Modeling of Complex Social Systems

MATH 800

Fall 2011

Complex Social Systems

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- A **complex system** is a system whose behavior cannot be easily or intuitively predicted

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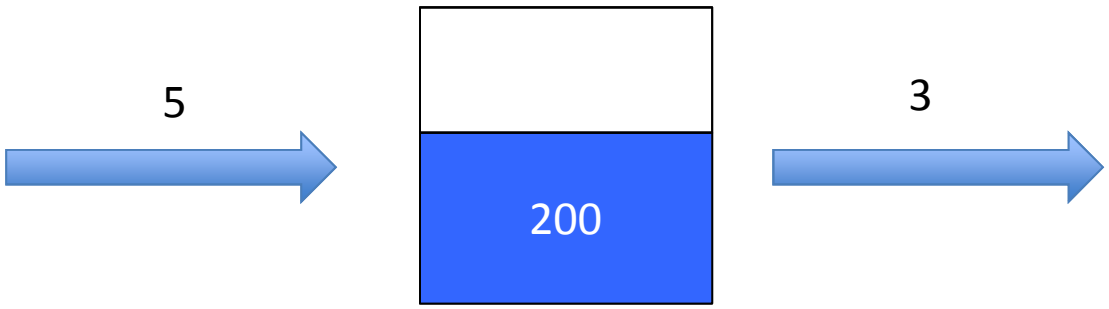

$300 = (5-3)\,t + 200$

Complex Social Systems

- A **social system** is a collection of individuals and interactions.
- A **complex social system** is a complex system whose behavior is primarily the result of the behavior of individuals

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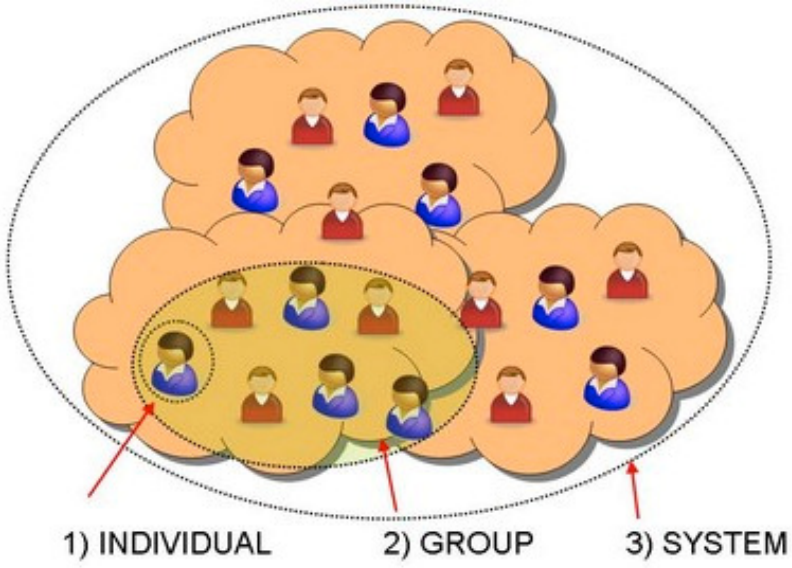


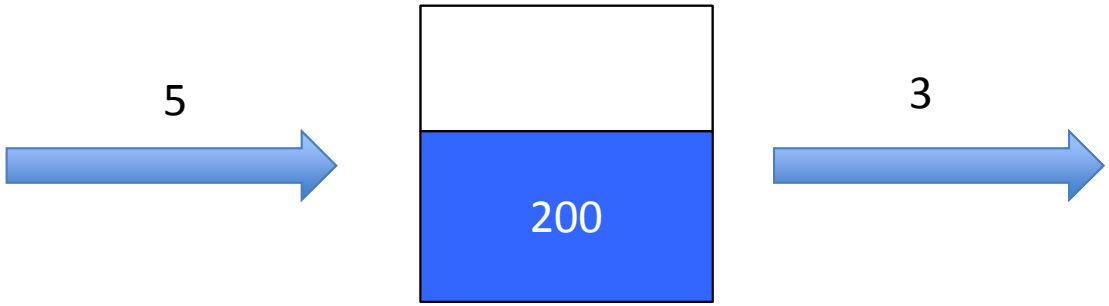
What is Modeling?

- is abstraction of reality!
- is a representation of a particular phenomena, idea, or condition.
- is never perfectly accurate.

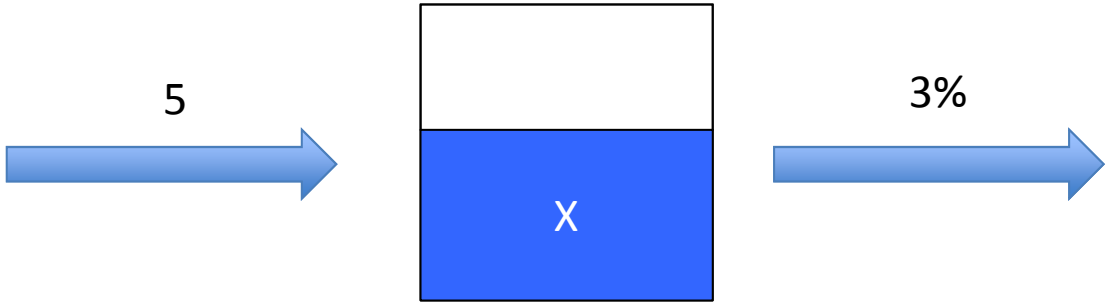
What is Mathematical Modeling?

- Framing questions in/about the real world in mathematical terms.
- Simplified representations of some real-world entity in equations
- It is characterized:
  - Variables (the things which change)
  - Parameters (the things which do not change)
  - Functional forms (the relationships)

What is Mathematical Modeling?



$$300 = (5-3)\,t + 200$$



$$X(t) = (5-3\%\ X(t-1)) + 200$$

Purpose of Modeling

- In General, Modeling helps
  - Answering specific questions
  - Understanding problems better
  - Communicating with others

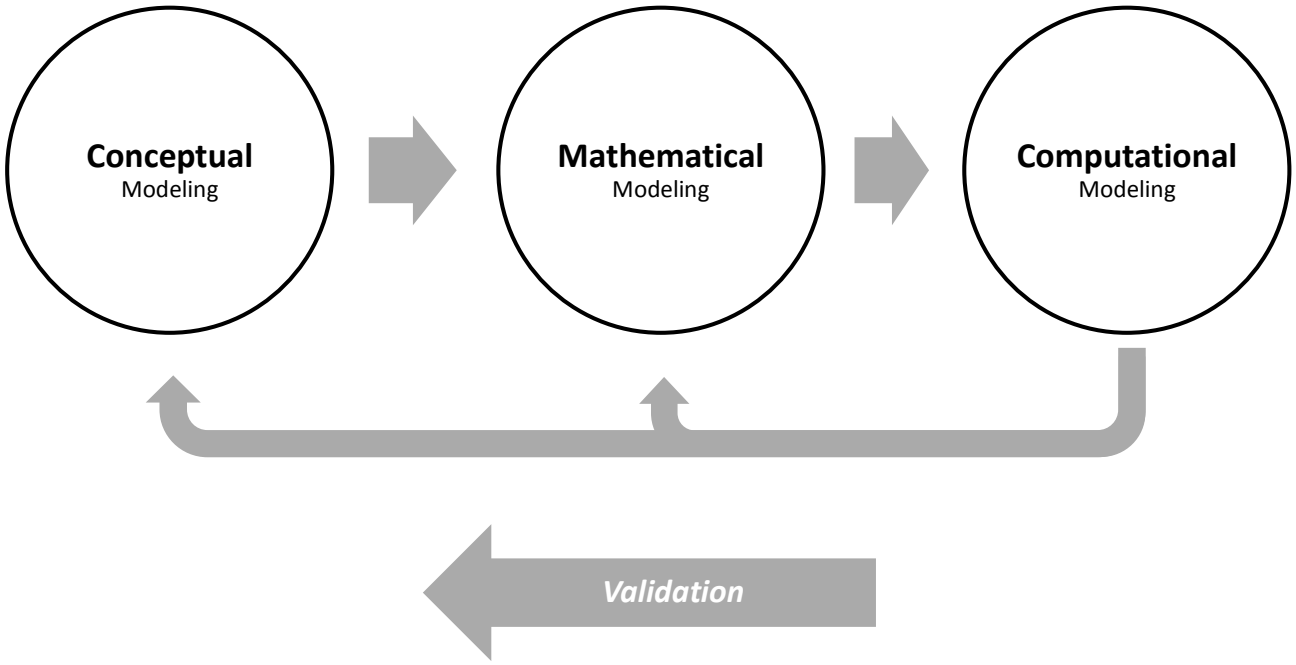
First Steps in Modeling

- Define systems and boundaries.
- Simplify assumptions.
- Draw an overall block diagram

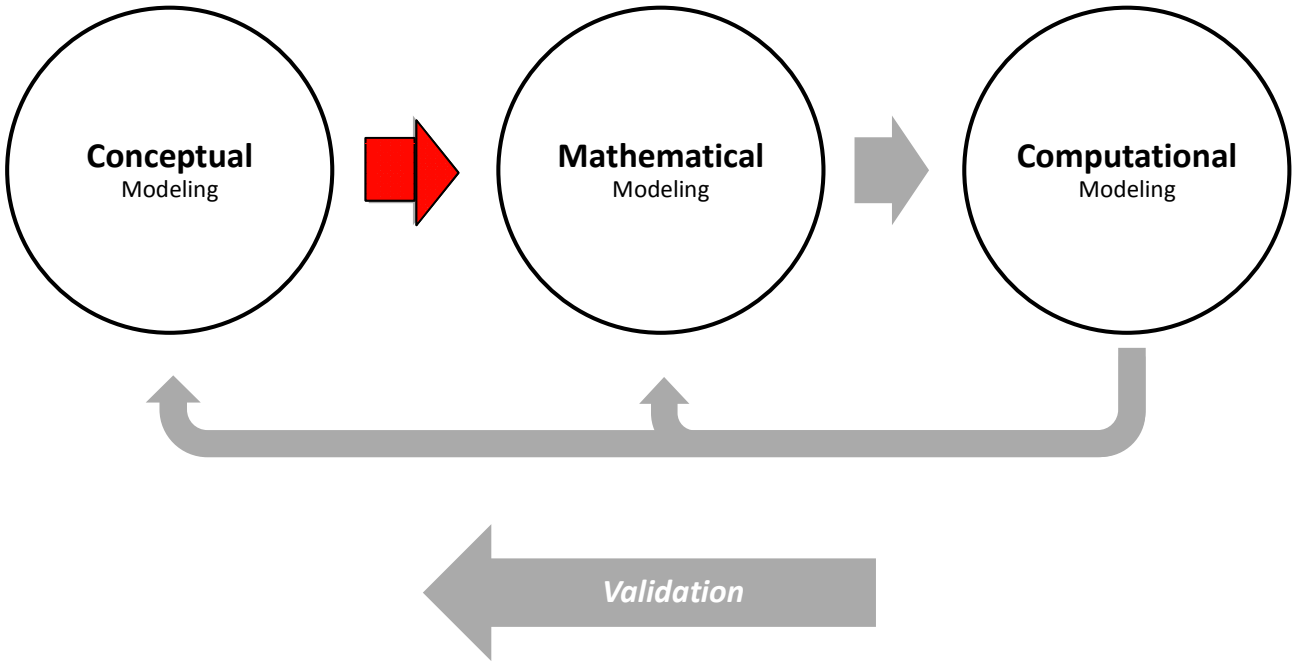
Good Models

- Simple
  - Have clearly defined questions
  - Have clearly stated assumptions
- Adaptable
- Reproducible
  - Have clearly defined variables
- Validated
  - Use the best data available
  - Interpret results with caution

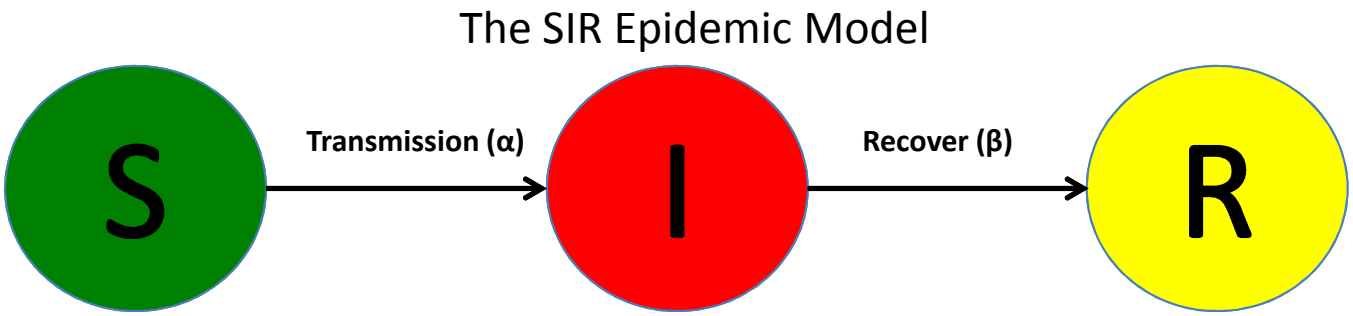
The Modeling Process



The Modeling Process



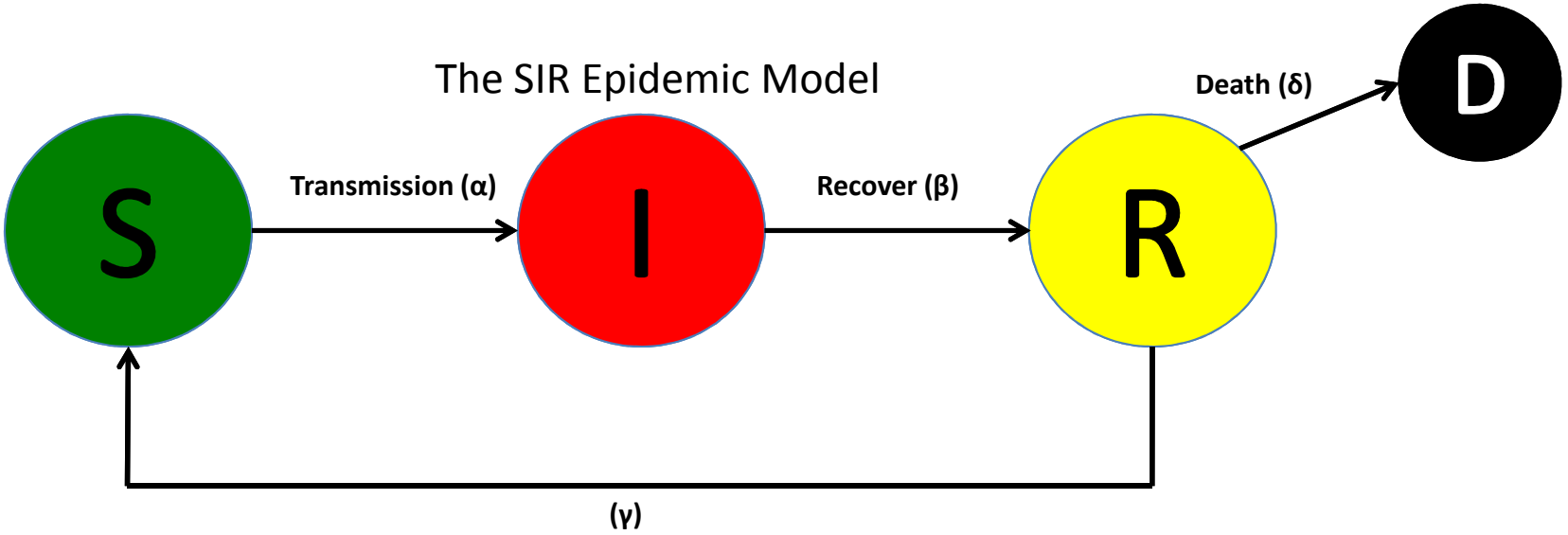
A Conceptual Modeling Diagram



Susceptibles (*S*): Individuals susceptible to the disease
Infectious (*I*): Infected Individuals able to transmit the parasite to others
Recovered (*R*): Individuals that have recovered, are immune or have died from the disease and do not contribute to the transmission of the disease

Parameters: α, β
Variables: S, I, R

A Conceptual Modeling Diagram



Susceptibles (*S*): Individuals susceptible to the disease
Infectious (*I*): Infected Individuals able to transmit the parasite to others
Recovered (*R*): Individuals that have recovered
Death (*D*): Individuals that have died from the disease

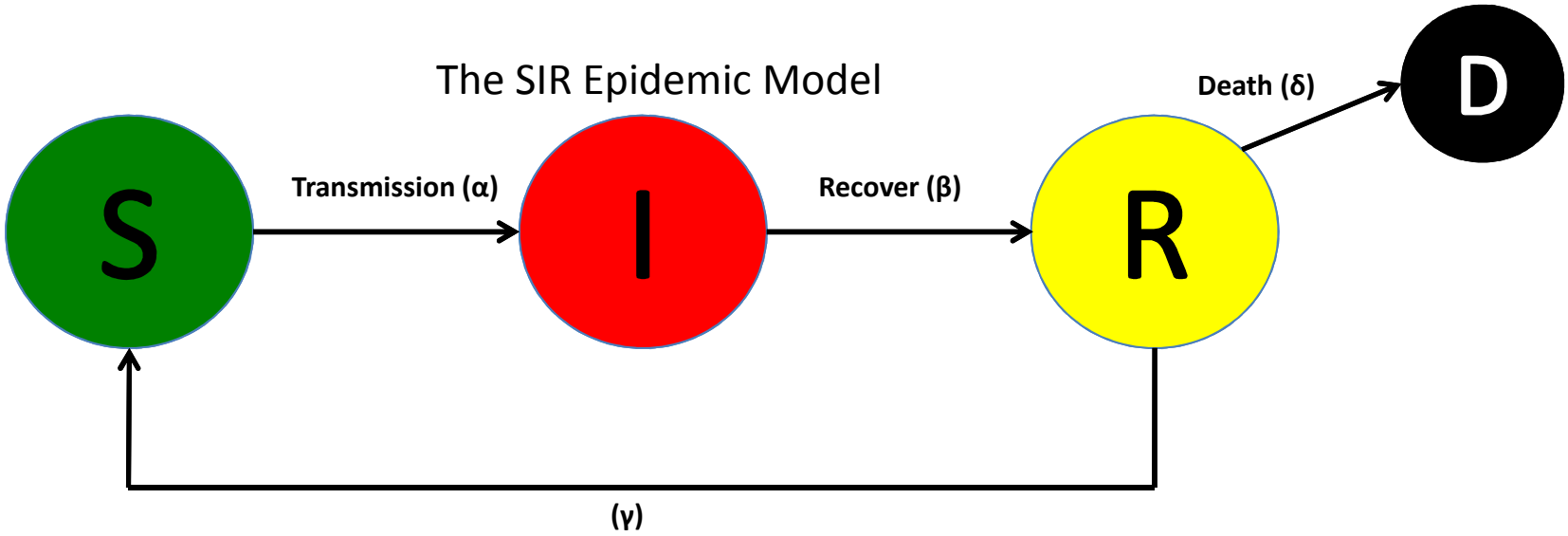
Parameters: α, β, γ, δ
Variables: S, I, R, D

Computational Modeling

- **Simulation:** Simulation is any technique for analyzing, designing, and operating complex systems.
- **Visualization:** Visualization is any technique for creating images, diagrams, or animations to communicate and describe the behavior of complex systems.

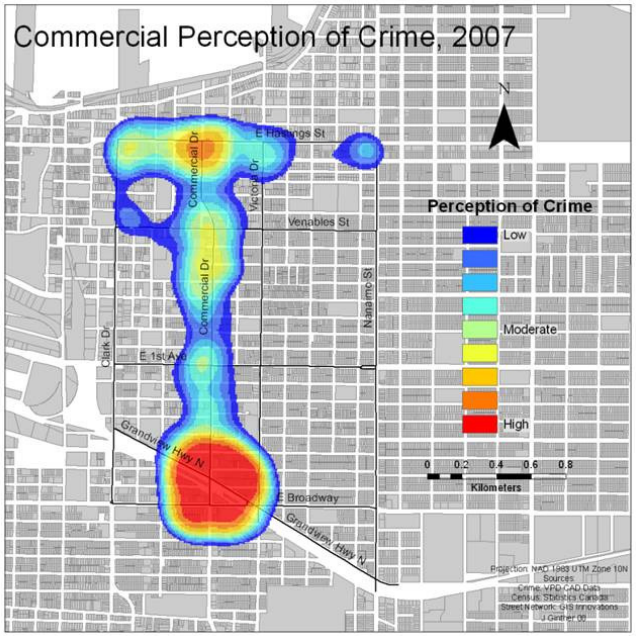
Types of Mathematical Models

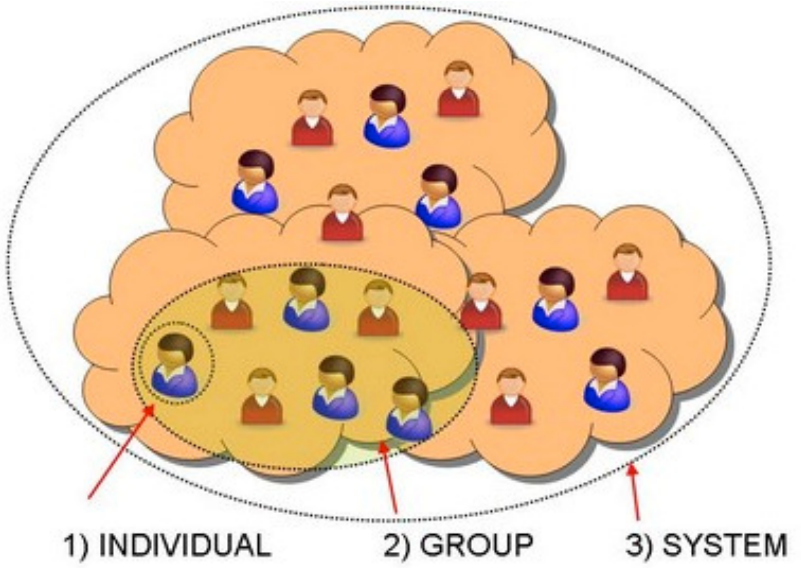
- Linear vs. Non-linear Models
  - In linear models all the variables and the parameters are connected by linear equations. Otherwise the model is non-linear.



Types of Mathematical Models

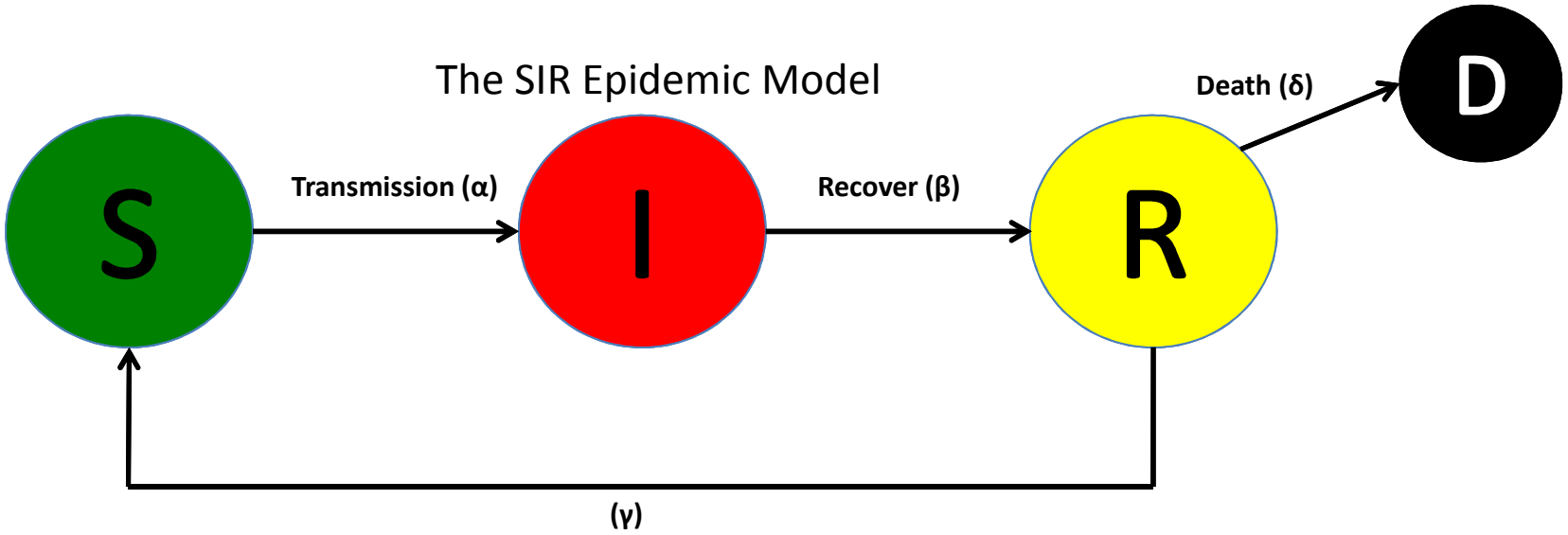
- Aggregate vs. Individual Models





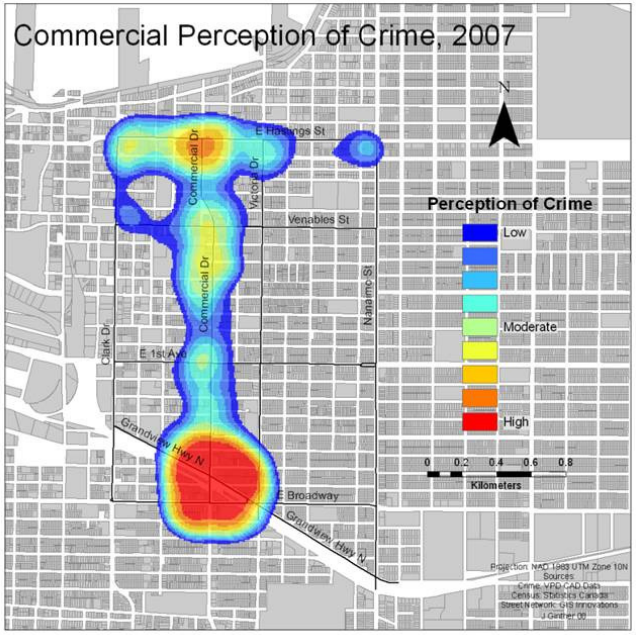
Types of Mathematical Models

- Deterministic vs. Stochastic Models
  - Deterministic models have no uncertain components (no parameters are characterized by probability), as opposed to stochastic models



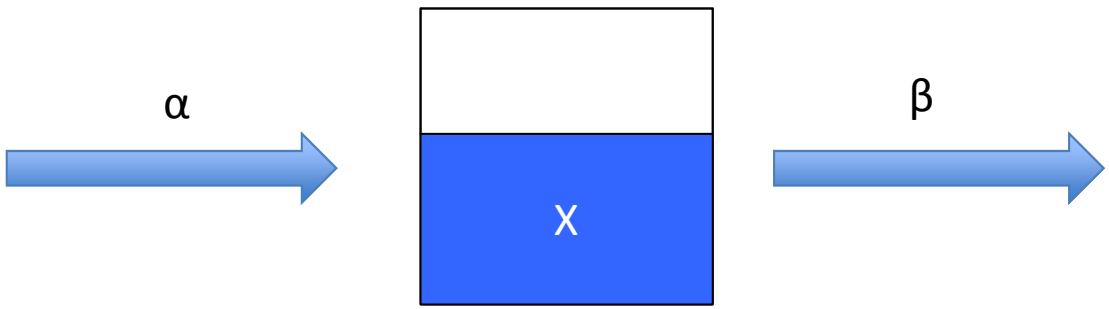
Types of Mathematical Models

- Static vs. Dynamic Models
  - A dynamic model refers to a system that changes over time, whereas static model refers to a system that is at steady state
  - Dynamic model is a representation of the behavior of the static components of the system.



Types of Mathematical Models

- Continuous vs. Discrete Models
  - In discrete Models variables change only at a countable number of points in time, whereas in continuous models variables change in a continuous way.



Types of Mathematical Models

- Qualitative vs. Quantitative Models
  - Quantitative models lead to a detailed, numerical predication about responses, whereas qualitative models lead to general descriptions about the responses.