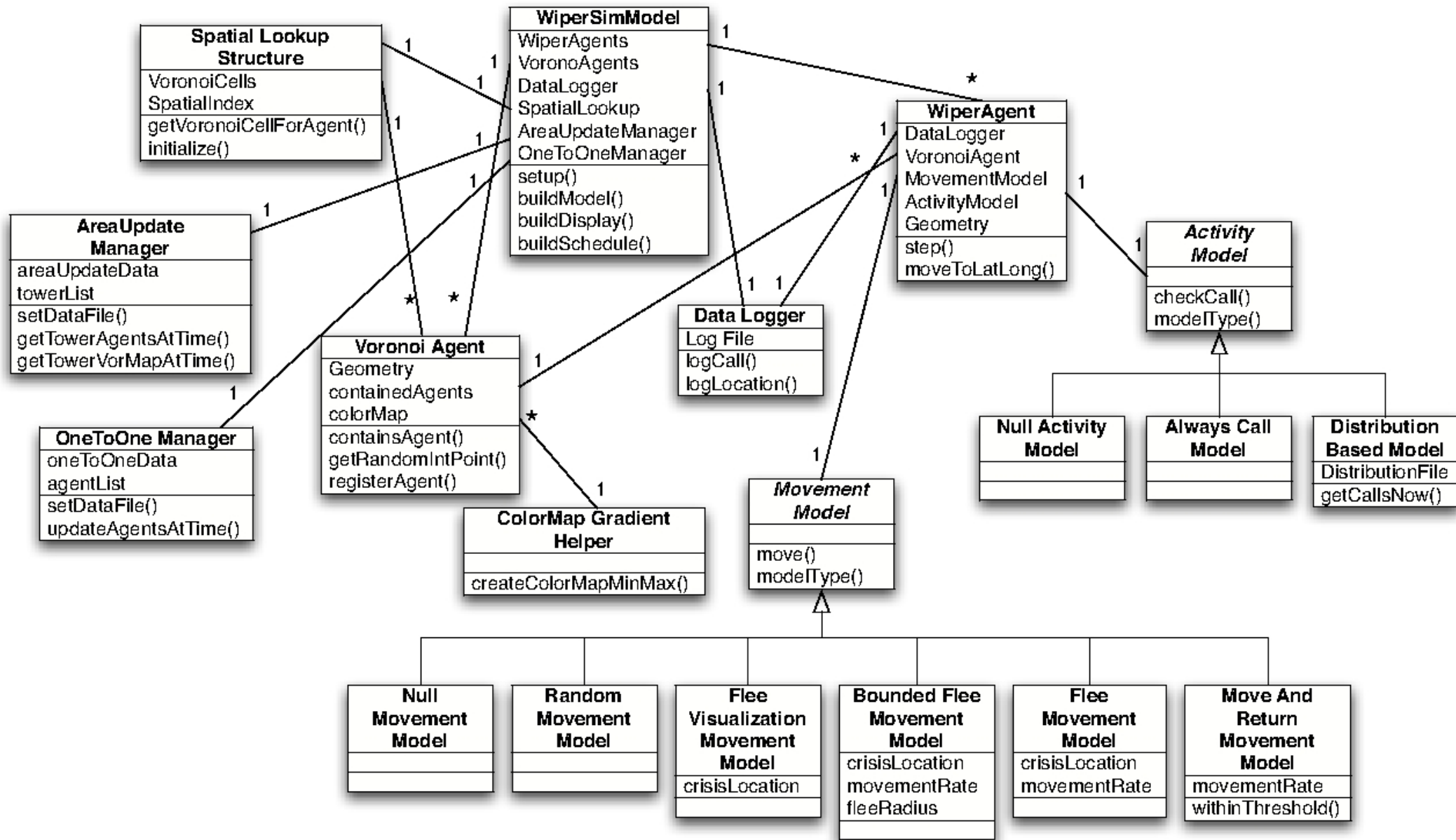
Patterns in Modeling

- Design Patterns
 - Technique for object-oriented design
 - Offer solutions to commonly occurring problems by specifying inter-object relationships
 - Can increase extensibility without sacrificing performance

Patterns in Modeling

- Singleton pattern
 - Restricts instantiation of a class to one object
 - Saves space
 - Allows easy updates of all agents with same movement model
- Strategy pattern
 - Encapsulates behavior in an object
 - Leverages polymorphism
 - All agents make same move() call regardless of movement model

Patterns in Modeling



Patterns in Modeling

- Other useful patterns for simulations
 - Memento pattern
 - Pattern for serialization
 - Would allow simulation to run in a distributed environment
 - Observer pattern
 - Approach for event-driven simulation
 - Can help manage agent interaction when events are infrequent and broadcasting information is costly

Patterns in Modeling

- Pattern-Oriented Modeling
 - Guides model development to reduce parameter range and validate model
- Design Patterns
 - Software engineering techniques to guide actual implementation of the simulation for increased flexibility and maintainability without sacrificing performance

Patterns in Modeling

- Lessons learned: POM
 - Repeat POM cycle to add more patterns and increase predictive power of model
 - POM can increase model development speed in early stages (although reducing parameter range can require lots of CPU time)
- Design Patterns
 - Good object-oriented coding practice when implemented early helps ensure simulation development goes smoothly

Patterns in Modeling

- Works Cited

- Design Patterns, Gamma, et al, 1995
- Individual-based Modeling and Ecology, Grimm and Railsback, 2005
- Pattern-Oriented Modeling of Agent-Based Complex Systems: Lessons from Ecology, Grimm, et al, 2005
- Using pattern-oriented modeling for revealing hidden information: a key for reconciling ecological theory and application, Wiegand, et al, 2003