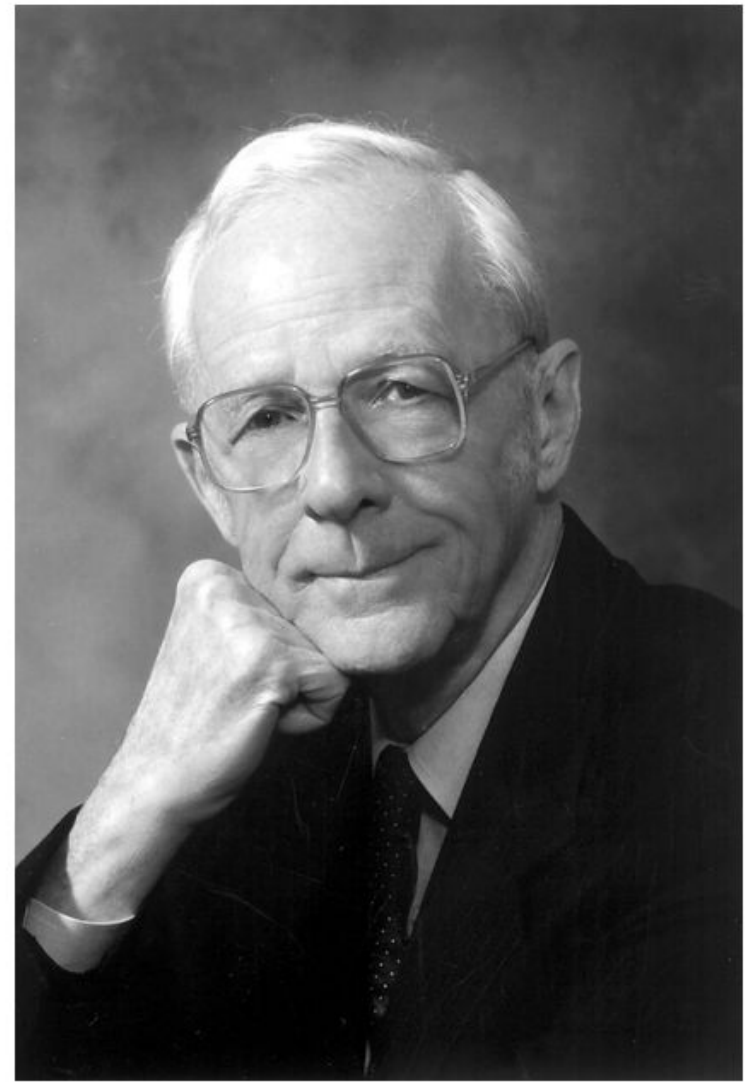
System Dynamics

System Dynamics

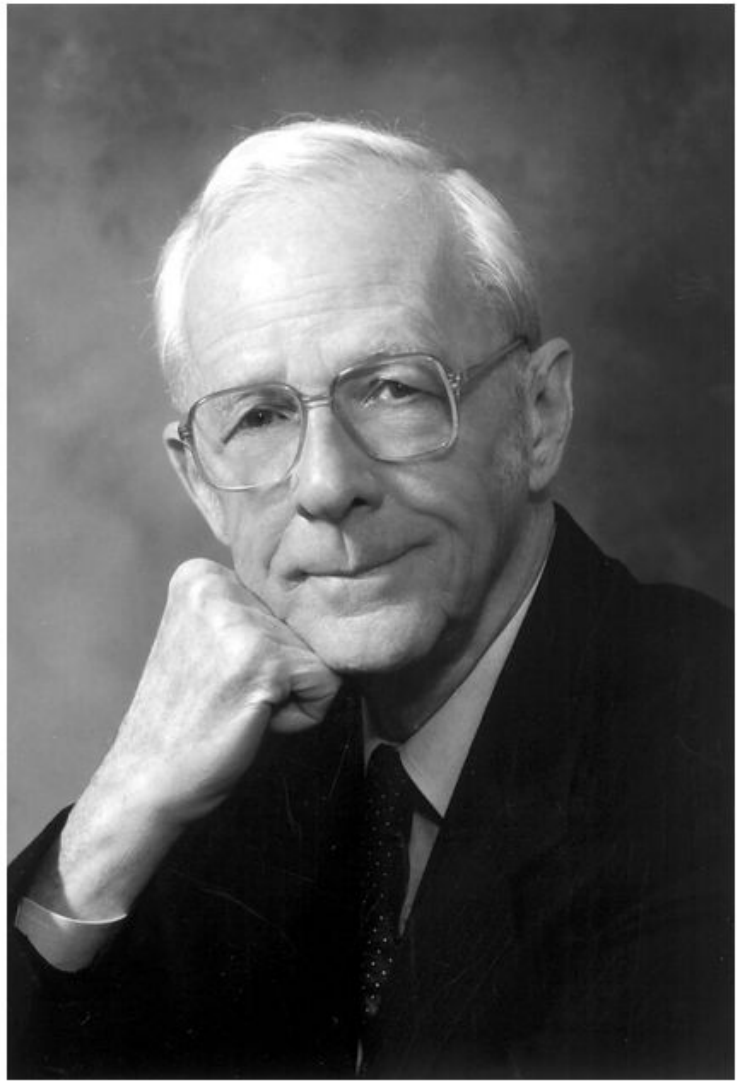
- System dynamics has its roots in systems of difference and differential equations (Forrester 1980).
- A target system, with its properties and dynamics, is described using a system of equations.
- The equations derive the future state of the target system from its actual state.
- System dynamics is restricted to the macro level in that it models a part of reality (the ‘target system’) as an undifferentiated whole

“If you can think it, you can model it.”



System Dynamics is a method for analyzing Complex Systems that uses computer simulations to reveal how known structures and policies often produce unexpected and troublesome behavior (Emergence)

- Jay Forrester, MIT



Complex Systems (A more structured definition)

- Complex system consists of **many interacting parts**
  - *Have a hierarchy of subsystems*
- ***No centralized control****: coherence/organization emerges from just local interactions alone*
- ***Non linear*** *(the whole is greater than the some of the parts)*
  - *The output is far greater than what individuals can accomplish in isolation*
  - *Has feedback loops which causes large effects even for minor changes*
  - *Dense or high level of interconnectivity making it somewhat irreducible*
  - *Aggregate properties or behaviour is not predictable (at least not easily!)*
- ***Autonomy and adaptation***

But remember there is no single acceptable definition and the boundary between the definition of simple-system<-> complex system is somewhat grey

System Dynamics vs Differential equations

- Discrete time is used as a coarse approximation for continuous time to achieve numerical solutions.
- Functions of all kinds, not just continuous functions, can be used.

Basic Building Blocks of Systems Dynamics

1. Stocks
2. Flows
3. Converters
4. Connectors (Influences)

Stock

A stock represents an amount you want to track in a model. It's an accumulation. It can be concrete, like the number of trees or animals in an ecosystem or abstract, like an amount of happiness.

Bison, U.S Fish & Wildlife, Public Domain

Sunset Hopping, by Reebs, CC 3.0

Flow

Flows go into and out from stocks. The amount of “stuff” of a stock increases or decreases through one or more flows. The flow is kind of like a river flowing into or out from a lake. Some rivers flow fast, while others move very slowly. Flows work in a similar way, showing how quickly “stuff” moves in or out of a stock.

Giffre River, Wikimedia Commons, Public Domain

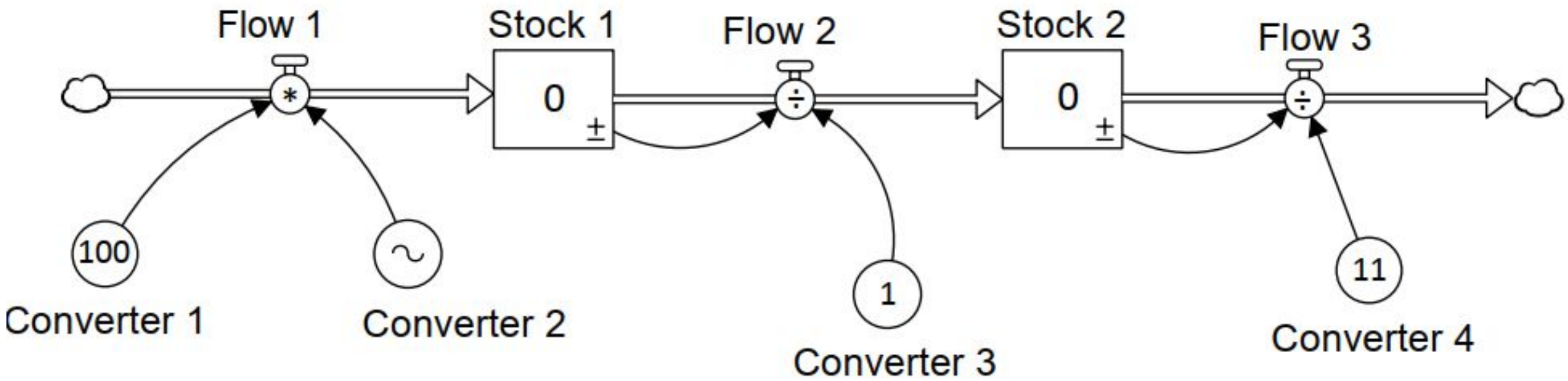
Converter

A converter represents part of how the system works, but it isn't a stock. For example, the number of people planting trees can be a converter.

Connector

Connectors show how elements affect one another. For example, the number of people planting trees affects the number of new seedlings in a forest.

Planting trees, NASA, Public Domain


Flow 1
Stock 1
Flow 2
Stock 2
Flow 3
0
0
100
Converter 1
Converter 2
1
Converter 3
11
Converter 4

Common Structures

- Feedback loops
  - Reinforcing
  - Balancing
- Delays
- Cause – Effect

Lets Practice

Item	Caffeine (mg) per serving	Caffeine (mg) per 100g
Brewed coffee	72	40
Brewed decaff coffee	1.5	1
Brewed tea	36	20
Cola	30	8
Reduced sugar cola	53	15
Red Bull	77	30
Dark chocolate coated coffee beans	336	869
Milk chocolate coated raisins	220	122
Jelly Belly Extreme Sport Beans	50	176
4Ever Caffeine Tablets	200	200