

# Application 1: Simulation

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# Weekly Objectives

- This week, we briefly learn the concept and the application of computer simulations
  - Introduction purpose
- Objectives are
  - Understanding the concepts of modeling and simulation

# Real world problems

- Role of ISE?
  - Developing a specialized solution through science and engineering?
  - Developing a managerial solution through computational analyses?
  - Both!
  - **However, you need to comprehend your problem first.**



**Military/Terrorism**



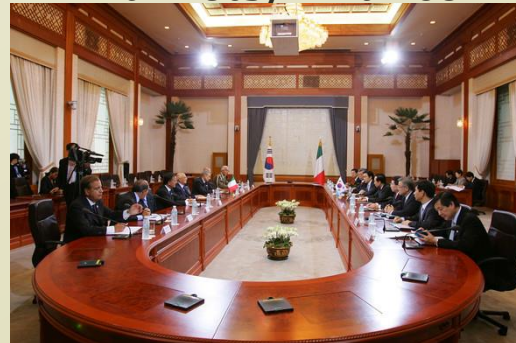
**Markets/Finance**



**Manufacturing**



**Management**



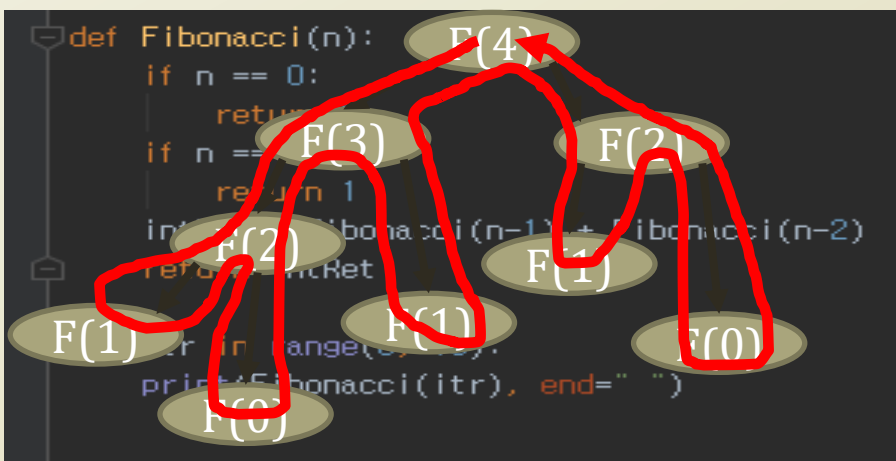
**Government/Politics**



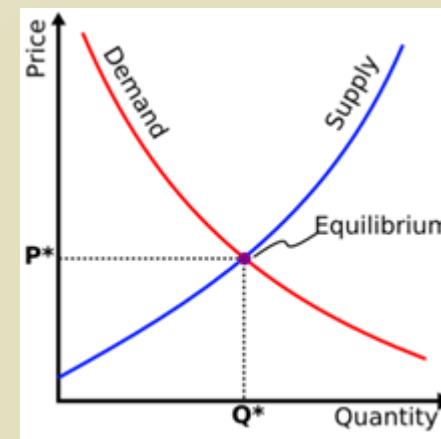
**Medicine**

# How to comprehend a problem?

- The way to comprehend a given program
  - Estimate the outputs of a given input
  - Estimate the progress of the program in the system
  - Just as we traced the function calls of the recursion in the execution timeline
- How to comprehend a problem?
  - Estimate the future of a given status-quo
  - Estimate the progress of problem factors in the system
  - However, the real-world problem is not a program in a well-defined programming language



Markets/Finance





# Models and why modeling?

- Since, it is difficult to trace the real-world problems.
  - We create a model that simplifies the real-world problems
    - The model is a simplification of the real world problems.
    - The model is an essence of the real world problems.
- Why use montage? Not picture?
  - Antoine de Saint-Exupery
    - Perfection is achieved, not when there is nothing more to add, but when there is nothing left to take away
- What to remove?
  - What to leave in the model
  - What to remove from the real world
  - Determined by objectives



Reduction  
by  
objectives

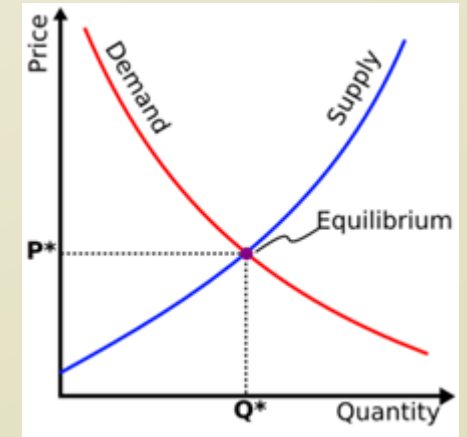


# Two Types of Models

- Models to solve
  - Numerical modeling
    - Linear programming, Integer programming
    - Goal: converting the real world problems into formula, then finding optimal solutions through solvers
- Models to simulate
  - System dynamics, discrete event models, agent based models
    - Event graphs, petri-net, agent modeling
    - Goal: approximating to the real world problems, then finding the optimal solutions through repetitive simulations



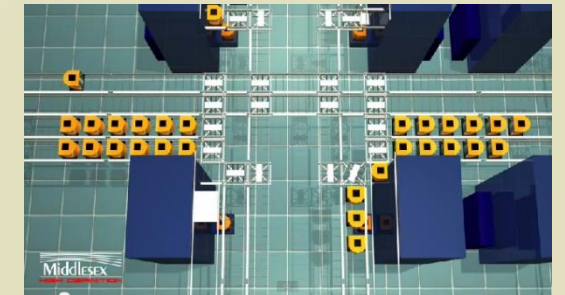
**Markets/Finance**



**Mathematical Solution**



**Manufacturing**



**Model Simulation**

# Infectious Disease

- SIR model (1925)
- A lifecycle of a patient
  - Susceptible
  - Infectious
  - Recovery
- More susceptible and infectious people
  - Infectious people increases
- After some time, infectious people get recovered
- This is a model without the loss of population
- See how to represent the interactions between infectious and susceptible populations

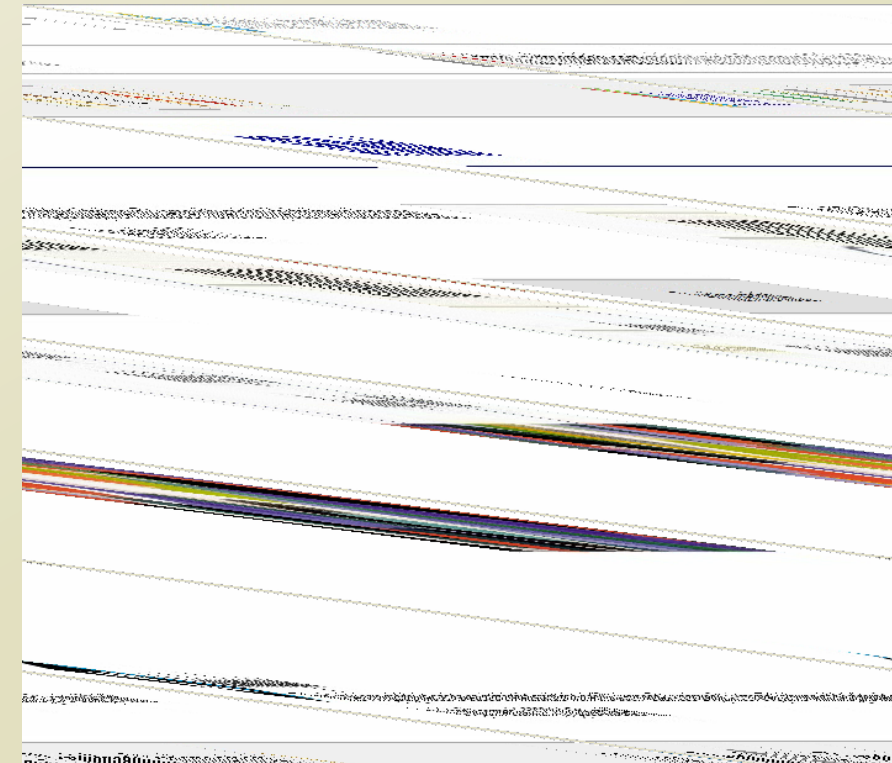


$$\frac{dS}{dt} = -\beta IS$$

$$\frac{dI}{dt} = \beta IS - \nu I$$

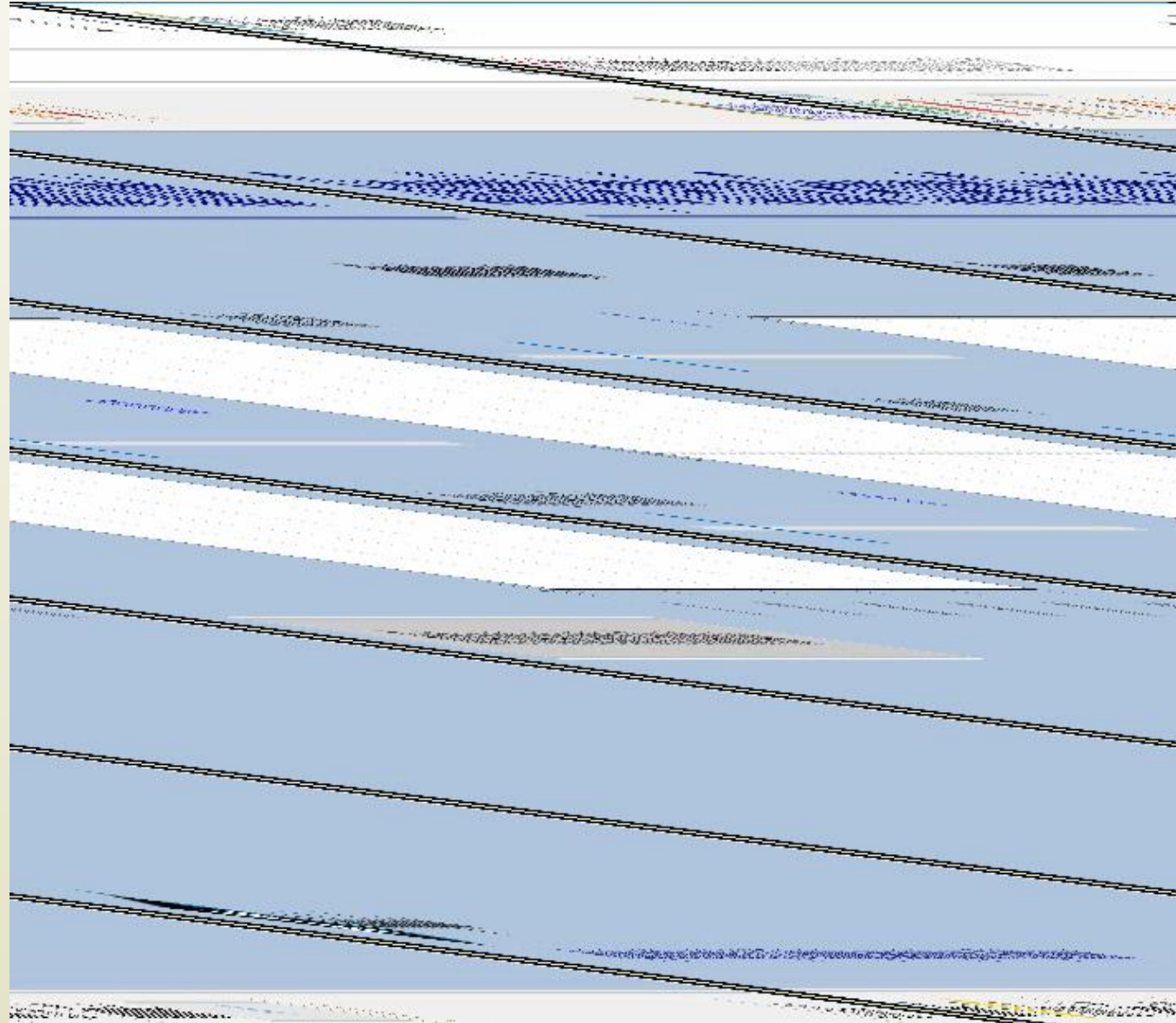
$$\frac{dR}{dt} = \nu I$$

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# SIR model in details

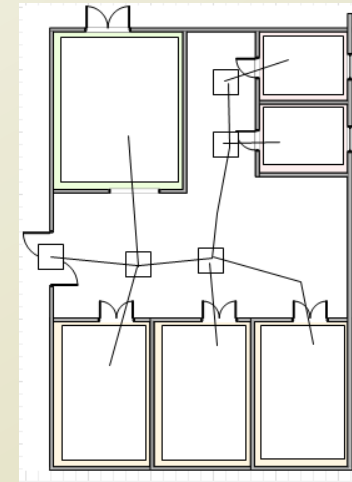
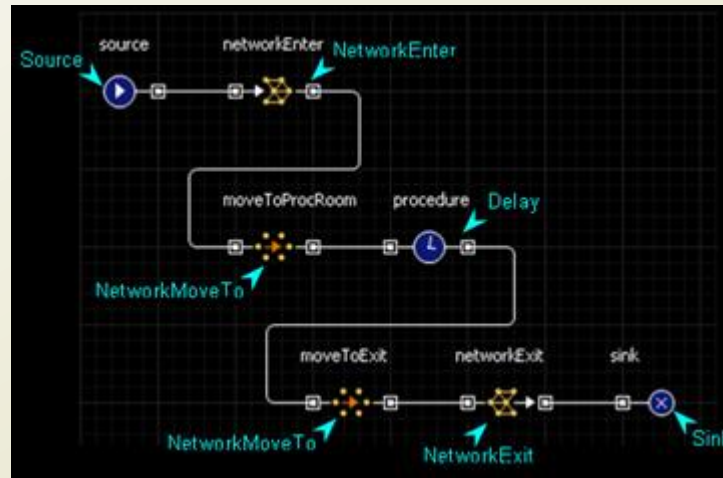


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# Hospital Management

- In hospitals
  - Patients go through
    - Waiting area
    - Exam room
    - Treatment room
    - Exit
  - These are a sequence of the patient care process

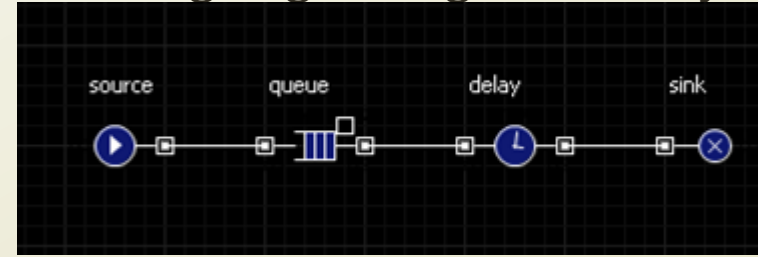


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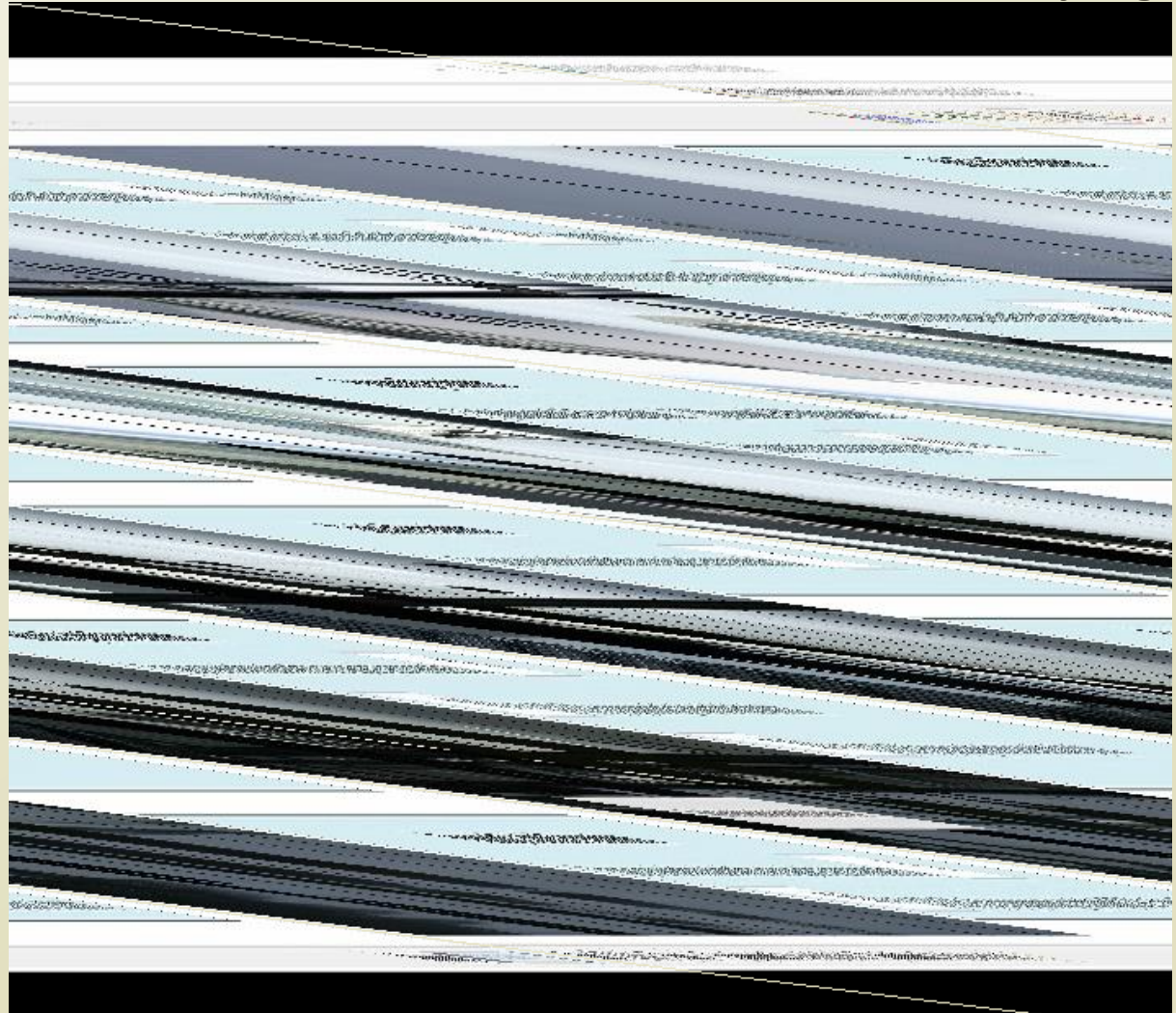
# Airport Model

- In airports
  - Passengers go through
    - Check-in counter
    - Security check
    - Maybe, restaurant
    - Gates
    - Plane
    - Gates
    - Maybe, border control
    - Baggage claim
  - These are a sequence of airport travel process

## Process of going through a security check



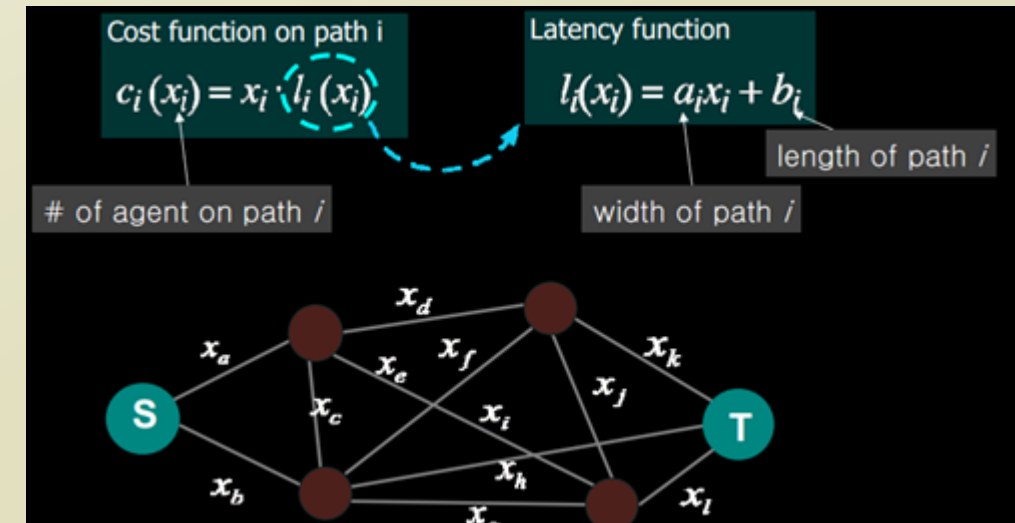
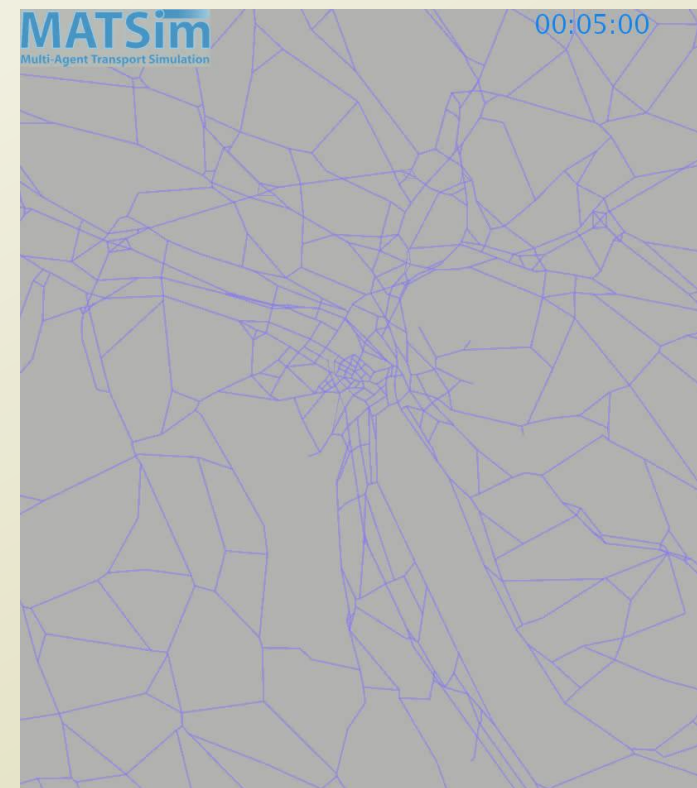
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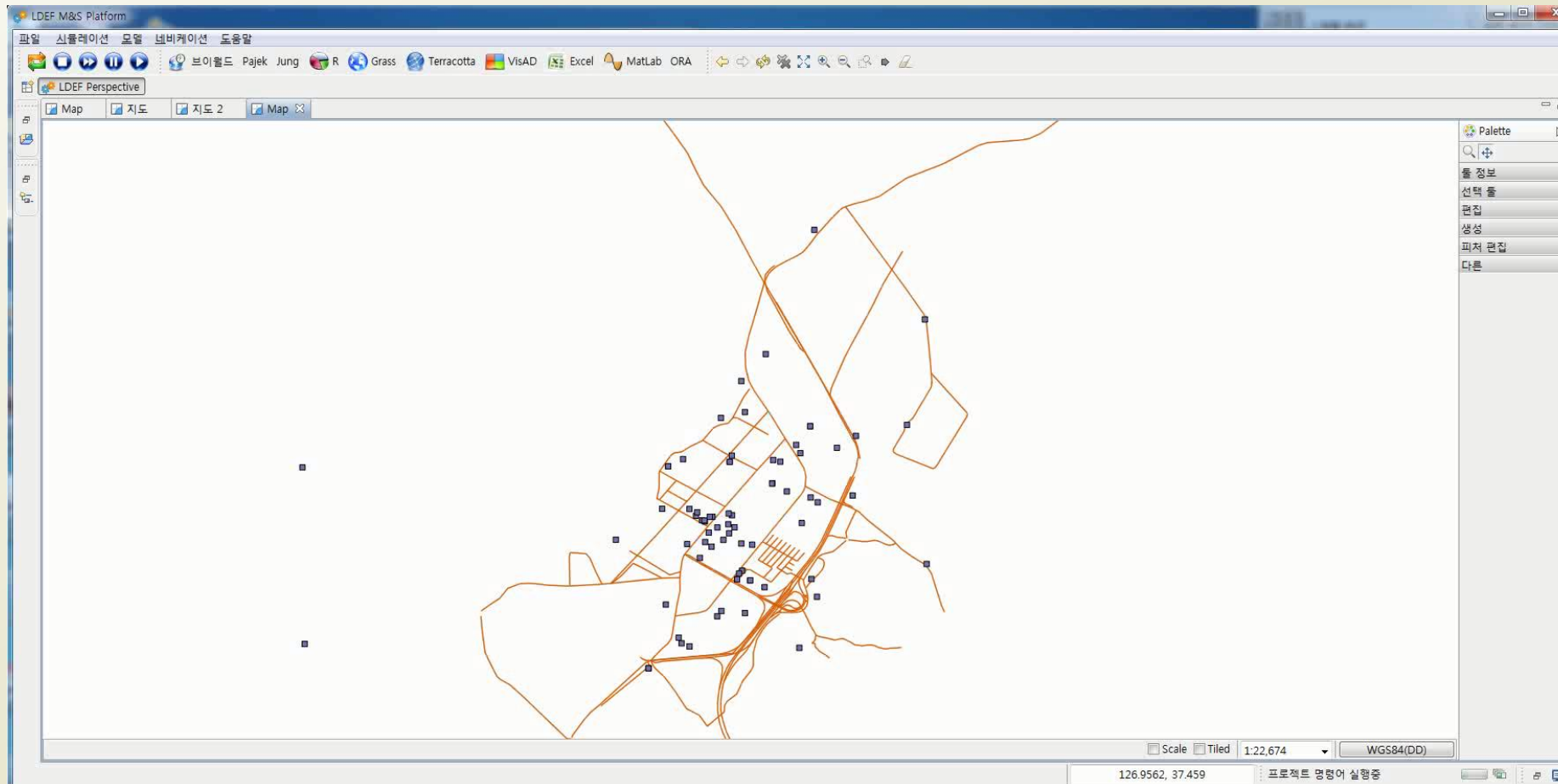
# Example: Traffic Network Modeling

- Traffic
  - Agent: individual vehicles
  - Space: road network
- Problem
  - No center control of agents
  - Agents choose their route based upon the latency from the selfish and rational perspective
  - Then, how to model and simulate this distributed traffic agent model?

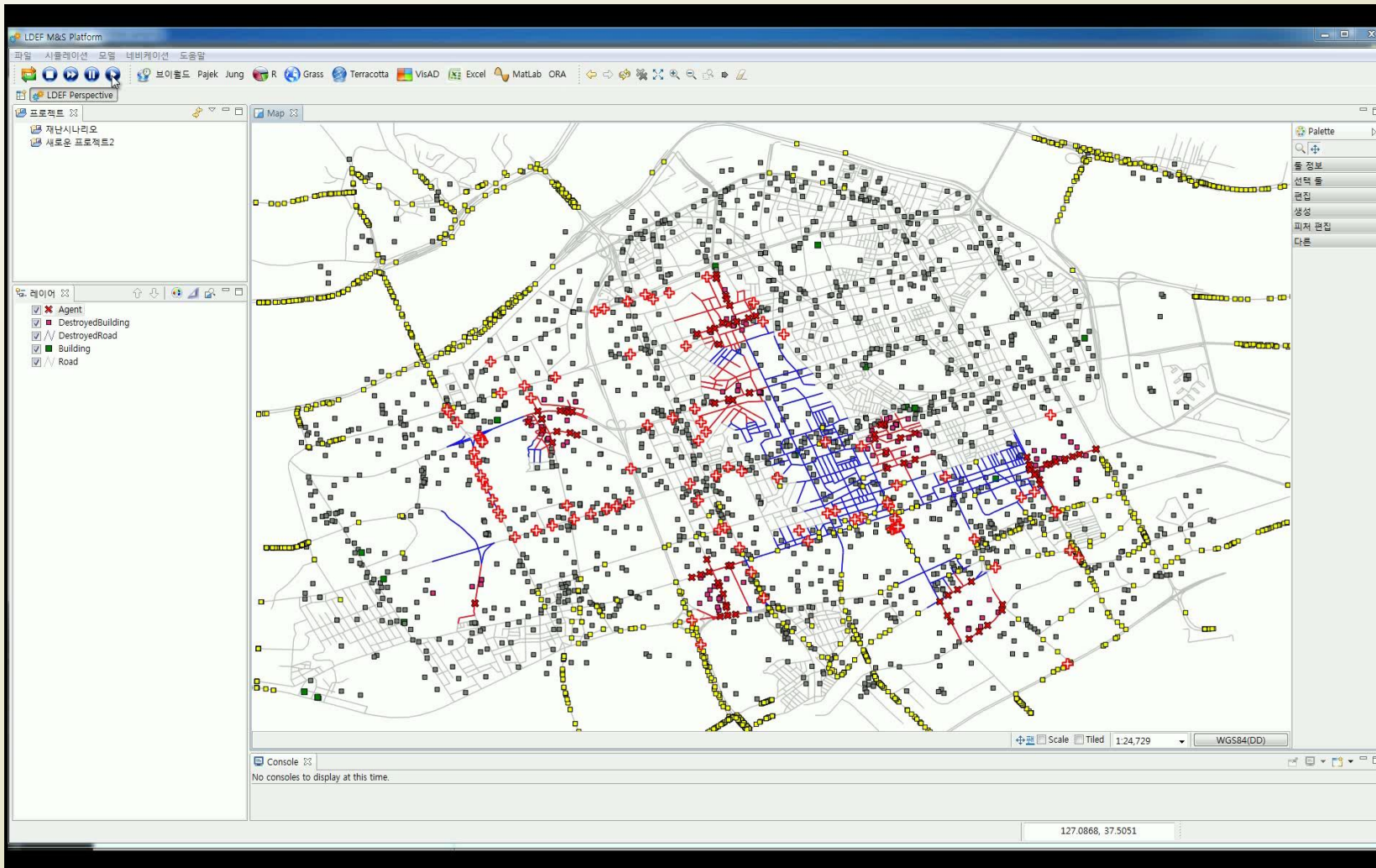




# Traffic Model



# Emergency Response Routing

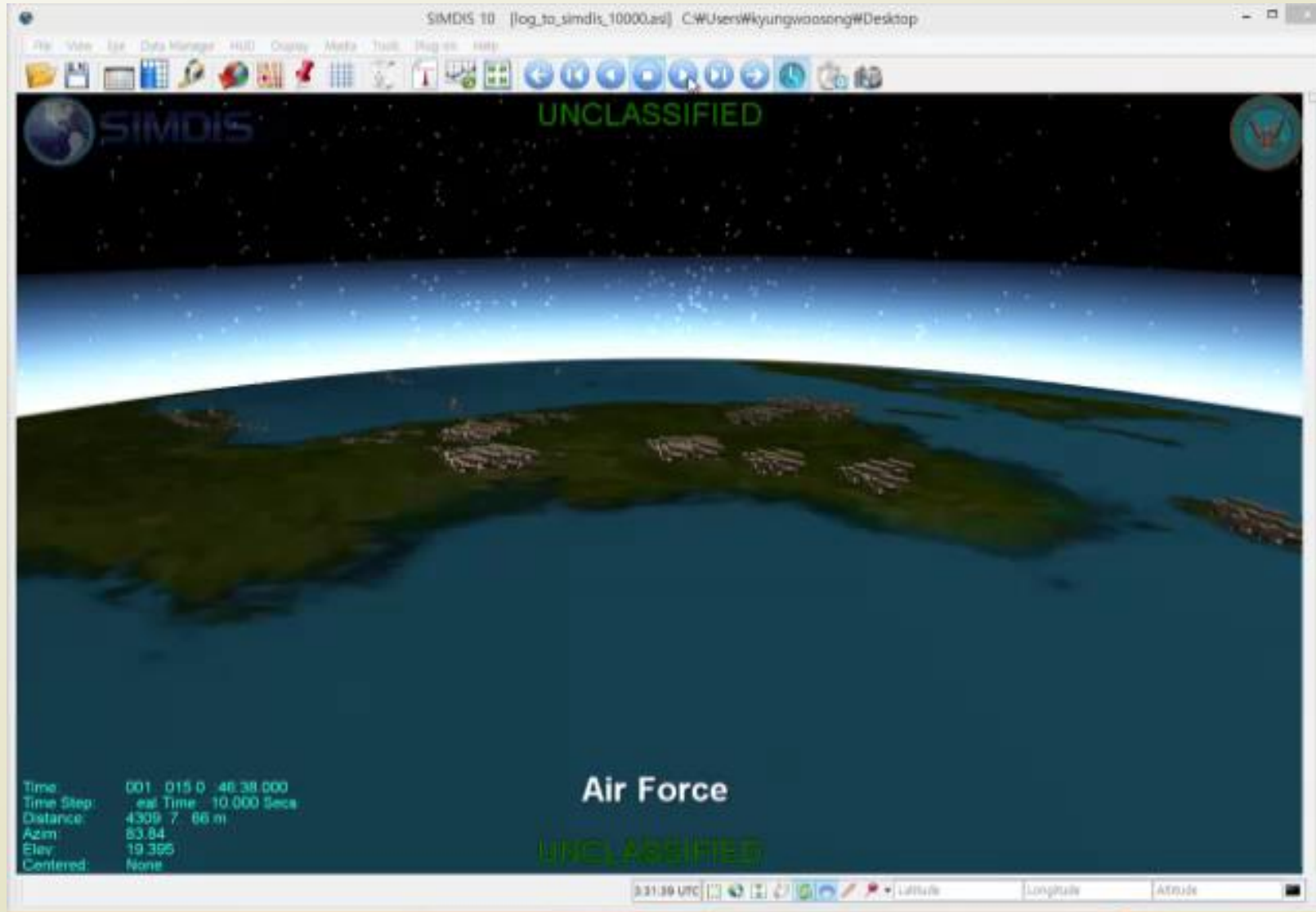


# Simulation for Military Training





# Simulation for Missile Defense

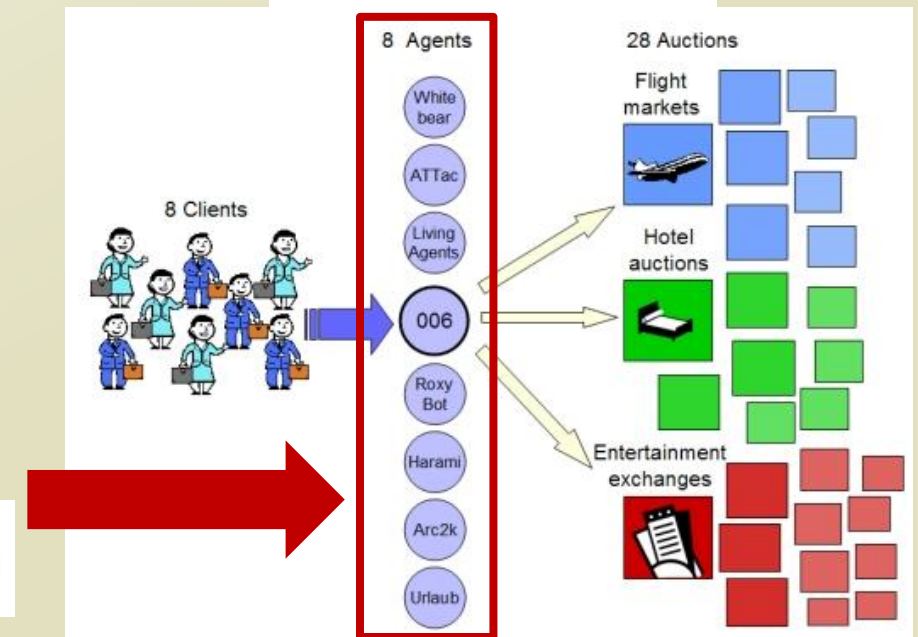


# Example: Trading Agent Competition

- Trading Agent Competition
  - An international forum
    - To promote high quality research into the **trading agent** problem
    - Basically, each research group produce a trading agent and starts free-for-all
    - Prof. Michael Wellman created the forum in 2002 based upon the “Travel agent scenario”
  - Then,
    - What is the trading agent?
    - Why does the trading agent problem receive attentions?
  - Let's follow the history of TAC



## Travel Agent Scenario TAC Classic



# Trading Agent Competition : PowerTAC

