

Preconditions

OC terminology

Objectives

Understand future development options of OC

Content

1. Engineering
2. Optimization
3. Interdependence

Social Mechanisms

Levels of Interdependence

To Dos

- Design-time to runtime
 - Elimination of designers?
 - Meta-design process

- Self-improving systems
 - Good enough for survival
 - Real-time

- Social agents

→ Self-engineering

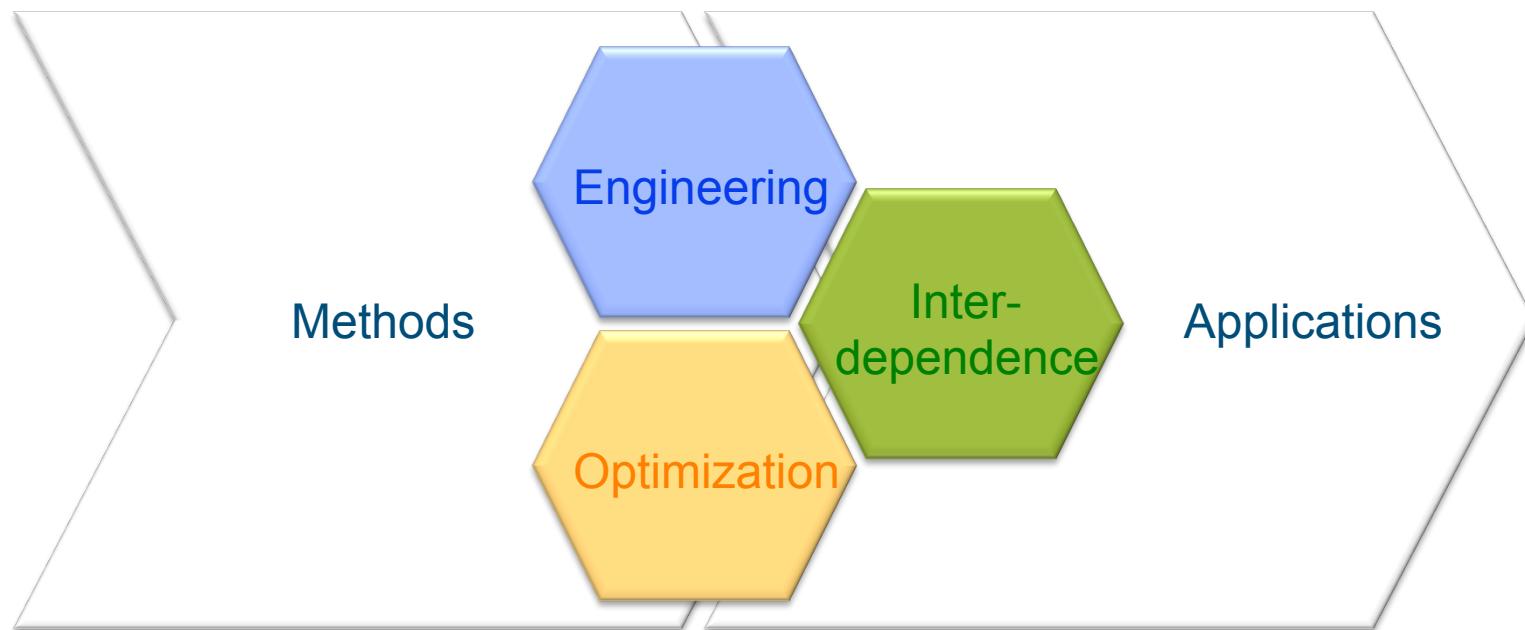


→ Online optimization



→ Interdependence



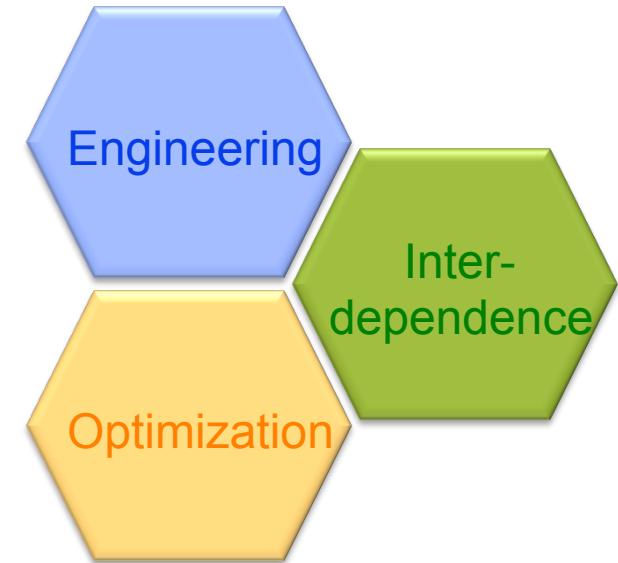


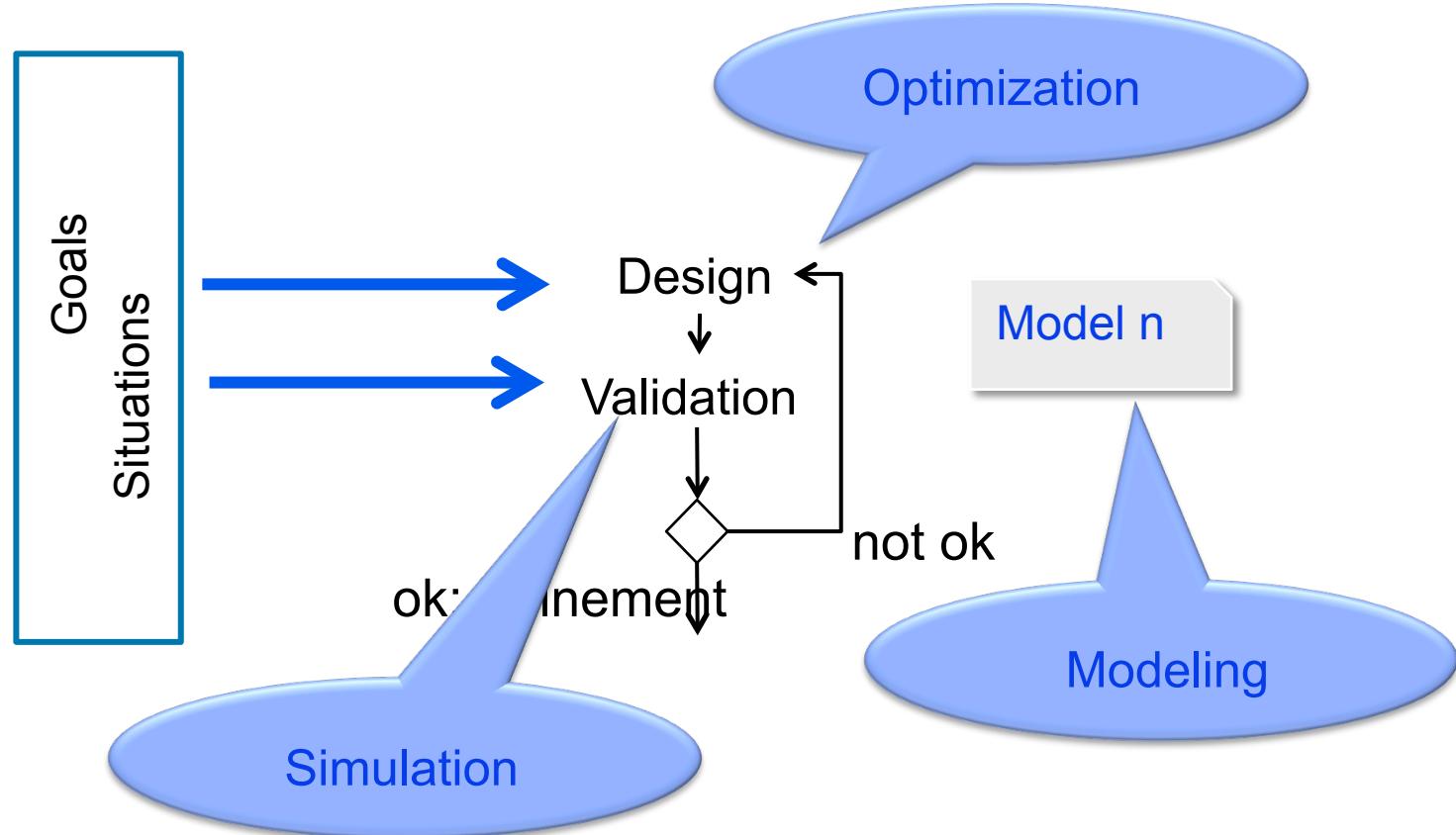
3 Three dimensions of OC

Organic Computing

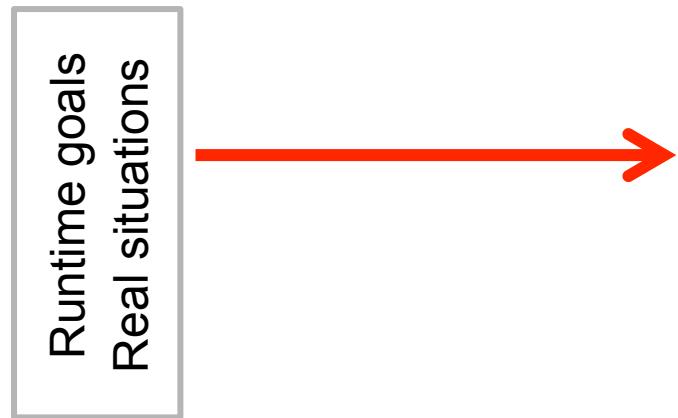
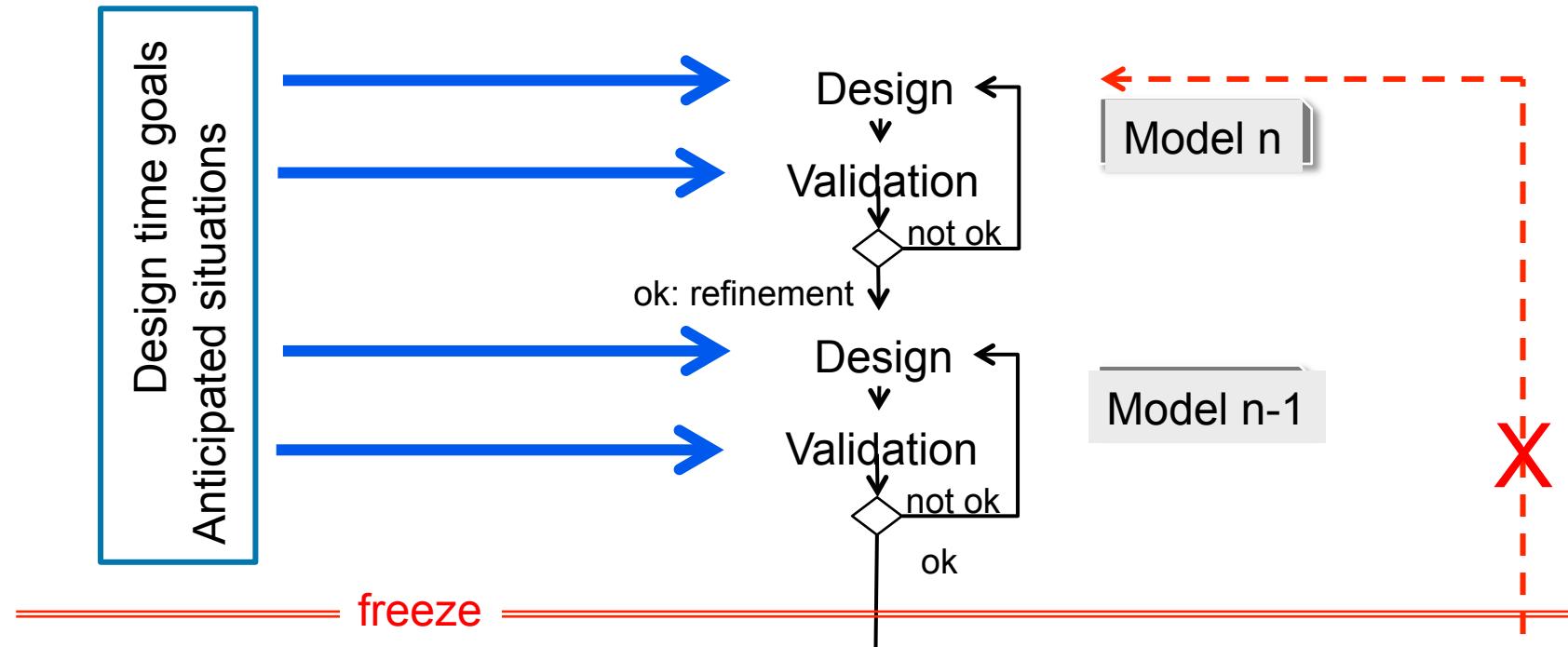
Three dimensions of OC

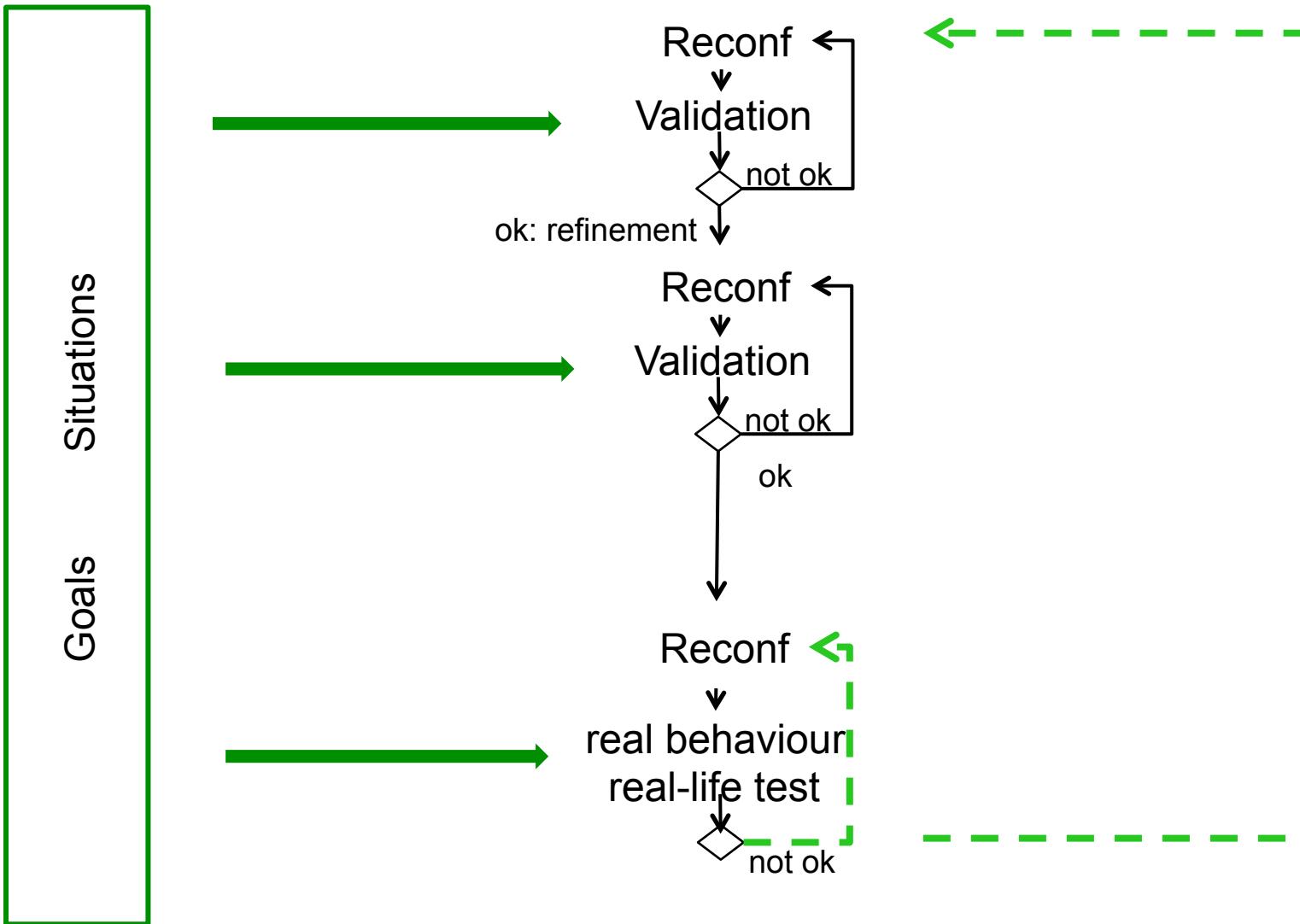
- Engineering
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- Interdependence
 - Social Mechanisms
 - Levels of Interdependence
 - To Dos





Traditional design process





Optimization

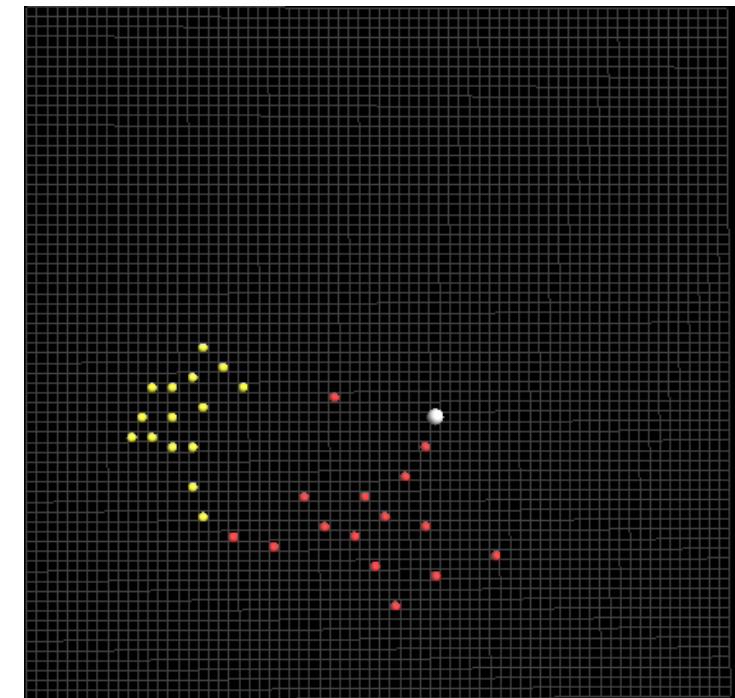
1. Online optimization

- Design space → configuration space
- Configuration space exploration
- Creative entity = agent
- Runtime learning
 - Real time?
 - Safety? → sandbox!

2. Runtime validation

3. Runtime modeling

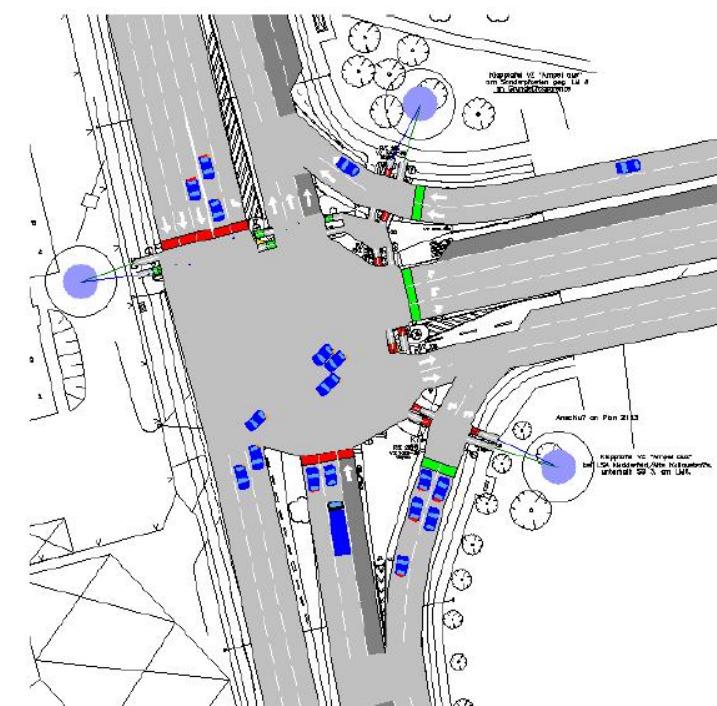
Optimization @ runtime



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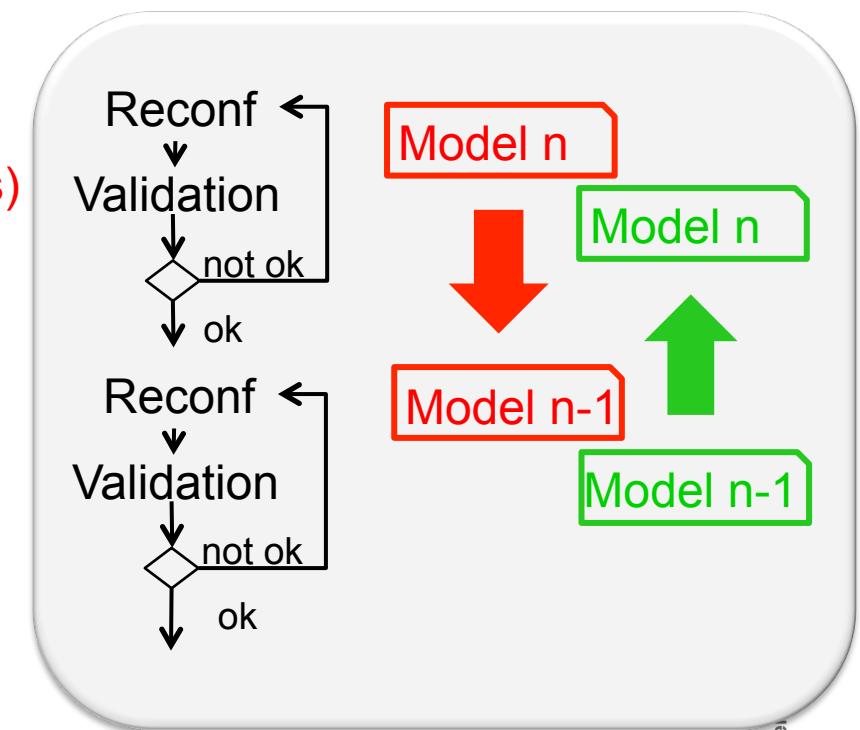
Simulation

1. Runtime optimization
2. Runtime validation
 - Learn from reality or from simulation?
 - Online simulation
 - Simulation speed?
 - Model calibration?
3. Runtime modeling



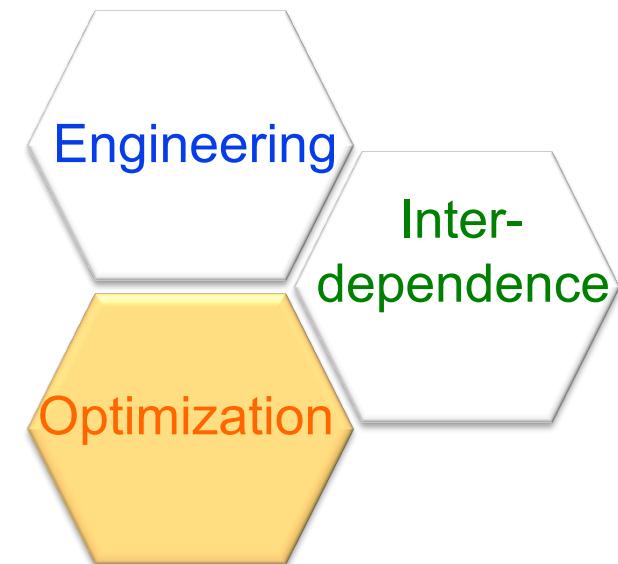
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- Modeling
1. Runtime optimization
 2. Runtime validation
 3. Runtime modeling
 - Model modification at runtime
 - Pre-scriptive models (top-down constraints)
 - De-scriptive models (bottom-up)
 - Consistency? Yo-yo



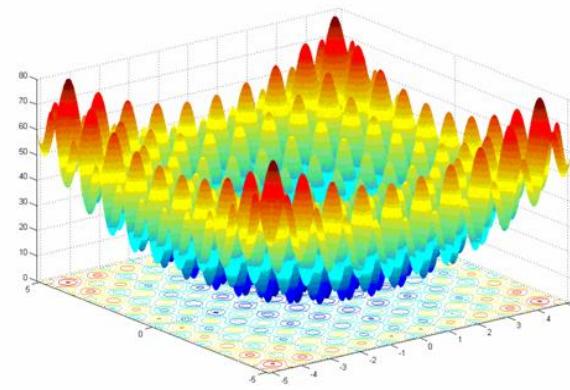
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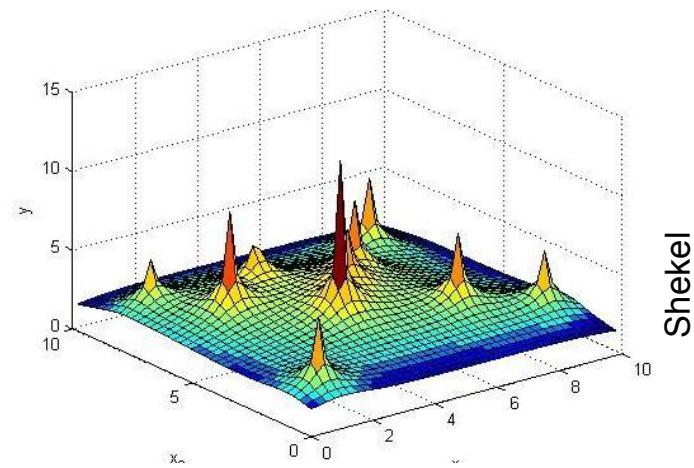




- ❑ Search agent(s) look for optimum in a fitness landscape.
 - Population-based (GA, PSO, ACO ...)
- ❑ Fitness landscapes (FL) in OC
 - High-dimensional
 - Dynamic
 - Stochastic
 - Unknown
 - → Evaluation by simulation or experiment
- ❑ More problems...



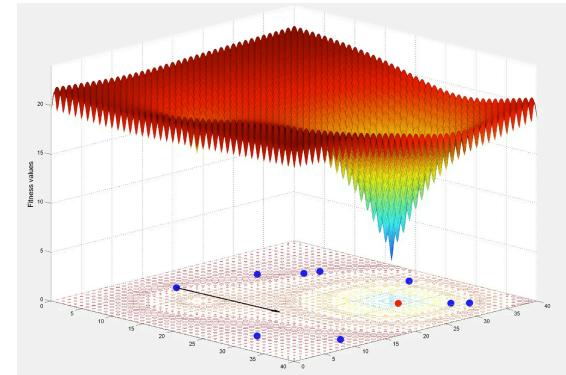
Rastrigin



Shekel



- ❑ More problems with online optimization
 - Search agent \equiv Action agent
→ Self-referential FL
 - Real-time
 - Safety-critical FL exploration!



Ackley function

Static Ackley



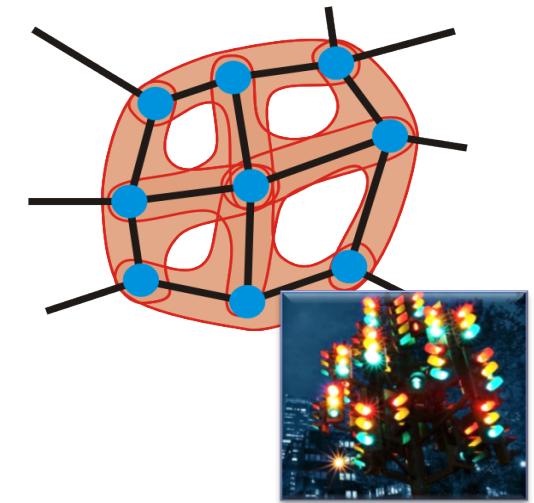
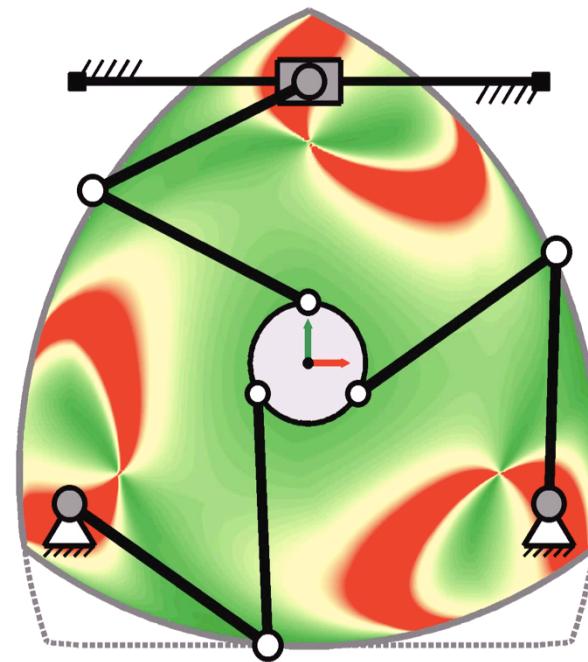
Self-referential Ackley





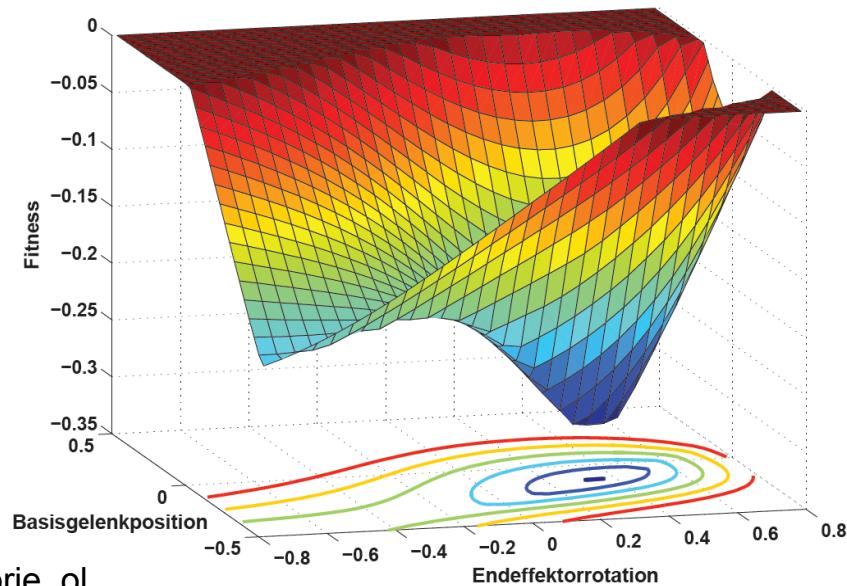
□ Examples

- Traffic: Traffic lights, road users
- Robotics: Trajectory optimization of multi-arm robots



□ Approaches

- Speed beats accuracy → „Good enough“ optima
- A-priori fitness landscape characterization
 - Properties estimation
 - Surrogate models
 - Heuristics preselection
- Populations with **memory**: elitists, anti-elitists, tabu zones
- **Adaptive** exploration vs. exploitation
- **Parallelization** (multi-cores, GPGPUs)

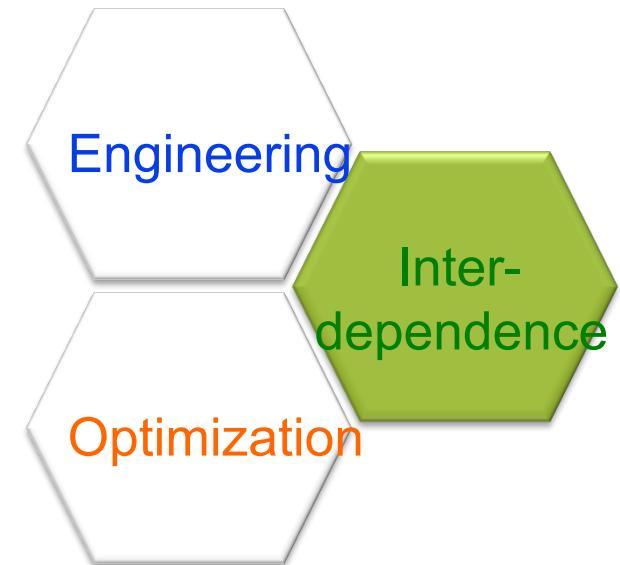


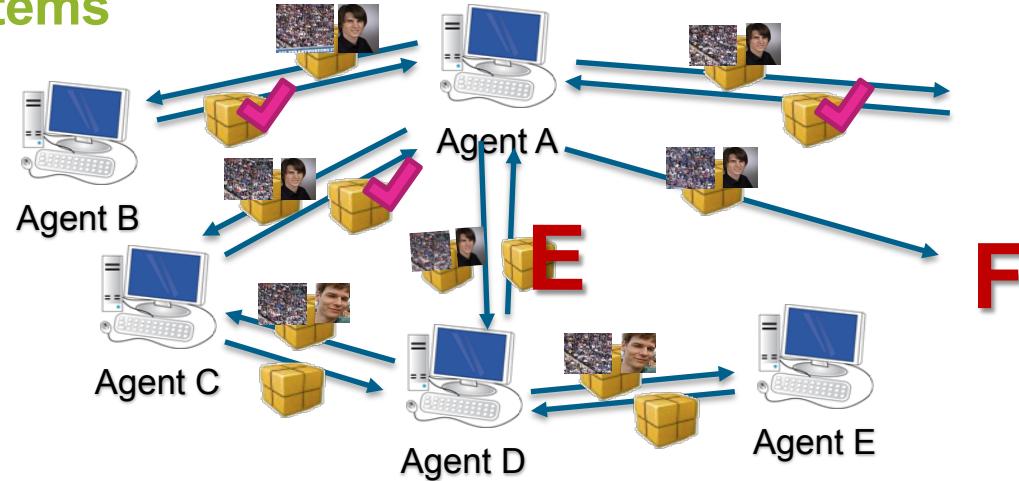
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Three dimensions of OC

- Engineering
- Optimization
- Interdependence
 - Social mechanisms
 - Levels of Interdependence
 - ToDos



The glue of social systems

□ Common Pool Resources

- Resource owned by no one: open access
- Risk of destruction: Overuse due to collective action (tragedy of the commons)

□ Solution

- Governance by common property regimes (E. Ostrom): Self-management in **Enduring Institutions**

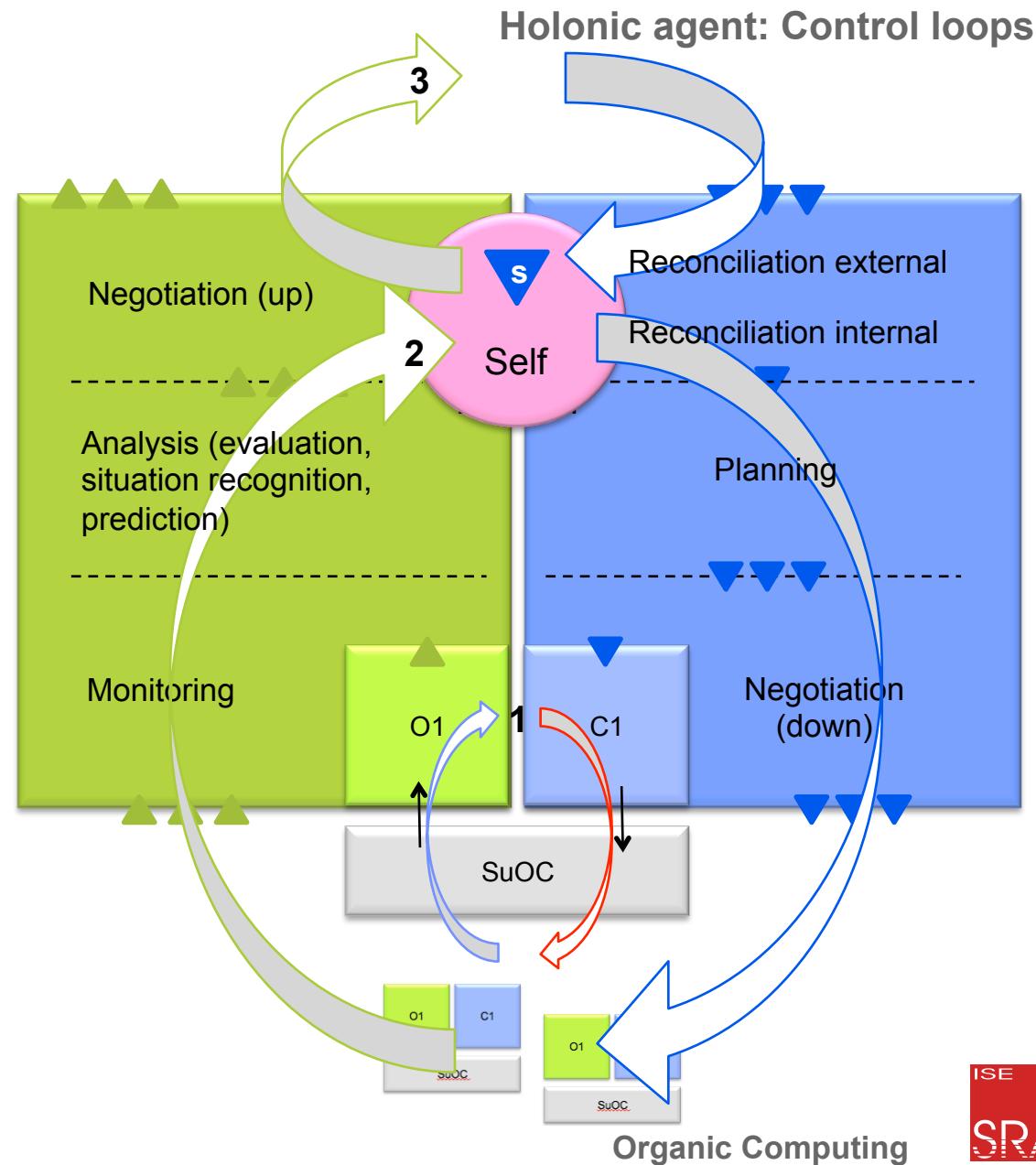


Elinor Ostrom: Nobel Prize in Economic Sciences 2009

Ostrom, E. (1990): Governing the commons: The evolution of institutions for collective action. Cambridge University Press

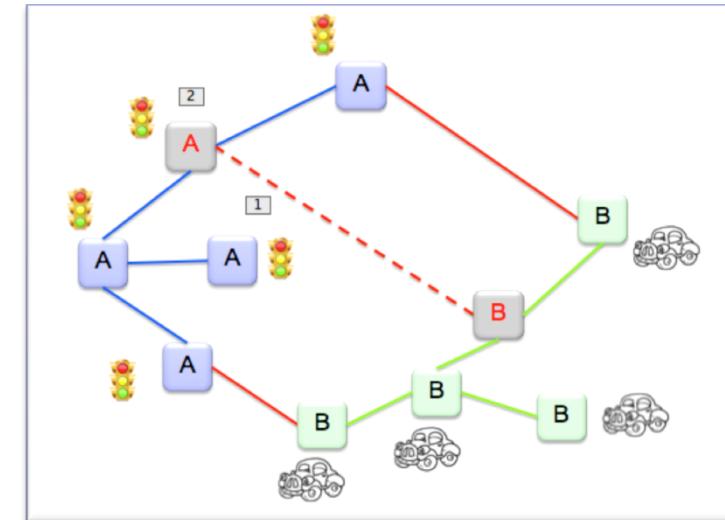
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- **Loop 1**
 - Goal is preserved; re-execution, re-planning
- **Loop 2**
 - Local goal (self goal) is modified.
- **Level 3**
 - Escalation to higher level (to issuer of the goal)



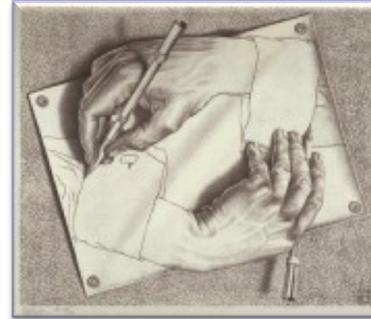
□ Some challenges of Interweaving

- Systems of systems
- Operational independence of agents
- Managerial independence of the organizations
 - Different vendors
- Cooperation or competition?
- Different objectives?
- Negotiation, goal reconciliation
- Interaction of organizations
 - Emergent behavior
- Uncertainty



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- ❑ Self-engineering
 - Design time to run-time



- ❑ Online optimization



- ❑ Interdependence

