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UNIVERSITY OF TECHNOLOGY



UNIVERSITY OF GOTHENBURG

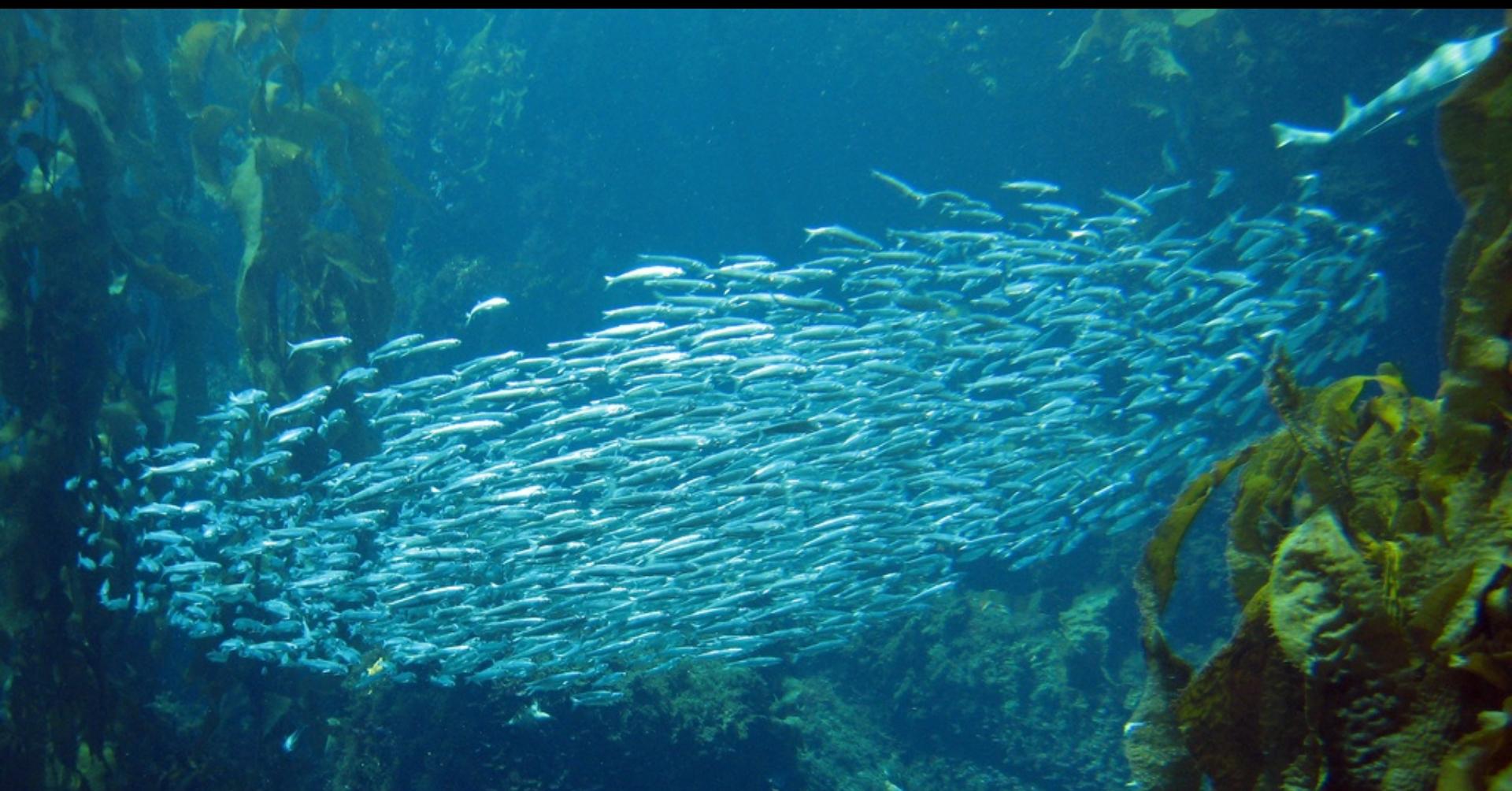
Adaptive systems: a primer (with a focus on feedback control)

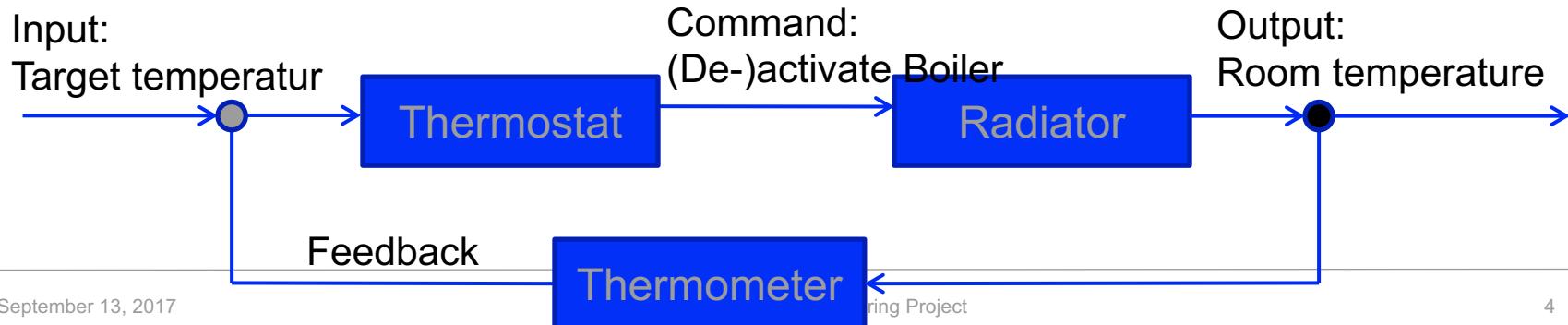
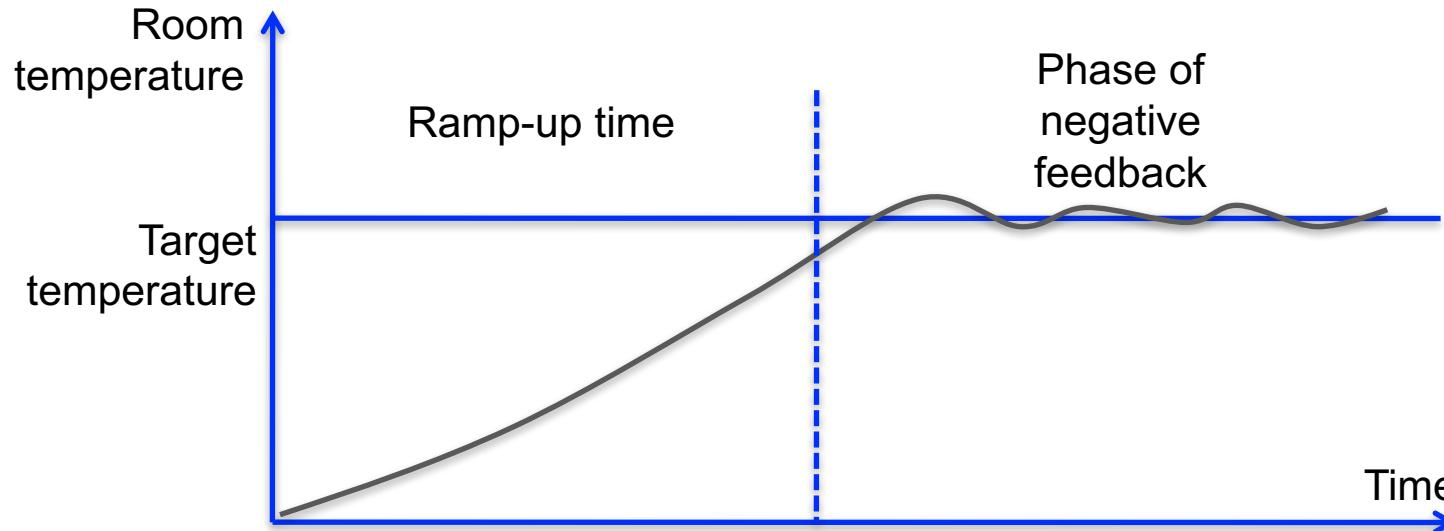
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September 13, 2017

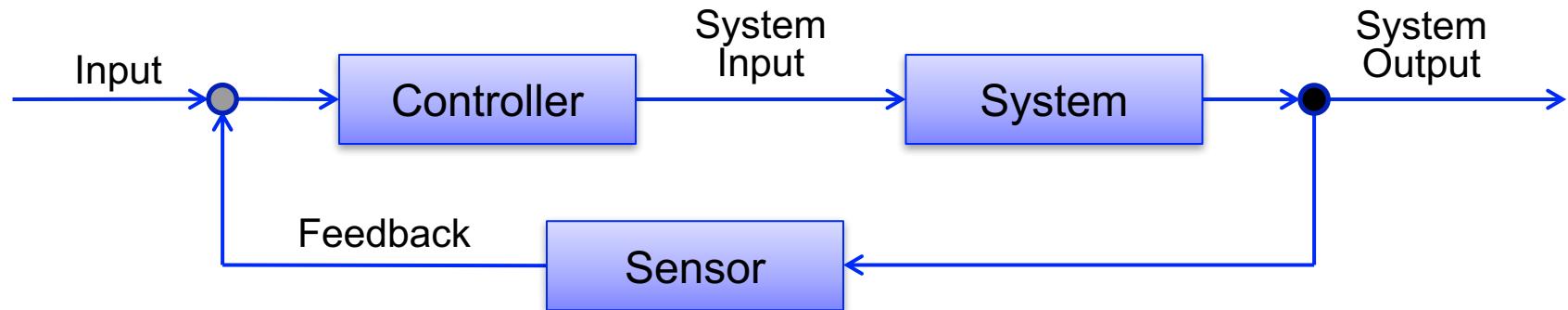
Jan-Philipp Steghöfer



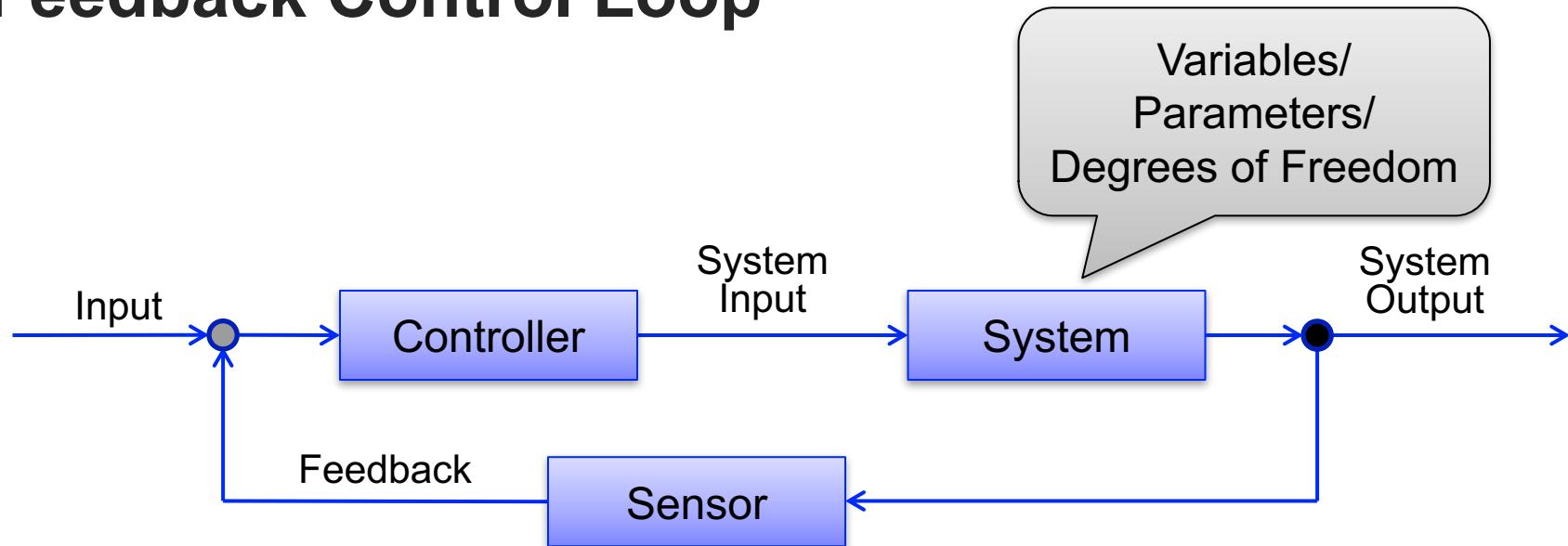




Feedback Control Loop

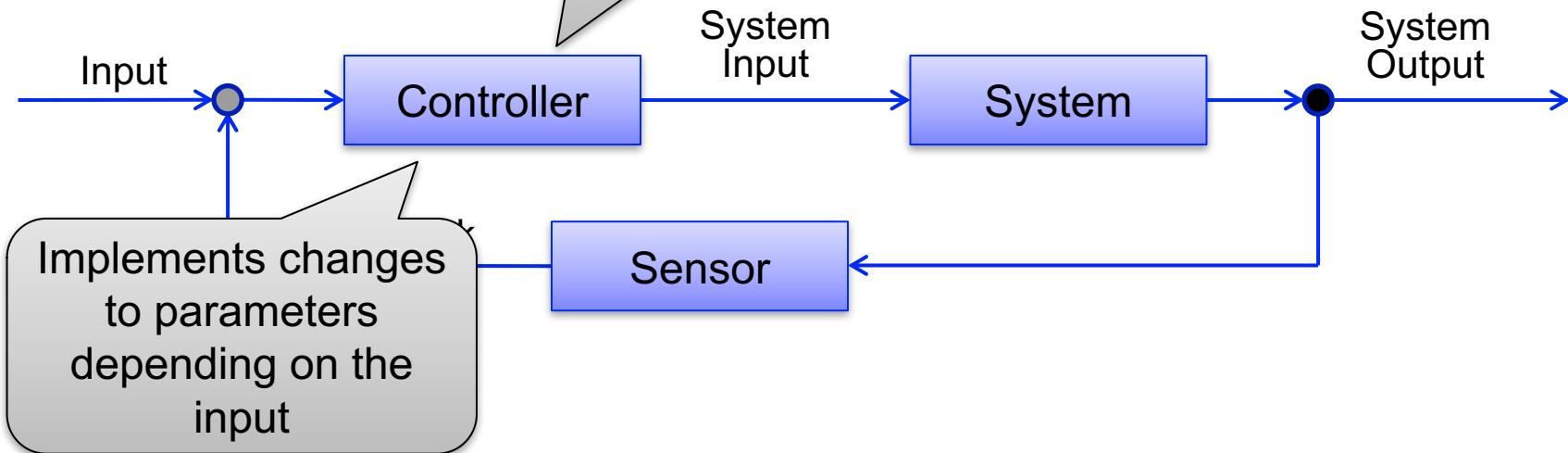


Feedback Control Loop



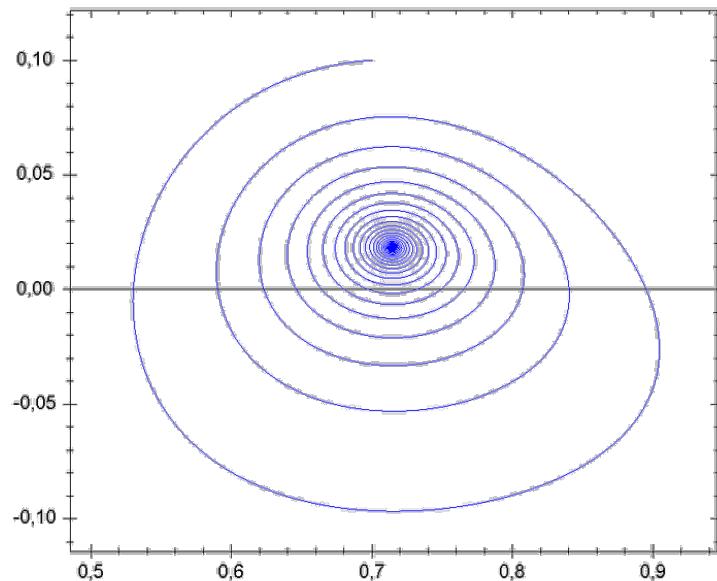
Feedback Control

Goal: reach and maintain stable state (homeostasis)



State space and degrees of freedom

- Space of all possible states of the system (also: phase space)
- n-dimensional, where n is the number of system variables (each variable defines an axis)
- Every possible system state is a point in space



Equilibria

- Usually attractors or saddle points



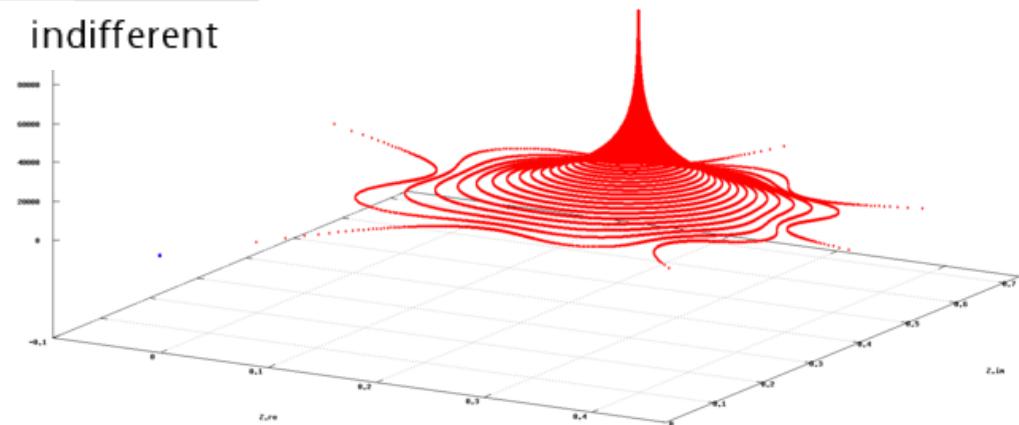
stabil



labil



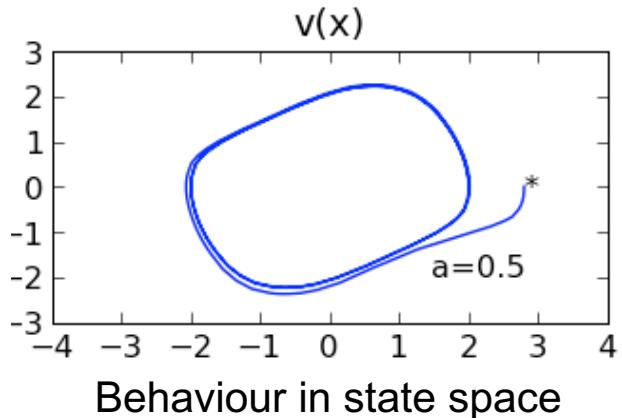
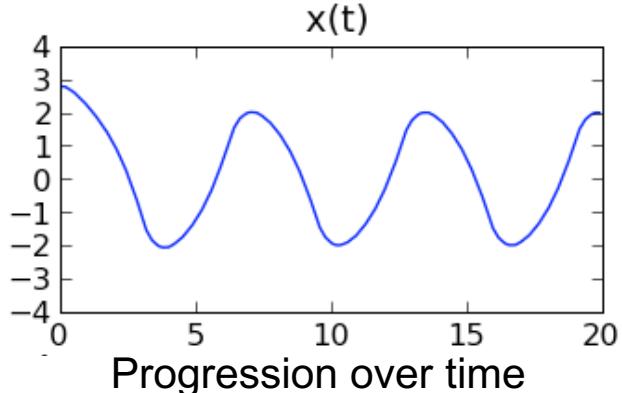
indifferent

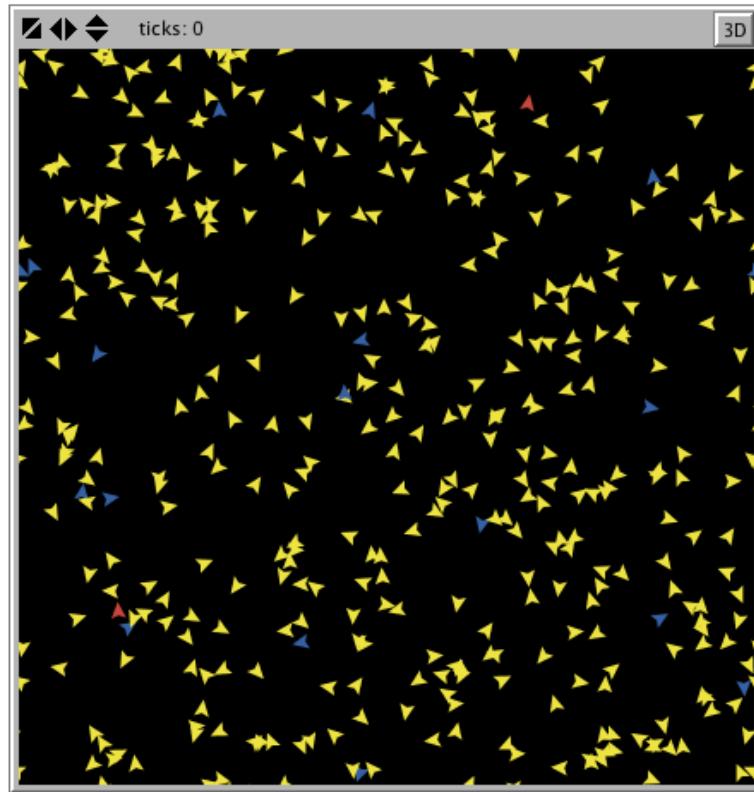
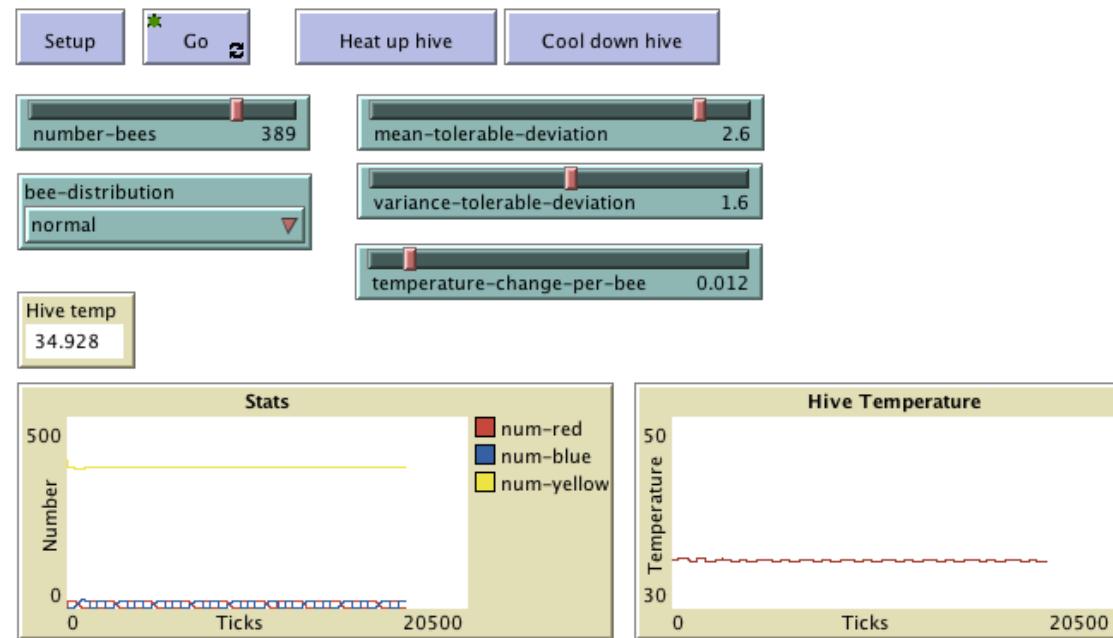


Oscillations

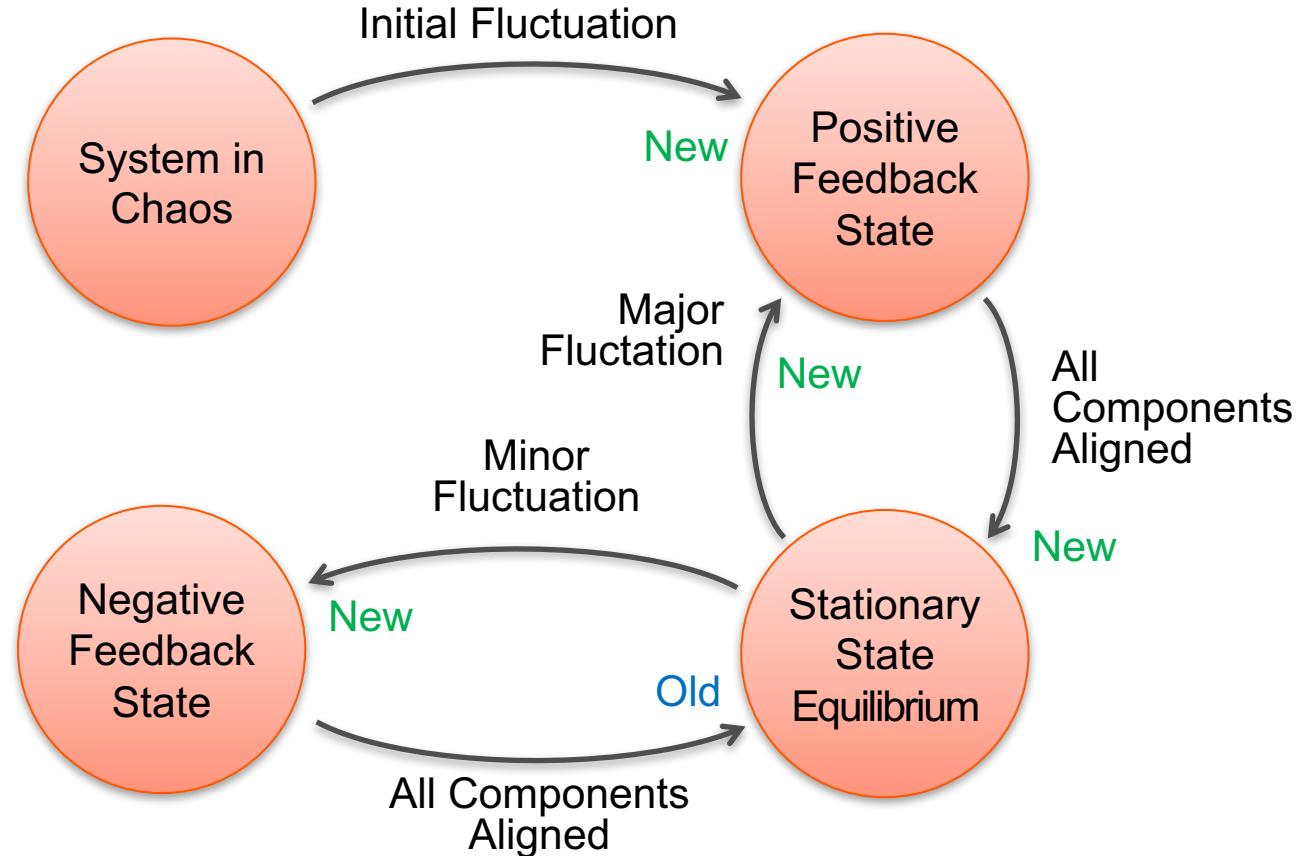
- Often occur if different feedback loops influence the same variables or when reactions are too strong
- Corresponds to a cyclic attractor in state space
- Example: Van der Pol-Oscillator

$$\ddot{x} - a(1-x^2)\dot{x} + x = 0$$





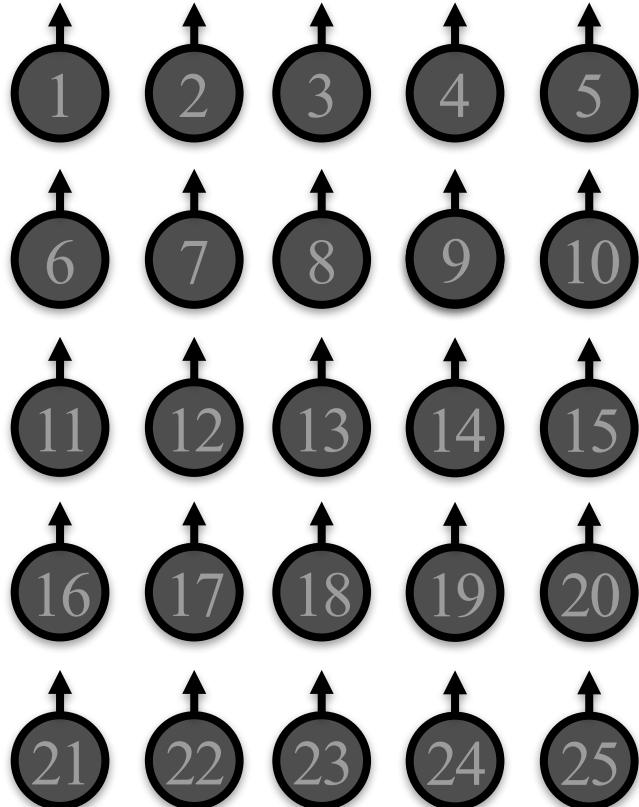
Lifecycle of a self-adaptive system



Following
Heylighen, 2002

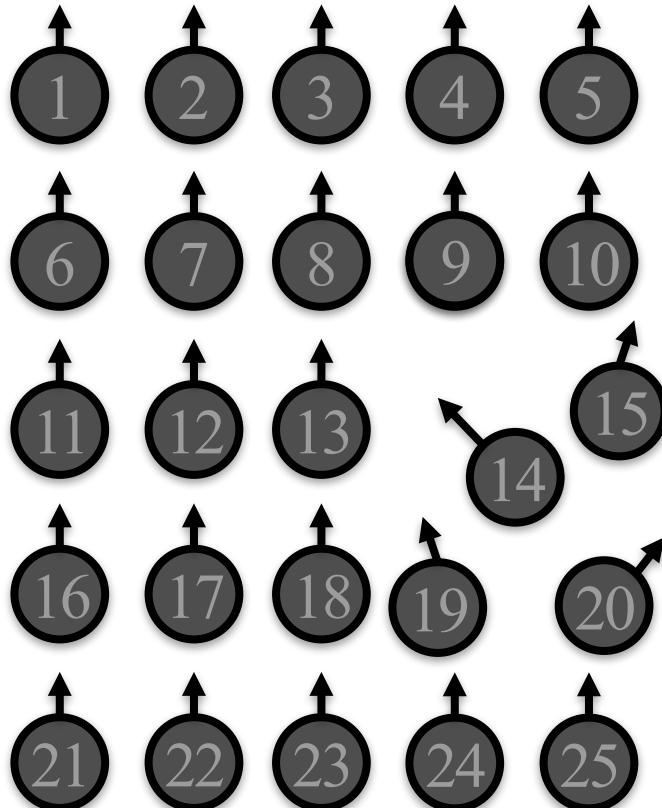
Lifecycle – Example

- System of mobile robots
- Goal: alignment in a grid with uniform orientation
- Robots sense each other and coordinate to create structure



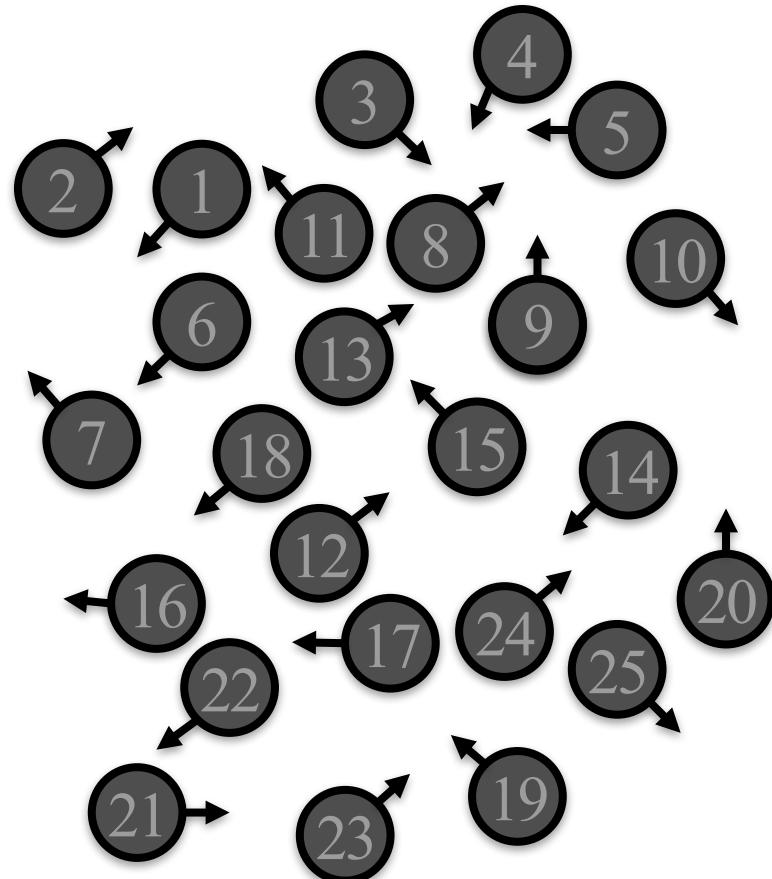
Lifecycle – Example Negative Feedback

- Small fluctuation by a small disturbance
- Relative position of some robots changes minimally
- Negative feedback dampens the change in the system and returns the system to its previous state



Lifecycle – Example Positive Feedback

- Strong fluctuations through massive disturbances
- Relative position of a large number of robots changes drastically
- Positive feedback amplifies the changes in position and conveys system to new stable state



setup go On
 Off show-energy?

Grass settings

On
 Off grass? 30

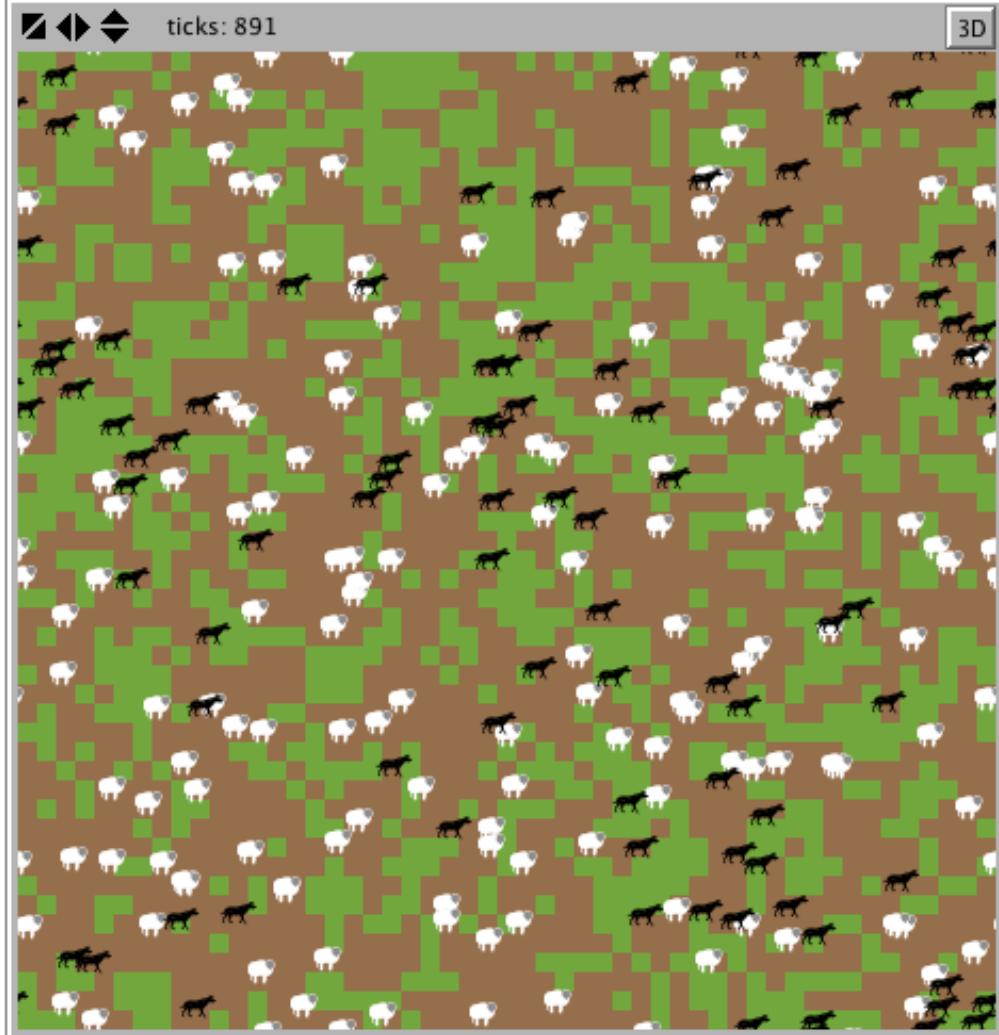
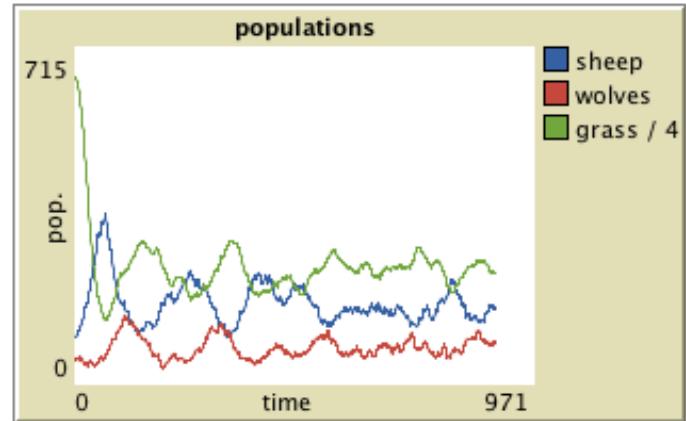
Sheep settings

100 50

4 20

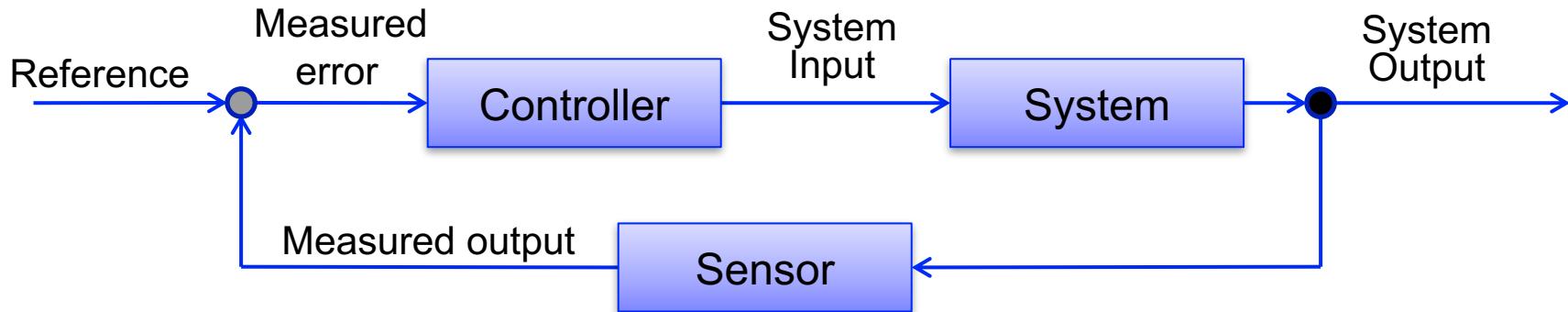
4 % 5 %

sheep 165 wolves 88 grass / 4 236



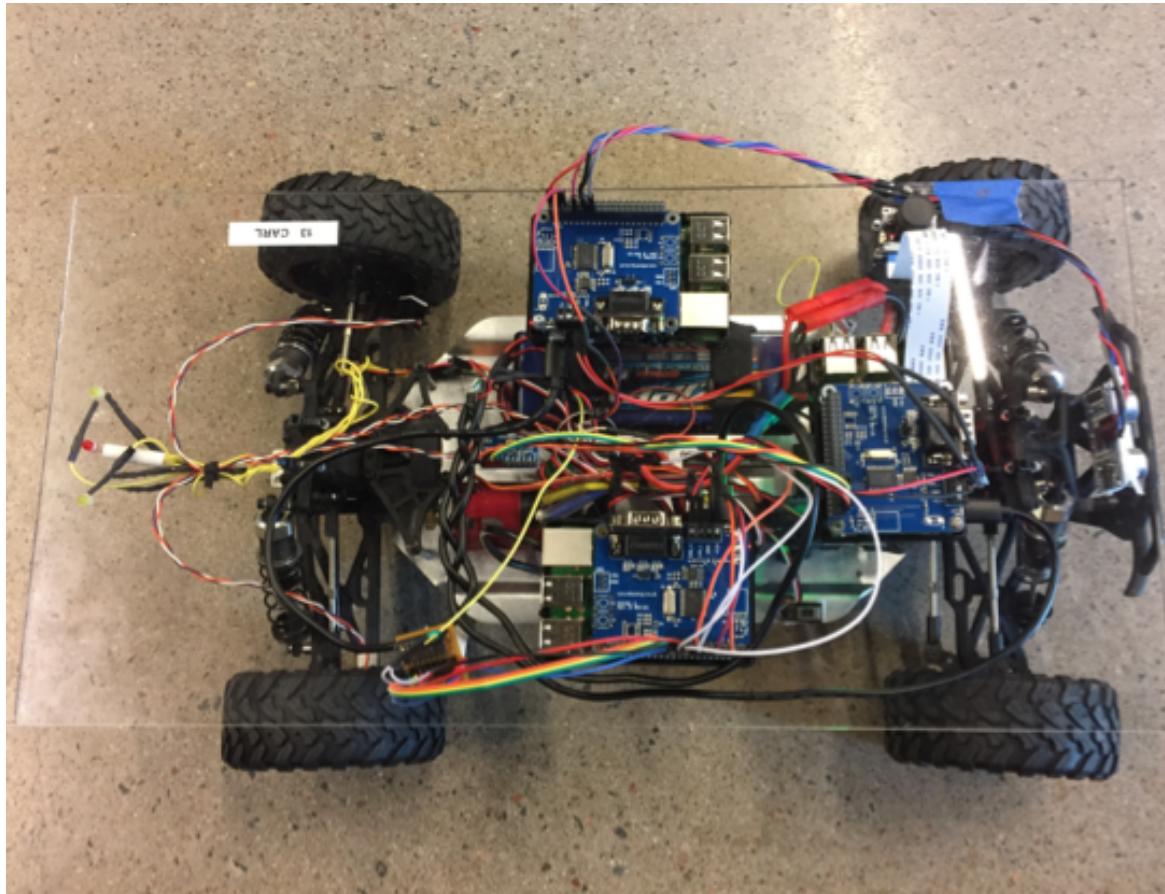
Feedback-Loop

Negative Feedback

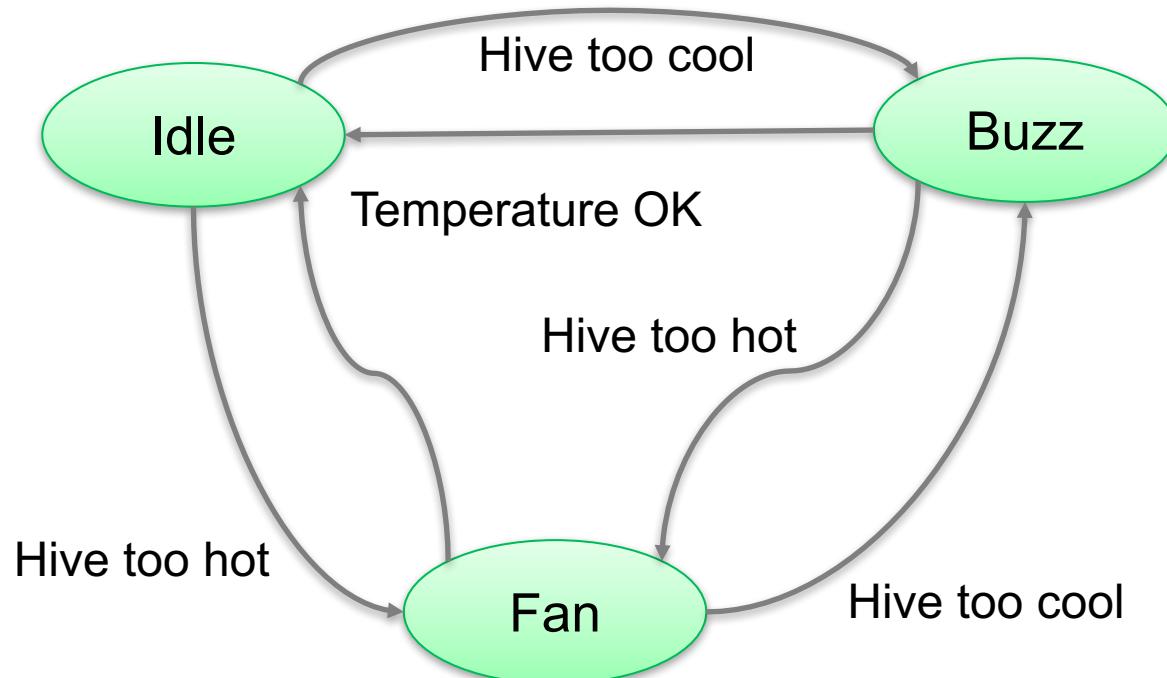


Agents

- Autonomous
- Knowledge-based
- Rational
- Reflective
- Reactive
- Social



State-based modelling of agents



Controller

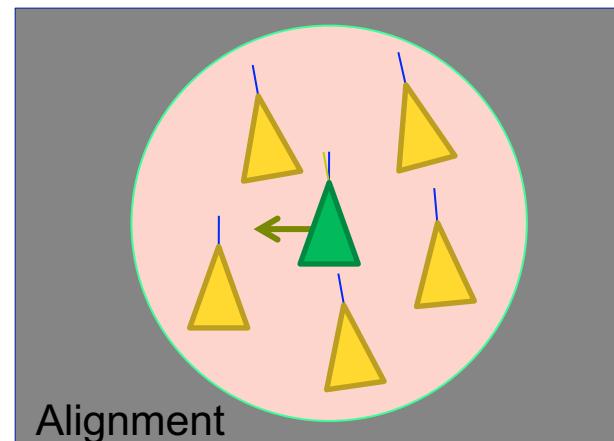
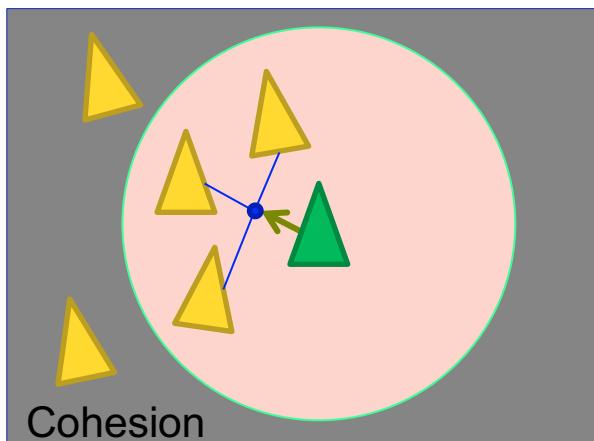
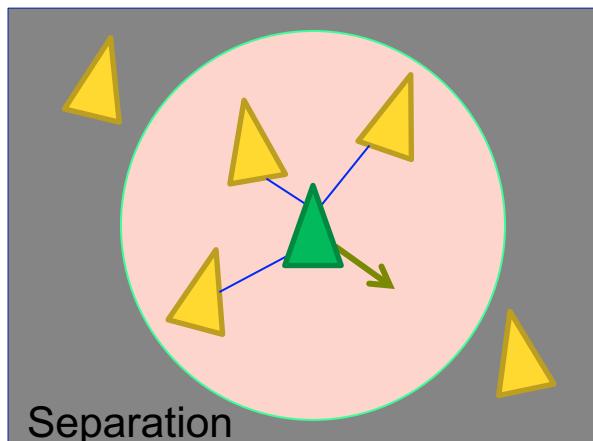
Implements changes to parameters depending on the input

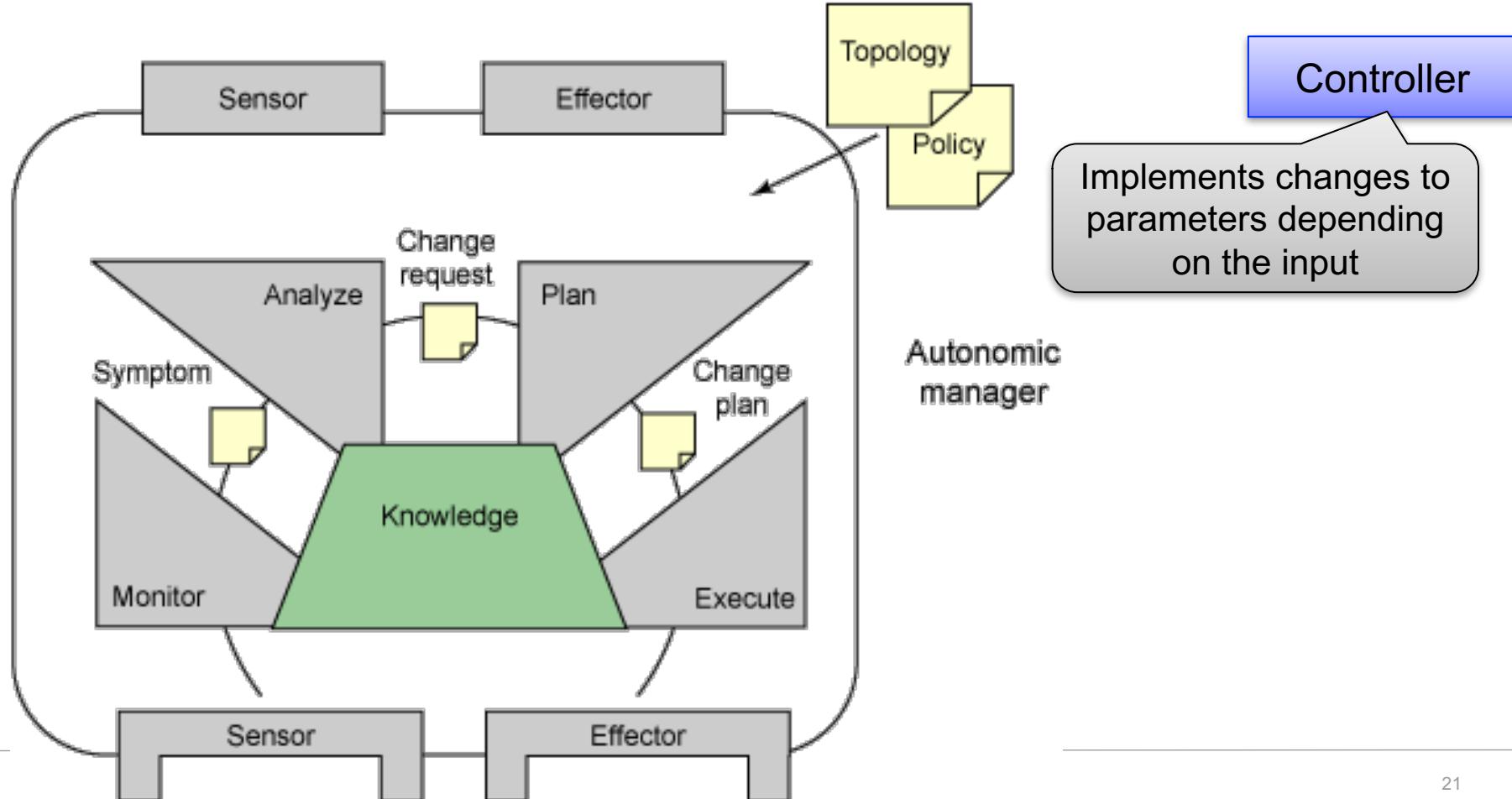
Current State	Situation	Next State
Idle	$F < 34$	Buzz
Idle	$F > 36$	Fan
Buzz	$34 < F < 36$	Idle
...

Rule-based modeling of agents

Controller

Implements changes to parameters depending on the input







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