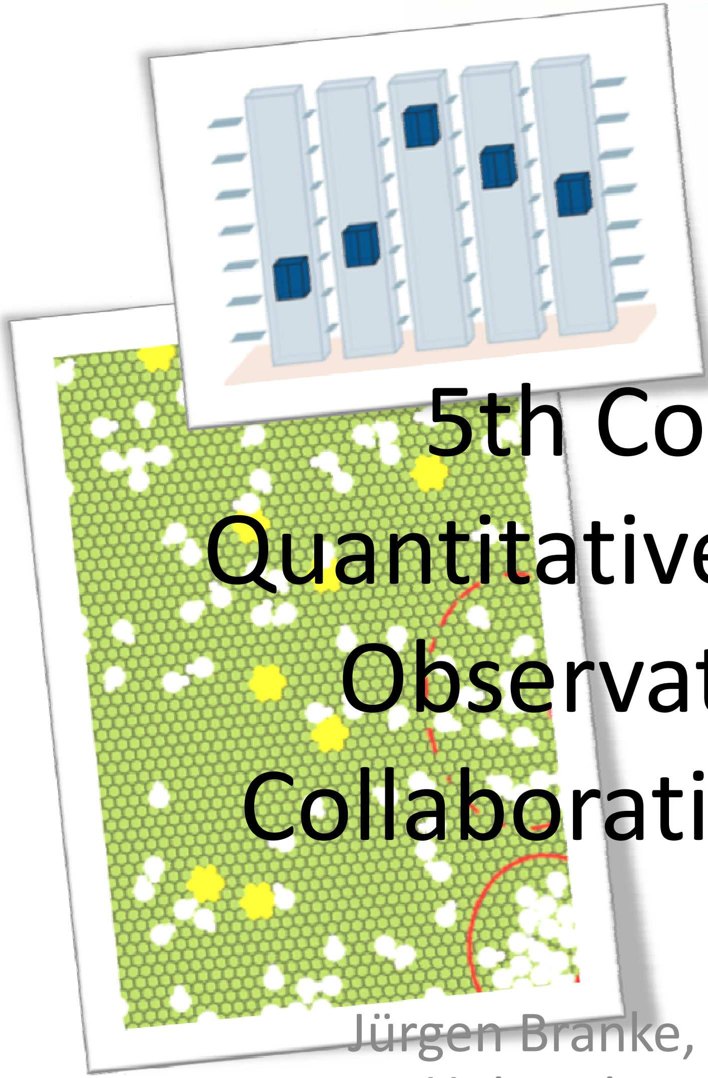

5th Colloquium SPP OC
Quantitative Emergence (phase I)
Observation and Control of Collaborative Systems (phase II)

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Motivation and goals

- Large number of interacting sub-systems
- Increasing complexity in technical systems
- Survive attacks, breakdowns, and other unexpected events with self-x-properties

→ Self-organisation

1. Development and investigation of metrics for the observation and analysis of emergence in self-organising systems (H)
2. Development and investigation of mechanisms to influence and control the effects of emergence in self-organising systems (K)
3. Realisation of tools and validation of the tools in various test scenarios

→ Observer/controller architecture as a generic toolbox with basic mechanisms to observe, analyse, and control emergent behaviour

Phase I

Clarification of emergence
- Entropy-based definition of emergence

Self-organisation terminology framework
- Adaptivity, autonomy, flexibility, self-organisation, and robustness
- Static/dynamic degree of autonomy

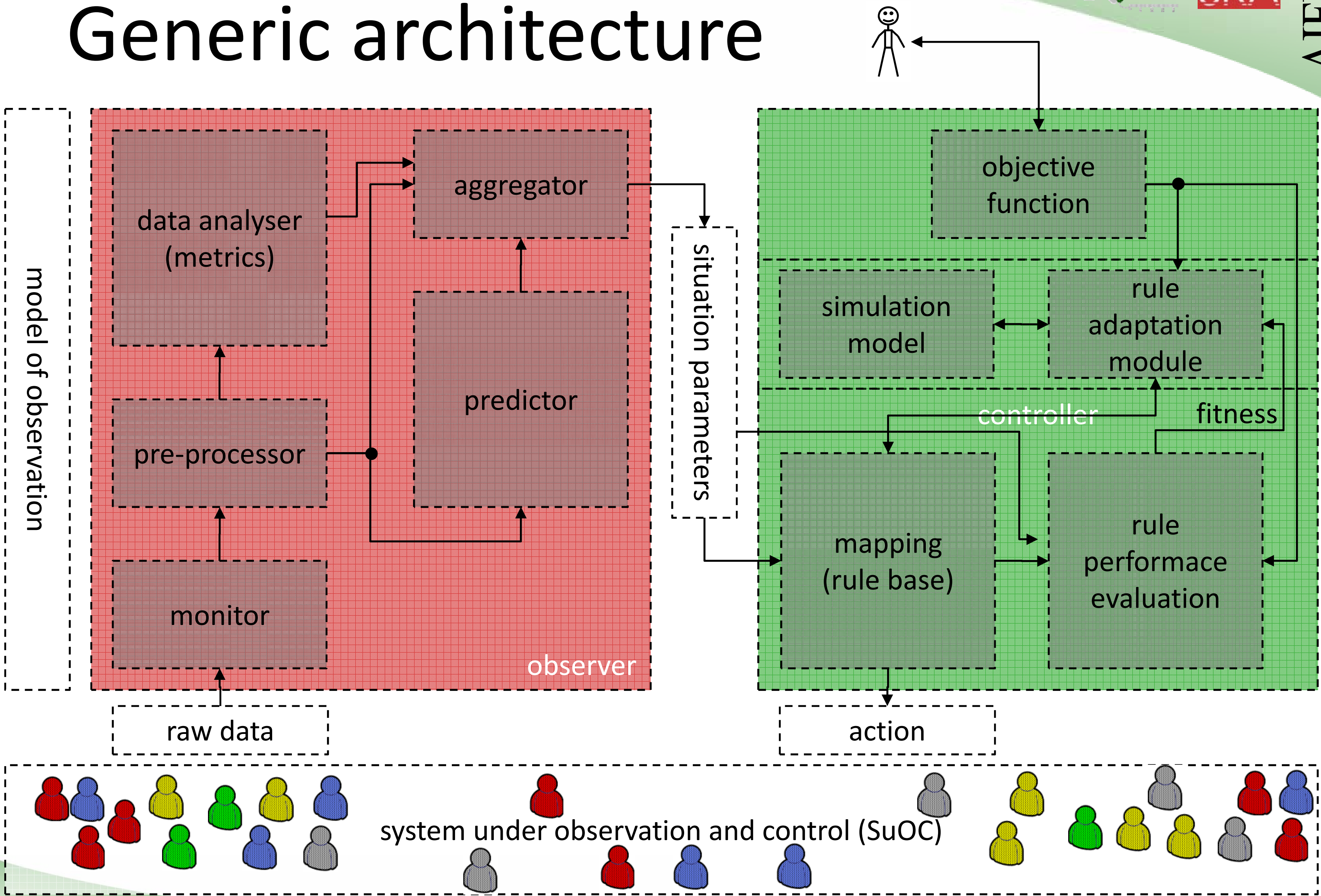
→ Talk of H. Schmeck
→ Two Papers, wiki

Generic observer/controller architecture

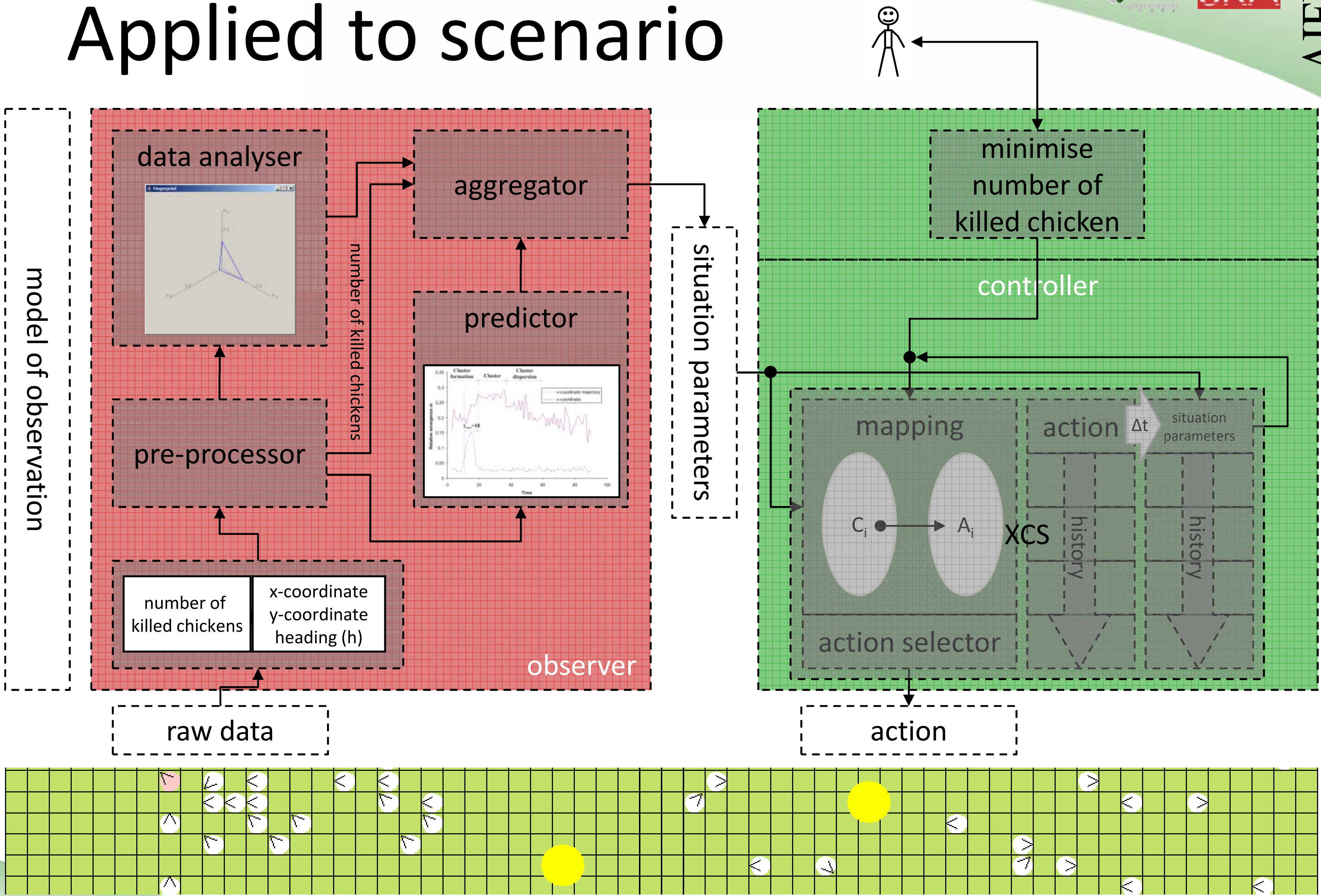
Controller with learning (XCS)

Application to multi-agent ensembles
- Chicken cage and lift simulation

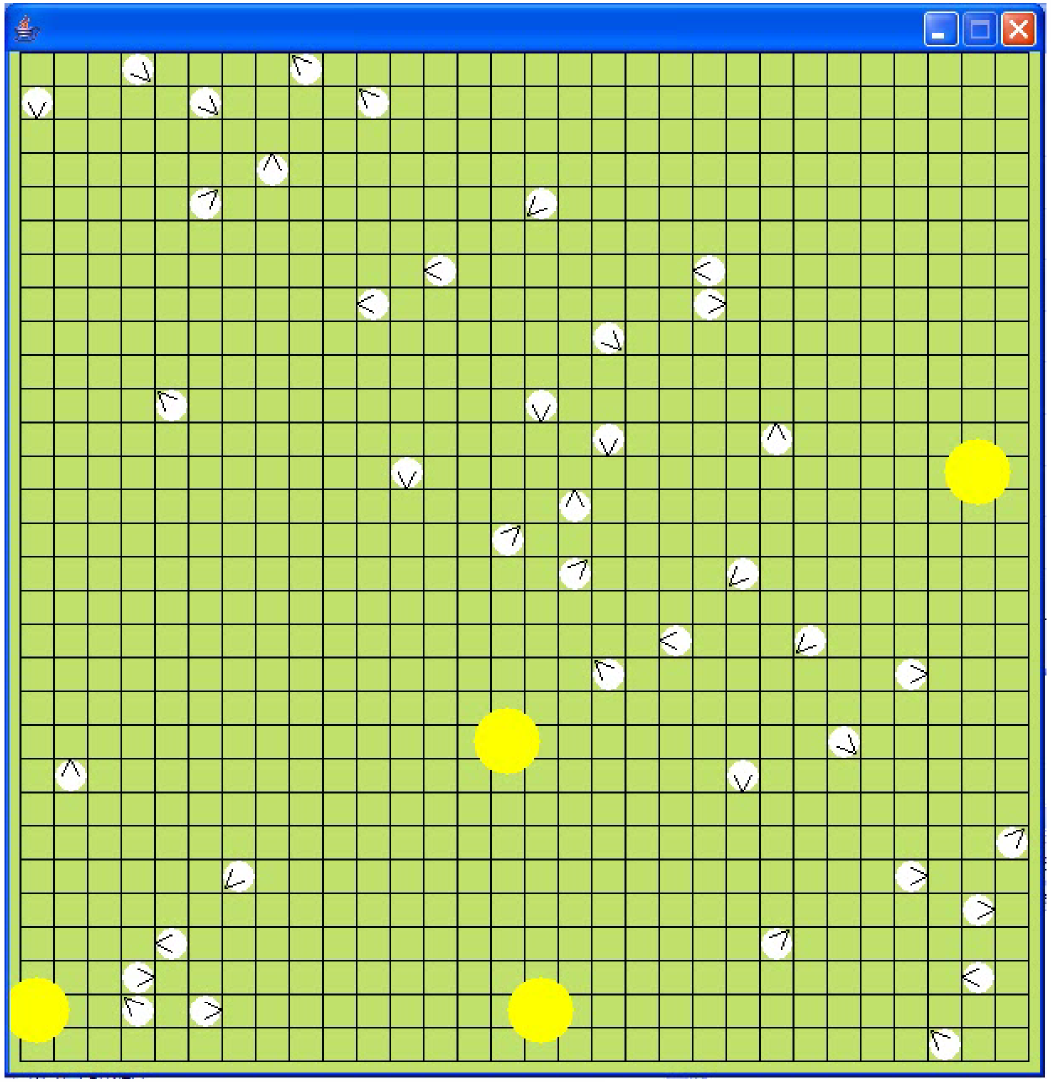
Generic architecture



Applied to scenario

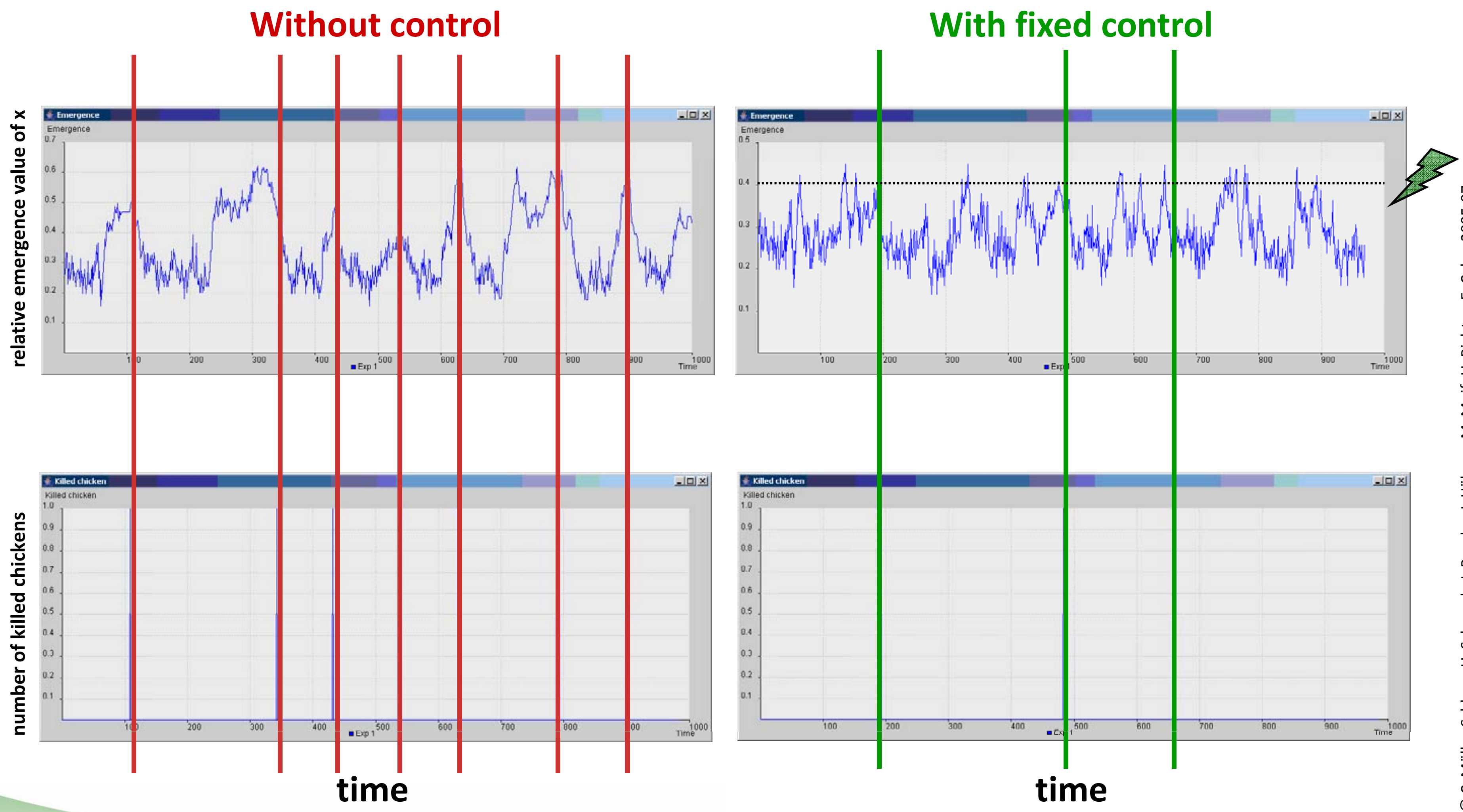


Chicken without control



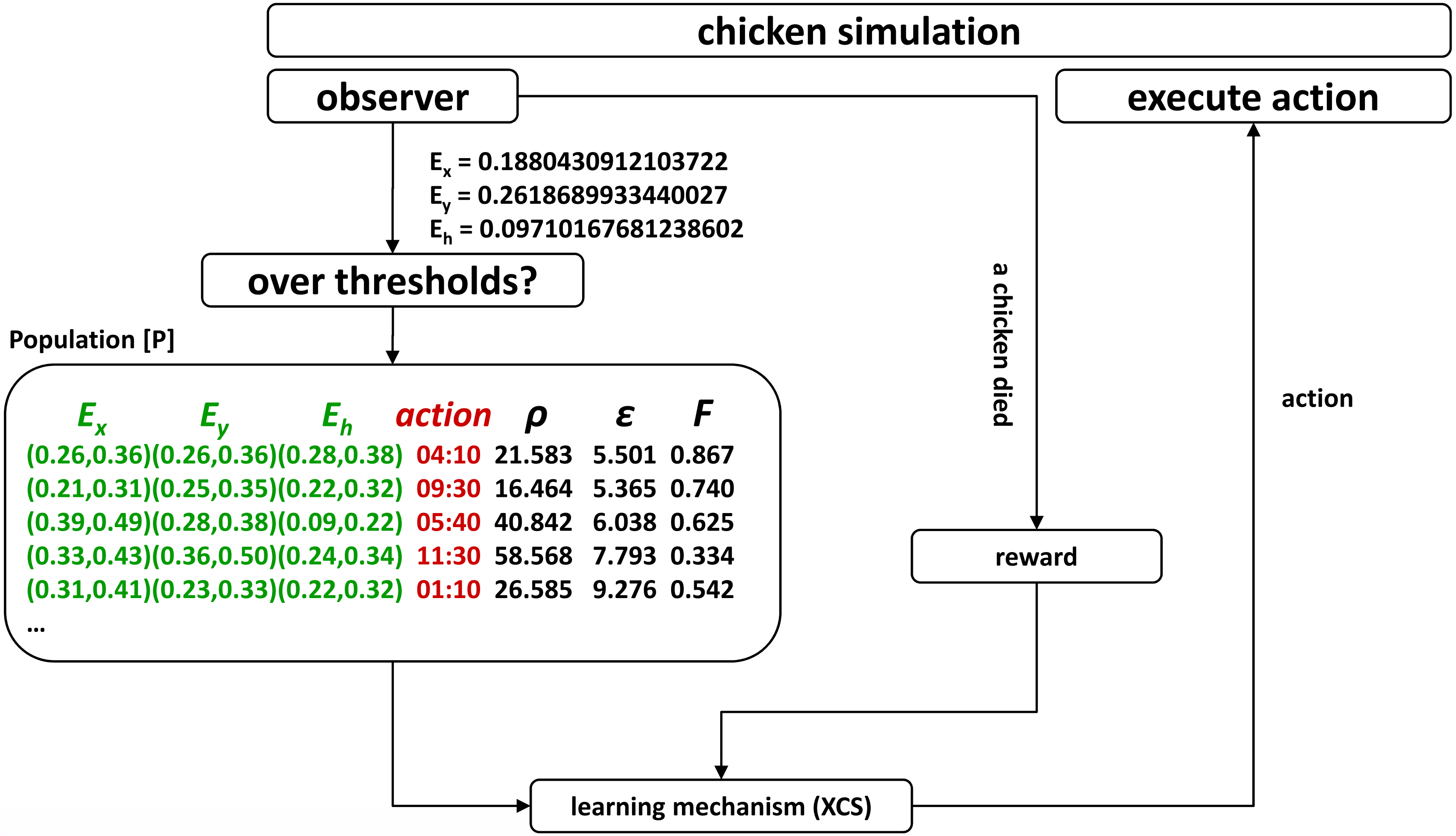
Experimental results

Fixed intensity, fixed duration, and fixed critical emergence values



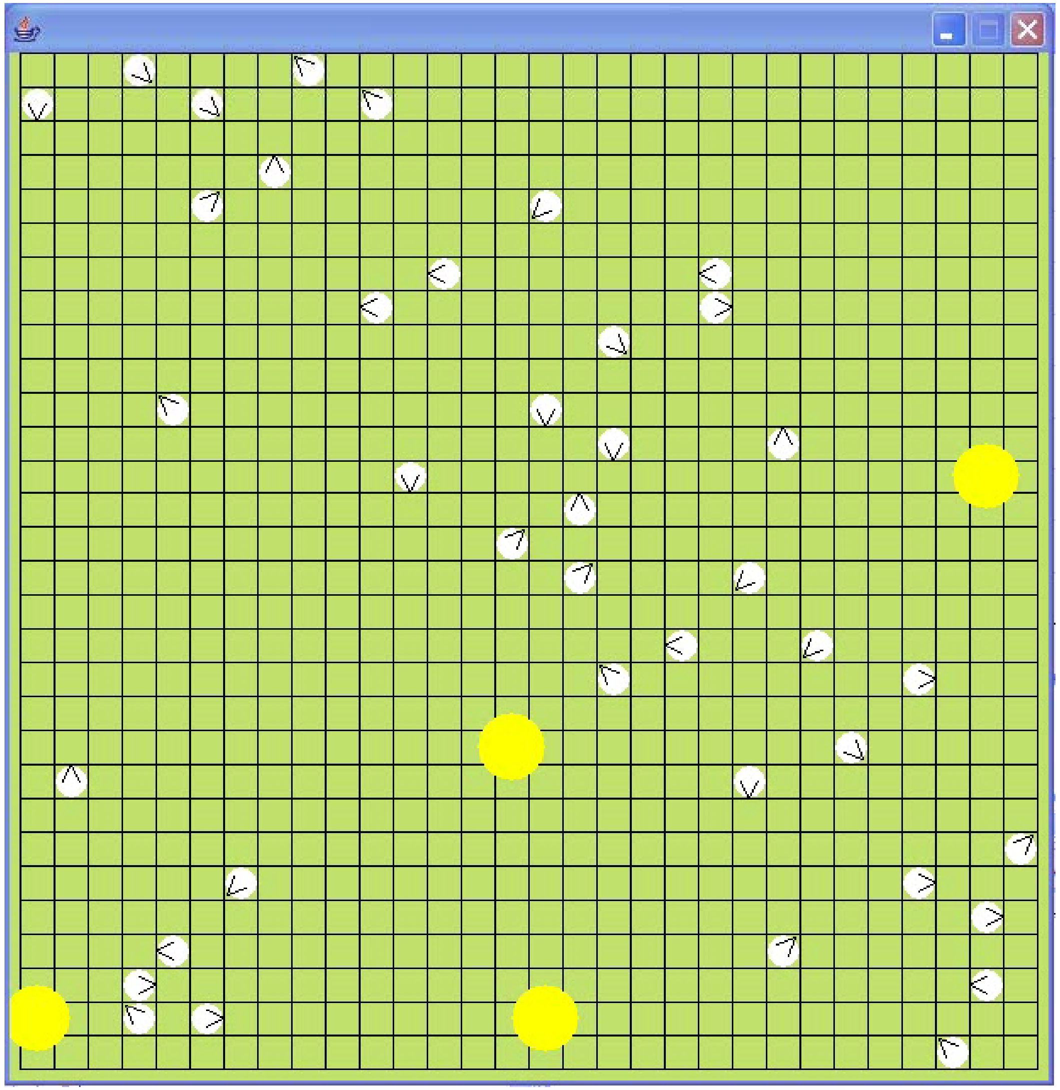
Learning to control

Variable intensity, variable duration, and fixed critical emergence values

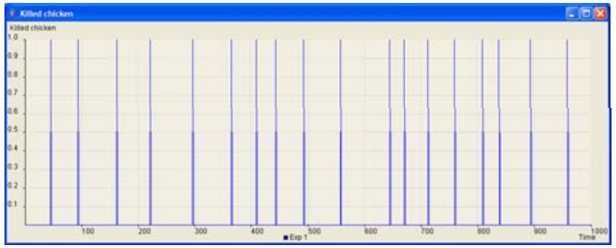


E_x	E_y	E_h	action	ρ	ε	F
(0.26,0.36)	(0.26,0.36)	(0.28,0.38)	04:10	21.583	5.501	0.867
(0.21,0.31)	(0.25,0.35)	(0.22,0.32)	09:30	16.464	5.365	0.740
(0.39,0.49)	(0.28,0.38)	(0.09,0.22)	05:40	40.842	6.038	0.625
(0.33,0.43)	(0.36,0.50)	(0.24,0.34)	11:30	58.568	7.793	0.334
(0.31,0.41)	(0.23,0.33)	(0.22,0.32)	01:10	26.585	9.276	0.542
…						

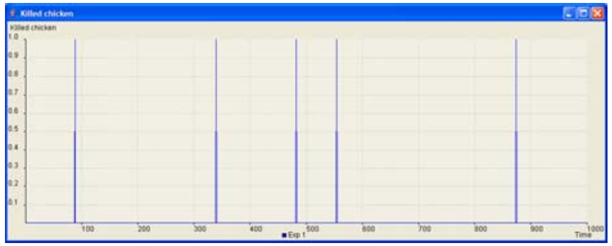
Chicken with control



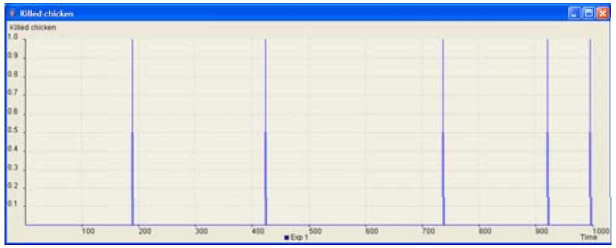
Without control

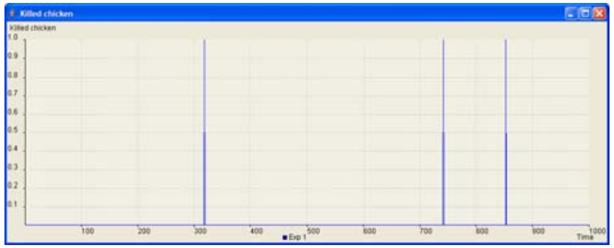


With fixed control



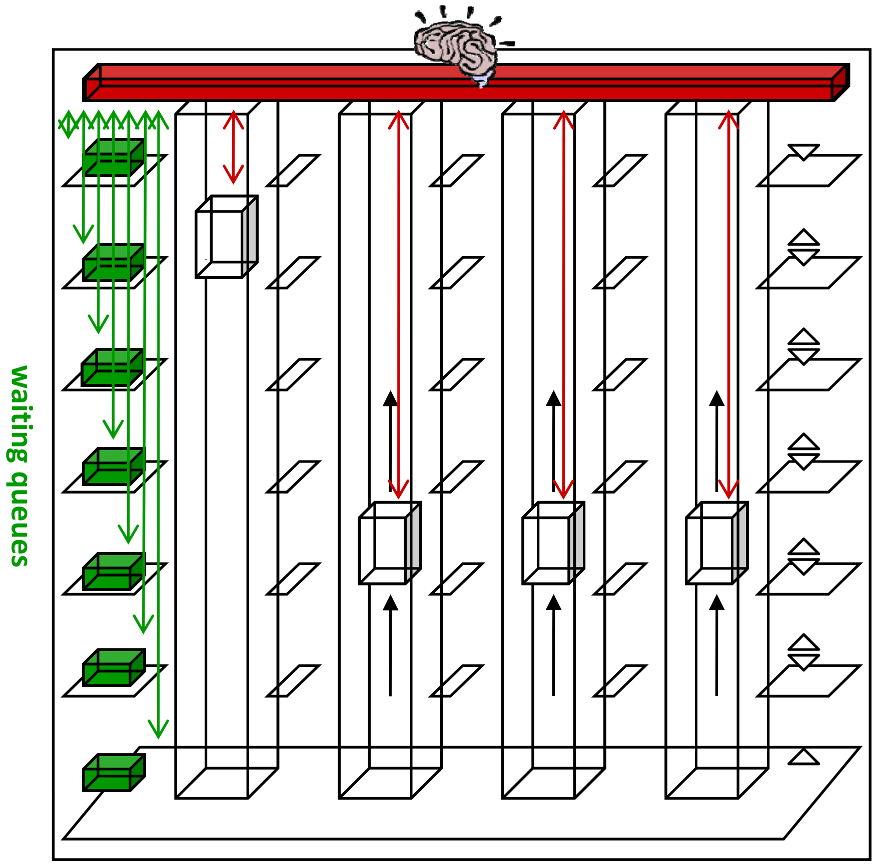
With variable control



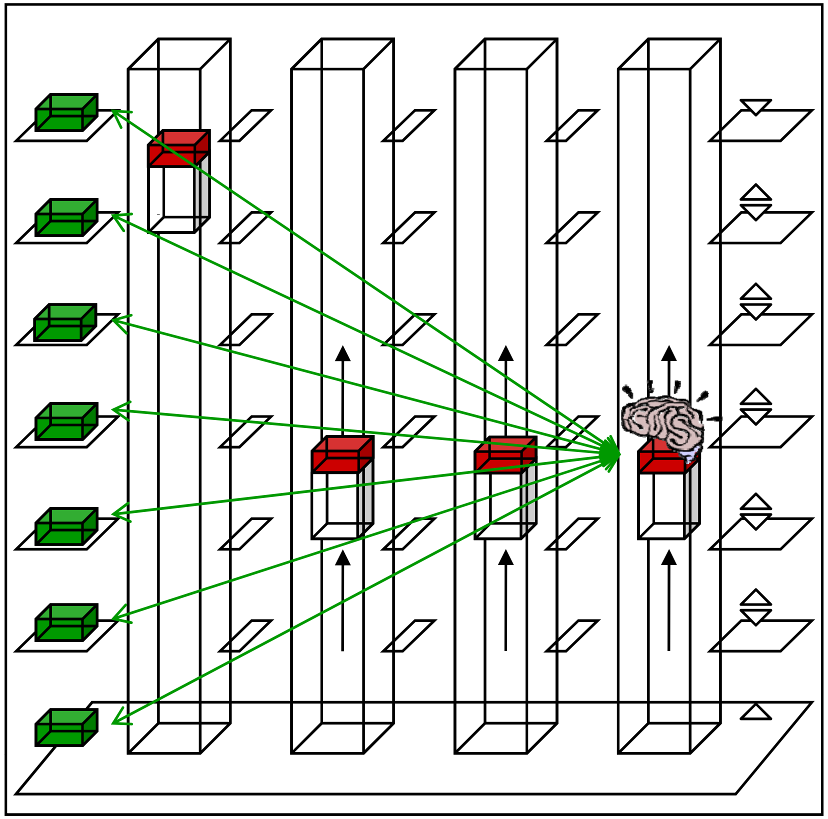


Lift simulation

With central control



Self-organising lifts



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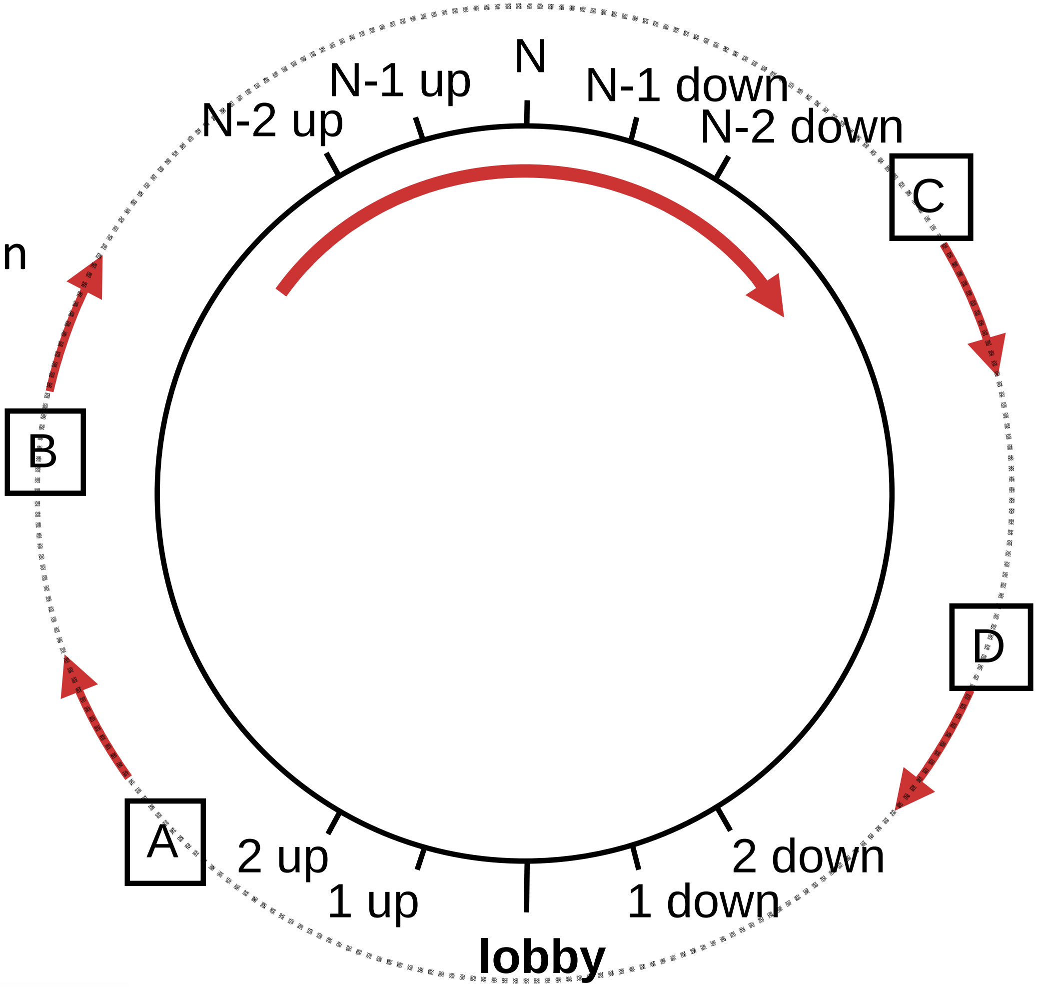
How to observe?

- Optimal group behaviour
  - Lifts travel clockwise around the circle
  - Measure the gaps between the lifts
  - Gaps between A and B, B and C, C and D, and D and A should be equal.
  - Sum of deviation serves as a characterisation of bunching.
- Bunching effects waiting time
- Bunching increases with the increase in system loading and the number of lifts.



How to control?

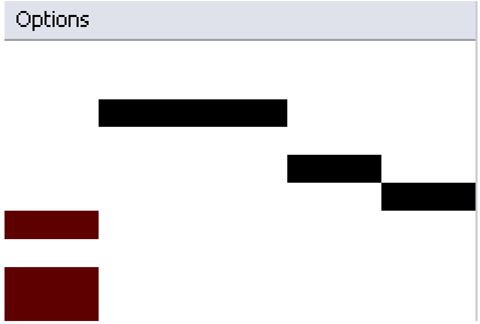
- Possible control actions
  - Delaying/parking lifts at the lobby
  - A lift drives past and passengers wait for another lift.

- singleCarBlind
  - Select the lift having the largest gap to the next lift in ride destination.
  - This lift goes blind and reacts no longer to any hall calls.
  - The selected lift is speeded up.

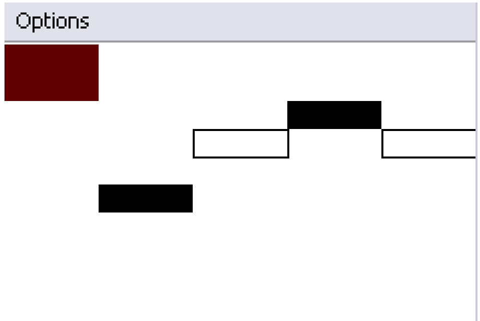
- nextCallHide
  - Select lifts having a larger gap to their next lifts in ride destination.
  - All selected lifts go blind for the next hall call in their directions.
  - All the selected lifts are speeded up.

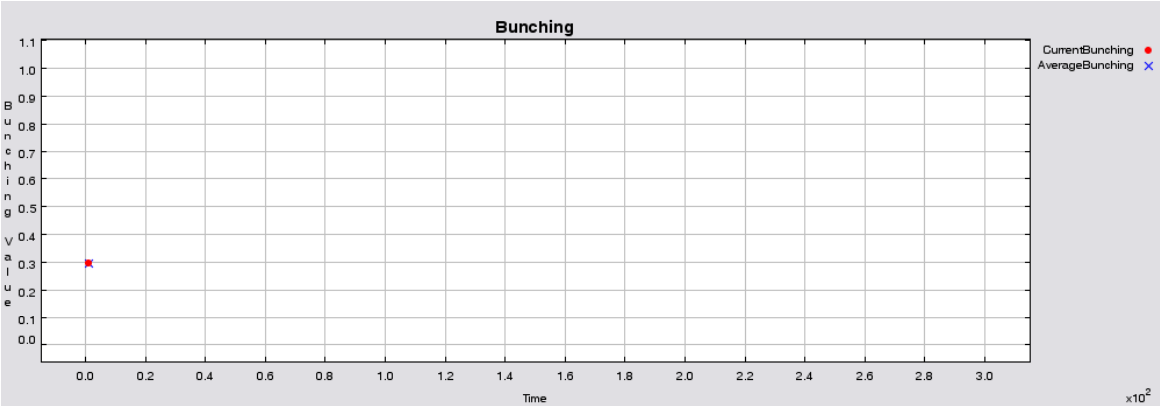
Simulation

Without control

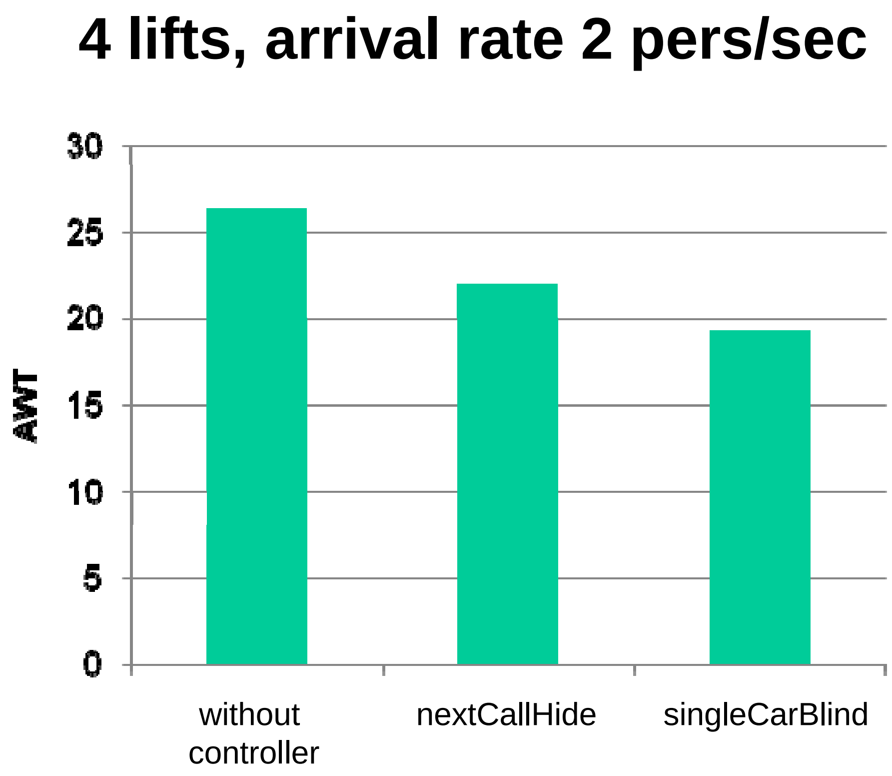


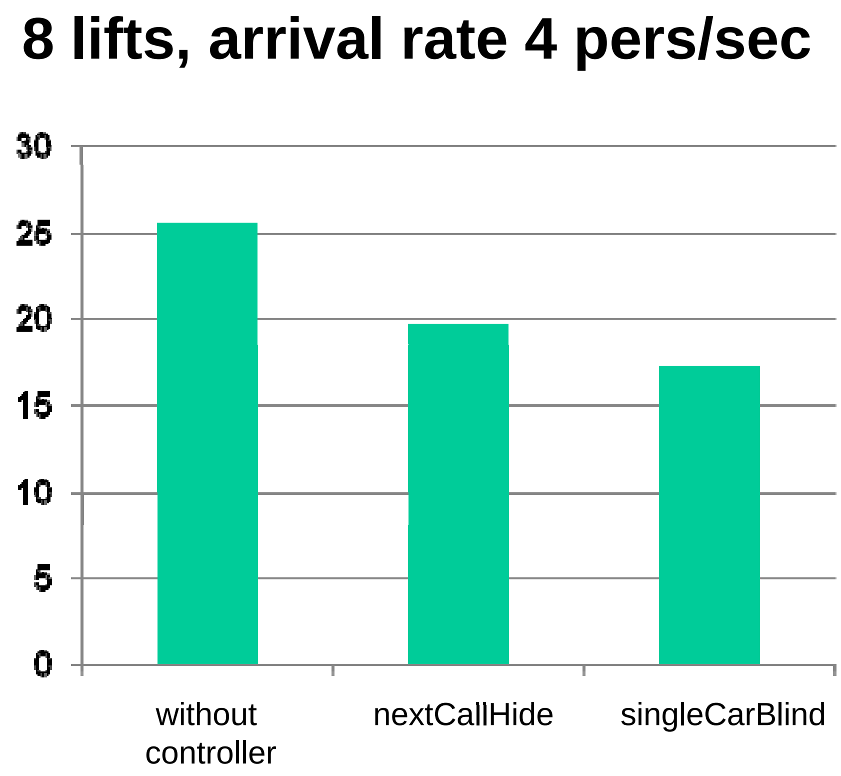
With control (singleCarBlind)





Results of control strategies

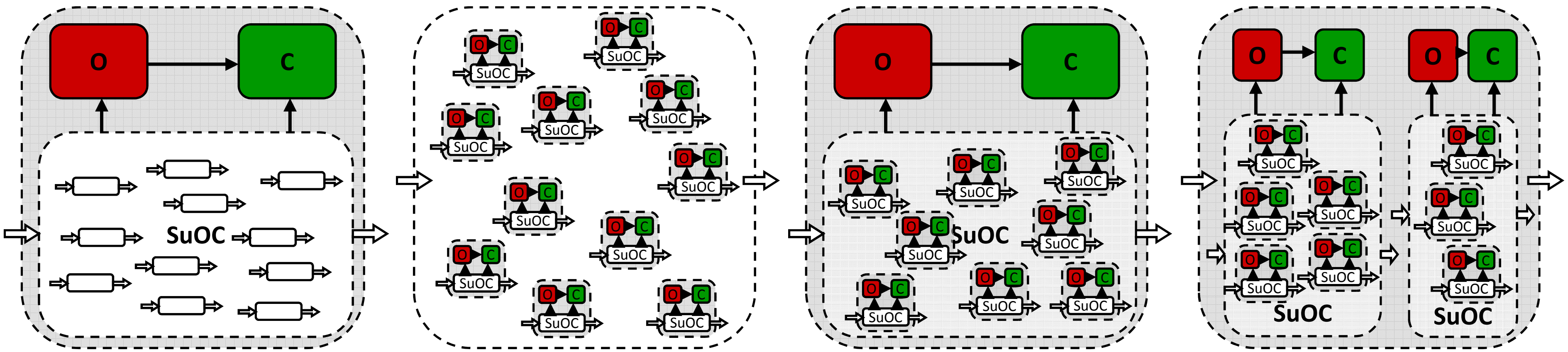




50 runs with a duration of 10.000 ticks, 4 lifts and a building with 10 floors, and all other parameters are equal.

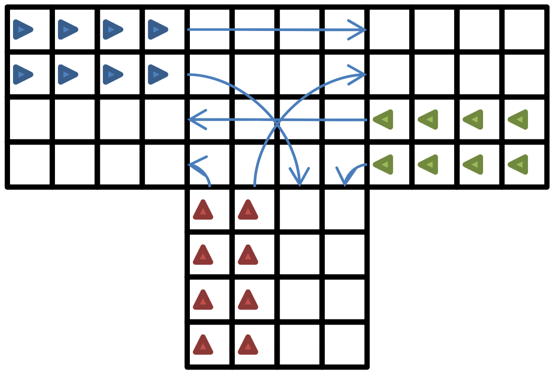
Phase II

- From central to distributed observer/controller architectures
- Focusing on the observation and control of collective OC systems
- Concentration on the aspects of collaborative behaviour
- Dealing with collective learning as part of the distributed controllers
- Systematic investigation of distribution patterns of observer/controller architectures



Validation

- Test scenarios
  - Chicken simulation
  - Lift simulation
  - Cleaning robots
  - Indian junction
- The distributed application of OTC
- Other scenarios of the projects of the priority programme



Summary and outlook

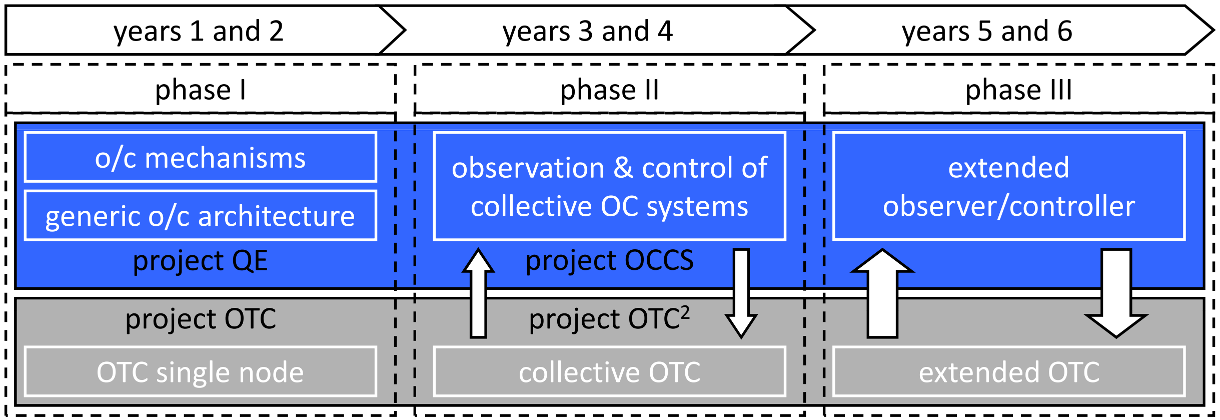
Summary of phase I

- Implementation of multi-agent test scenarios (chicken, lifts,…)
- Clarification of emergence (definition of emergence as self-organised order)
- Terminology framework of self-organisation (adaptivity, autonomy, flexibility, and robustness)
- Generic observer/controller architecture
- Integration of machine learning
- Experimental results

Outlook for phase II

- Distributed observer/controller architectures
- Collective learning

→ OC design patterns



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