Introduction to Agent Based Modeling

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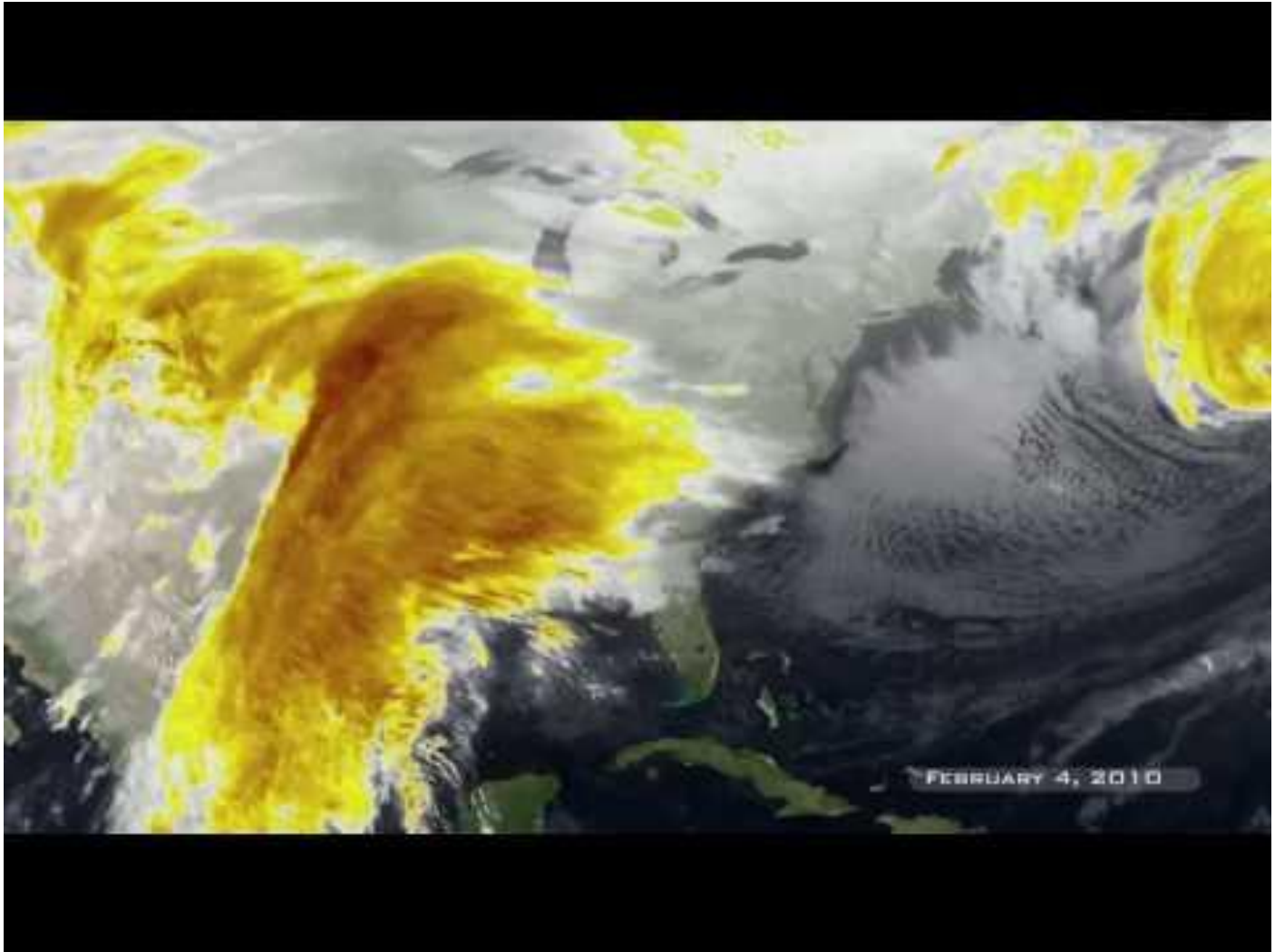
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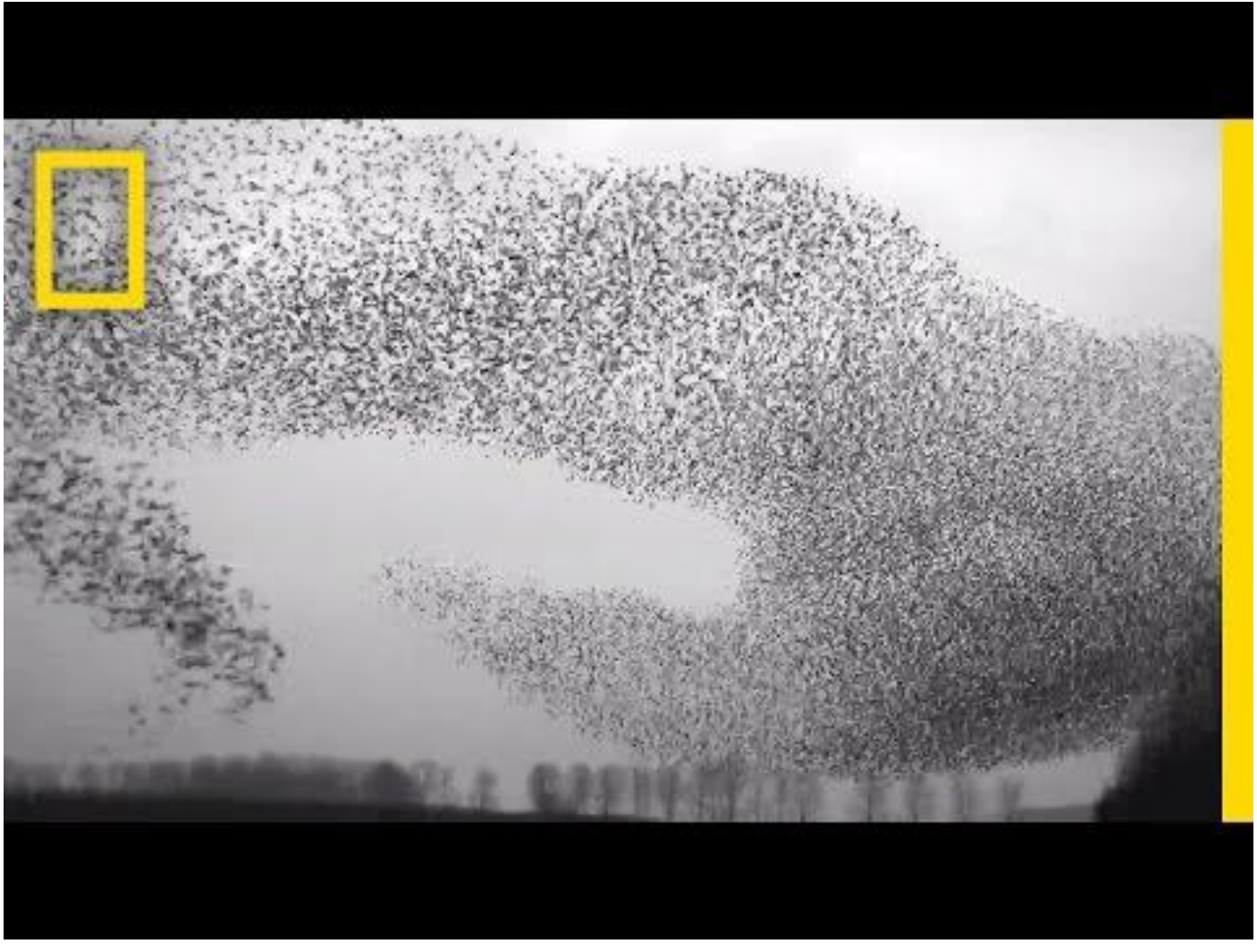
Inspirations for Agent or “individual” based Models

- Starling “murmurations”

STARLING MURMURATIONS

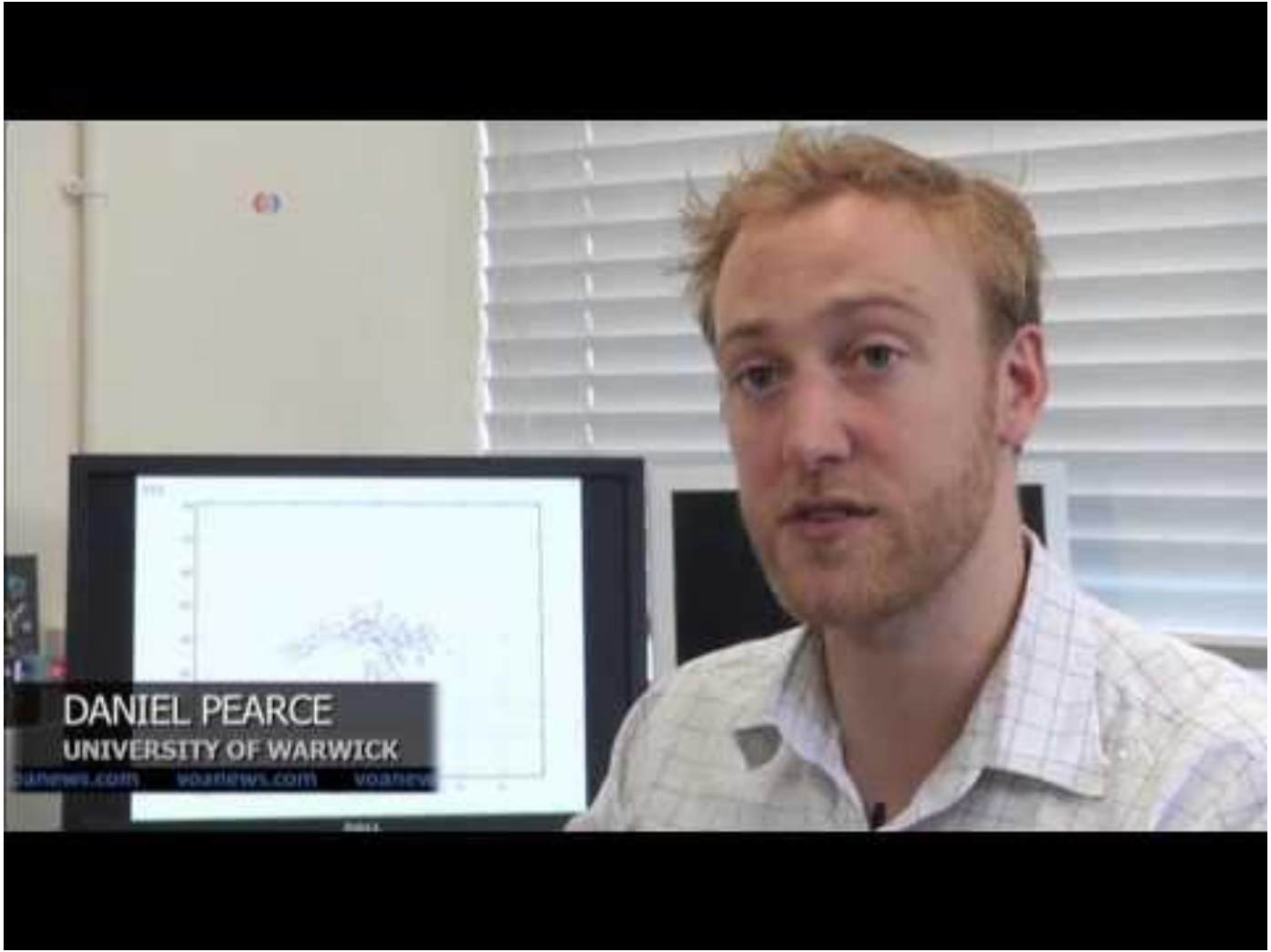
Starlings are a small to medium-sized passerine (perching) birds from the family Sturnidae.

They produce an interesting flocking phenomenon called “murmurations” which baffled scientists



“Murmurations” answered

- This seemingly complex and eerie phenomenon was answered
- The results were very surprising
  - there is no rehearsal
  - there is no coordination or communication
  - there is no hierarchy or leader
- This seemingly complex structures **emerge** out of simple “local” behavior
  - I’ll let the scientists do the talking (University of Warwick)

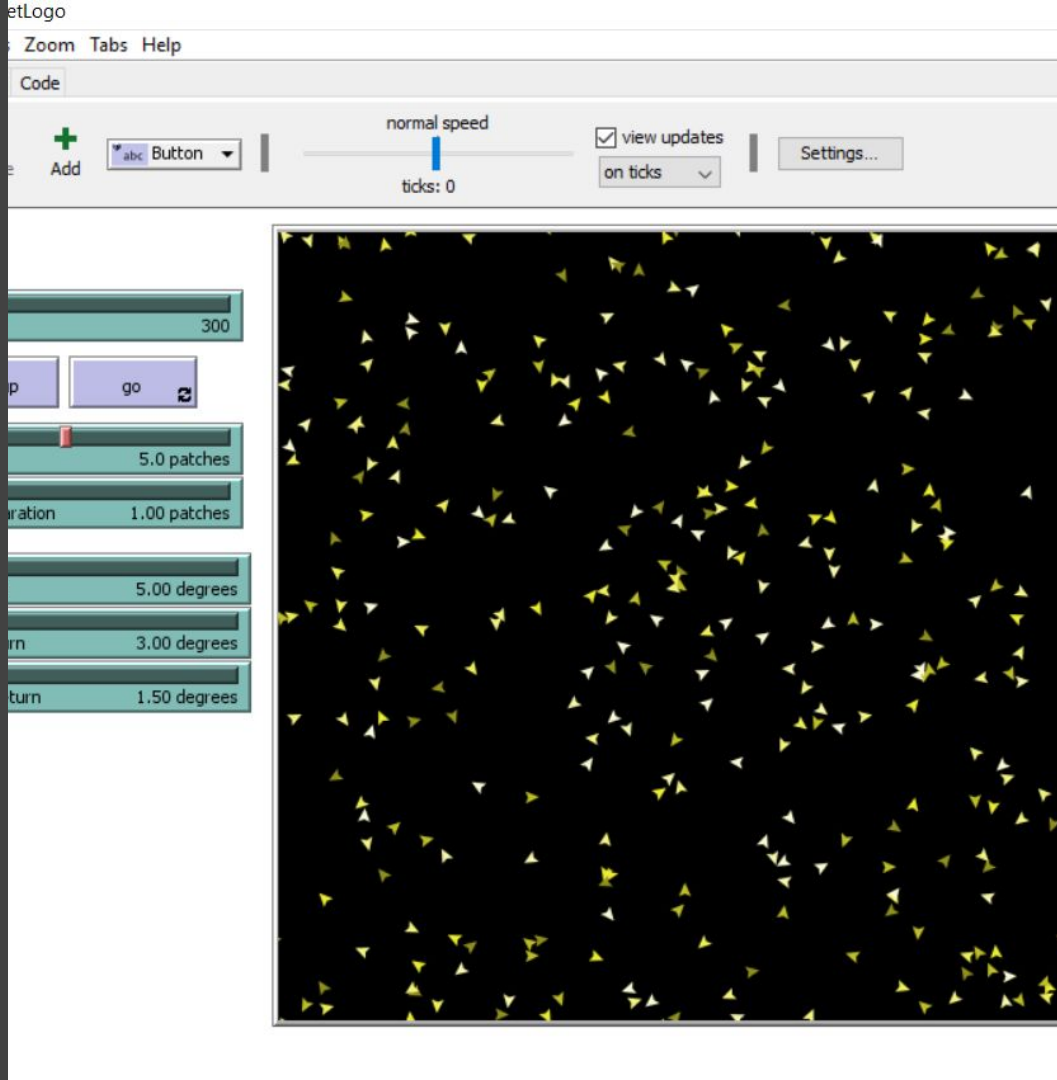

DANIEL PEARCE
UNIVERSITY OF WARWICK

Inspirations for Agent or “individual” based Models

- Starling “murmurations”
- Fish schooling
- Human Intelligence?
  - At least connectionists think so
  - Most Won’t Disagree

Now let's look into our own

- Let's see the model of flocking in NetLogo Model Library
- You will learn more about NetLogo in this course



Interesting....but is it useful?

- Other than studying interesting natural phenomenon where can we apply agent based modeling?
- Motivating example: Epidemiology
  - A severe Rabies outbreak in Europe
  - (Jeltsch et al. 1997) ABM model accurately simulated the spread of rabies over both space and time.
  - Dirk Eisinger and Hans Hermann Thulke modified the ABM specifically to evaluate how the distribution of vaccination affects rabies
  - **A big Success Story!**
- Can you name a "disease" that ABM could be used for investigating the spread and control strategies? Hint: Its starts with “C”

What about in the Industry?

- **Operations research/Operational Research/Operations Analysis** is a discipline that deals with the application of advanced analytical methods to help make better decisions
- ABM has proven itself many times in Operations Research


Product Delivery
Animation
Statistics
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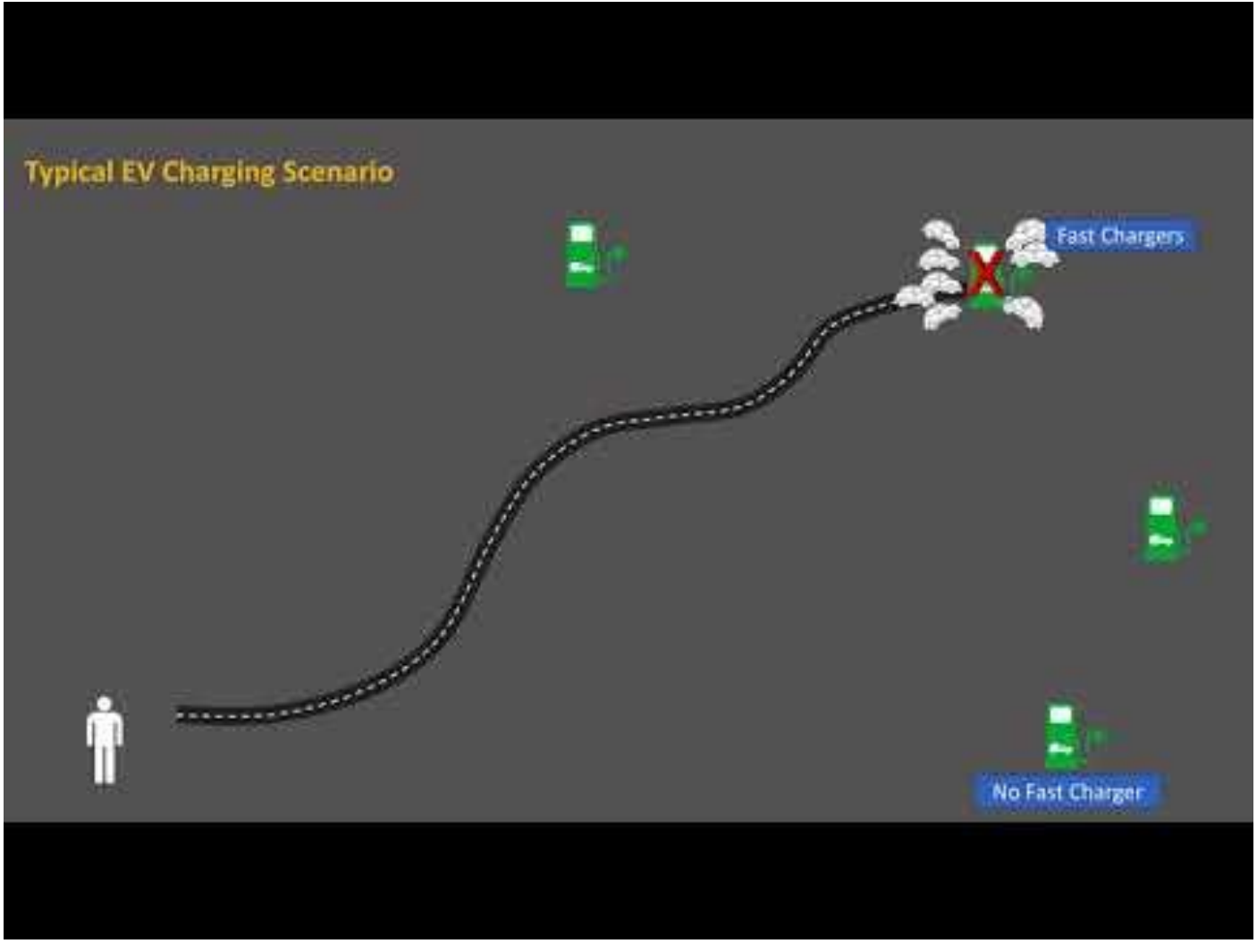
Industry examples

- Southwest Airlines used an agent-based model to improve how it handled cargo (Seibel and Thomas, 2000).
- Eli Lilly used an agent-based model for drug development (Bonabeau, 2003a).
- Pacific Gas and Electric: Used an agent based model to see how energy flows through the power grid (Bonabeau, 2003a).
- Procter and Gamble used an agent-based model to understand its consumer markets (North et al., 2010)

More Industry examples

- Hewlett-Packard used an agent-based model to understand how hiring strategies affect corporate culture (Bonabeau, 2003b).
- Macy’s used ABM for store design (Bonabeau, 2003b).
- NASDAQ used it to explore changes to Stock Market's decimalization (Bonabeau, 2003b; Darley and Outkin, 2007).
- ABM has been used to explore capacity and demand in theme parks (Bonabeau, 2000).


Typical EV Charging Scenario
Fast Chargers
No Fast Charger

Widely applied in the following domains

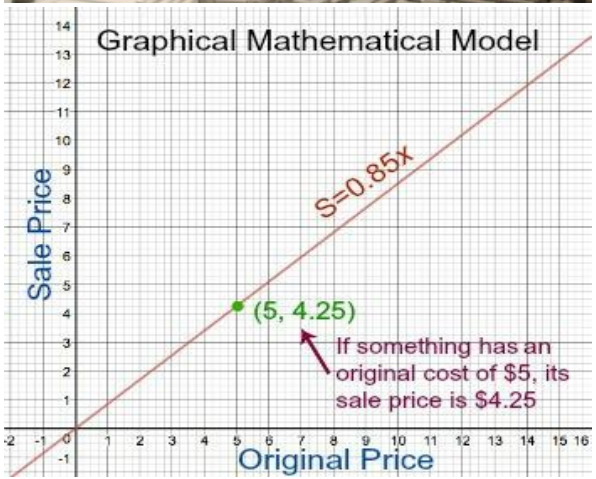
- Traffic and Pedestrian Modeling
- Epidemiology, Disease dynamics
- Ecological Studies
- Many more.....
- In general we can say
    - We can study any/most dynamic adaptable complex systems

But what is a “model”?

“ A model is a ***purposeful representation*** of some real system “ (Starfield et al. 1990)

“By a model, we mean an **abstracted description** of a process, object, or event” (Wilensky, Uri 2015)

“a **simplified representation** of a system intended to promote understanding of the real system (Bellinger 2004)”



An easy way to understand " model "

- Helps you to **understand** how something works (or ***looks***)
- Helps you make **predictions**
- Which can then help you **answer questions** and **solve problems**
- But remember
  - Models make assumptions
  - In the process of simplification, it misses out certain detail/info deemed irrelevant for answering the questions

" All models are Wrong, but some are useful" - George Box

What are Agent Based Model(s)?

- A **computational model** is a model that takes certain input values, manipulates those inputs in an algorithmic way, and generates outputs.
- **Agent Based Models** are computational models where
  - individuals or agents are described as unique and autonomous computational entities
  - The agents interact with each other in a simulated environment, locally
  - Agents may represent organisms, humans, businesses, institutions, and any other entity that pursues a certain goal
- In Certain fields it is also called as “Individual” based modeling
  - Some argue that they are the same. Some would argue that there are minor differences...

Agent Based Modeling

Agents – individuals with specific characteristics: location, behavior, etc.

Agent Based Modeling

Environment – The simulated world where these agents are deployed

Agent Based Modeling

Agent-to-Agent Interaction - How agents interact (cooperate/compete/coexist) with other agents

Agent Based Modeling

Agent-to-Environment Interaction – How agents are affected-by/reacts-to the environment and How the environment is affected by the action(s) of the agent(s)

Agent Based Modeling

Is the idea that the world can be modeled using

- **Agents** – individuals with specific characteristics: location, behavior, etc.
- **Environment** – The simulated world where these agents are deployed
- **Agent-to-Agent Interaction** - How agents interact (cooperate/compete/coexist) with other agents
- **Agent-to-Environment Interaction** – How agents are affected-by/reacts-to the environment and How the environment is affected by the action(s) of the agent(s)

Some Logistics discussion

- Tutorial
- UG3 v UG4
- Projects
  - Individual Participation marks
- Slides

A simple class participation Quiz/Survey