HPI Hasso Plattner Institut

IT Systems Engineering | Universität Potsdam

Self-Awareness: A Game Changing Topic for Cyber-Physical Systems?

Game Changing and Controversial Topics in CPS,
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Holger Giese
System Analysis & Modeling Group,
Hasso Plattner Institute for Software Systems Engineering
University of Potsdam, Germany
holger.giese@hpi.uni-potsdam.de

Cyber-Physical Systems ...

Internet of Things

Smart City

(Networked)
Cyber-Pyhsical Systems
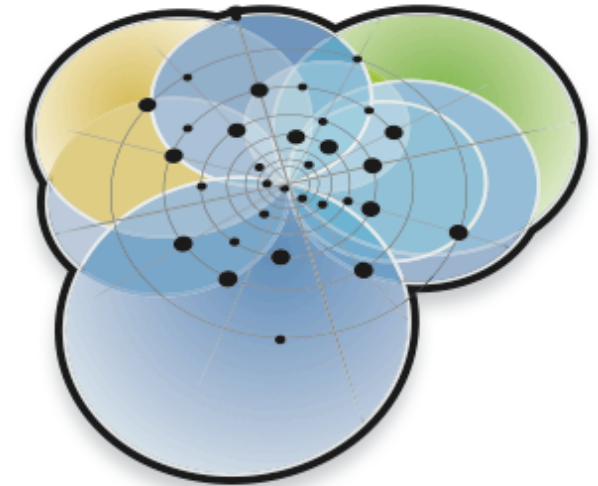
Ultra-Large-Scale Systems

Smart Home

Smart Factory -
E.g. Industry 4.0

E-Health

System of Systems

Smart Logistic

http://oceanservice.noaa.gov/news/weeklynews/nov13/ioos-awards.html

Ambient
Assisted Living

Micro Grids

Focus: collaborative case

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Ant colonies operate as a **superorganism** that combines information processing of many ants and their interaction with the environment at the physical level.

Observations:

☐ In particular social insects like ants do not communicate directly but rather indirectly with each other to achieve an overall desirable behavior.
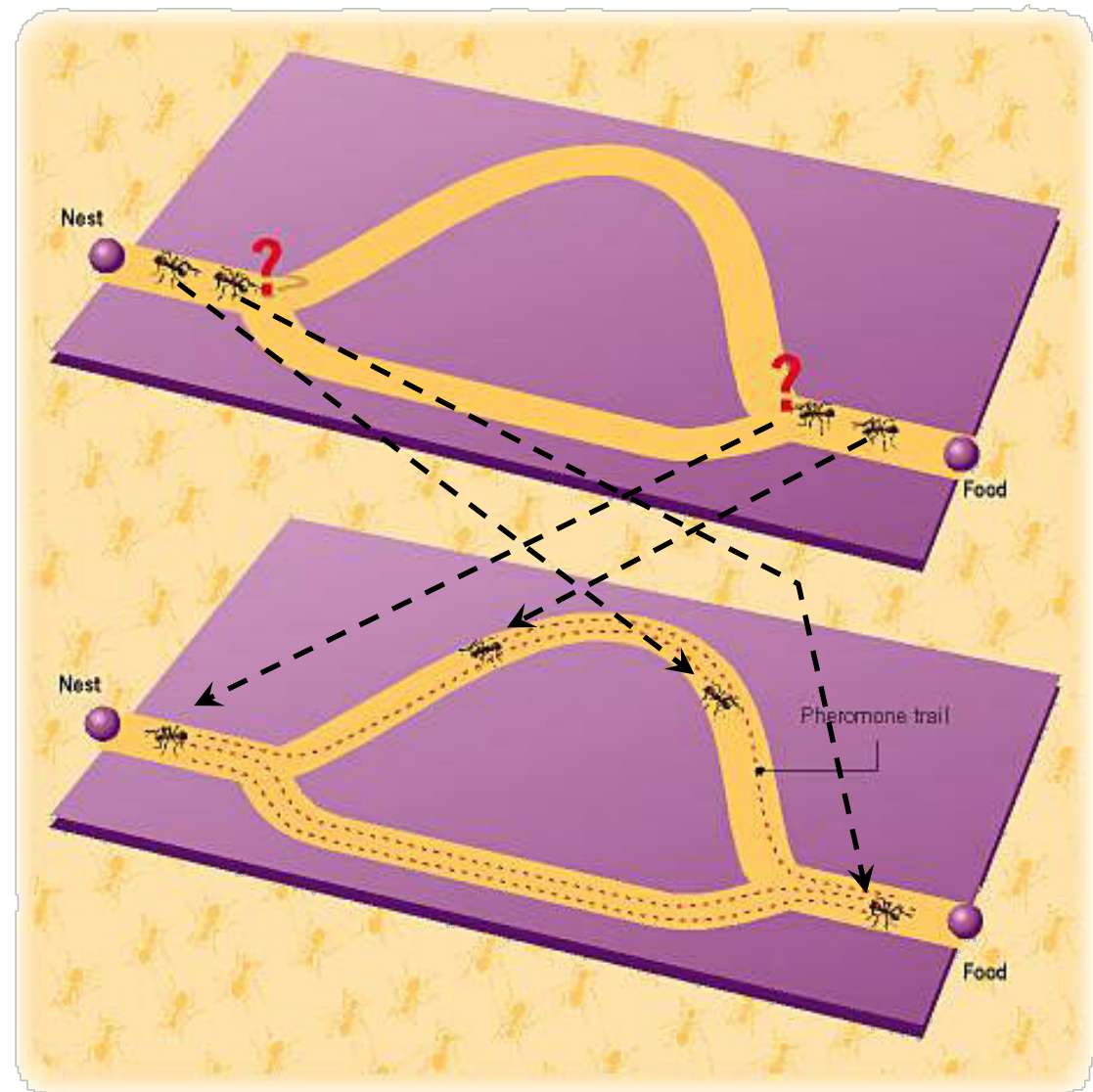
Stigmergy:

☐ Stigmergy is a **coordination mechanism** without any direct communication (employed by biological systems of individuals).

☐ The indirect communication is mediated by **modifications of the environment (marks)** by the individuals, which in turn influence the actions of the individuals.

Stigmergy: Asymmetric Binary Bridge Experiment

Observations:

- ☐ Initially both options will be taken with the same probability.

- ☐ The concentration of the pheromones will increase faster on the shorter path.

- ☐ The higher concentration of pheromones on the shorter path will make it more likely that an ant choses this shorter one.

- ☐ Positive feedback will amplify this effect and thus finally the longer path will only be used seldom.

Stigmergy: Dynamic Obstacle Avoidance

a)   b)   c)
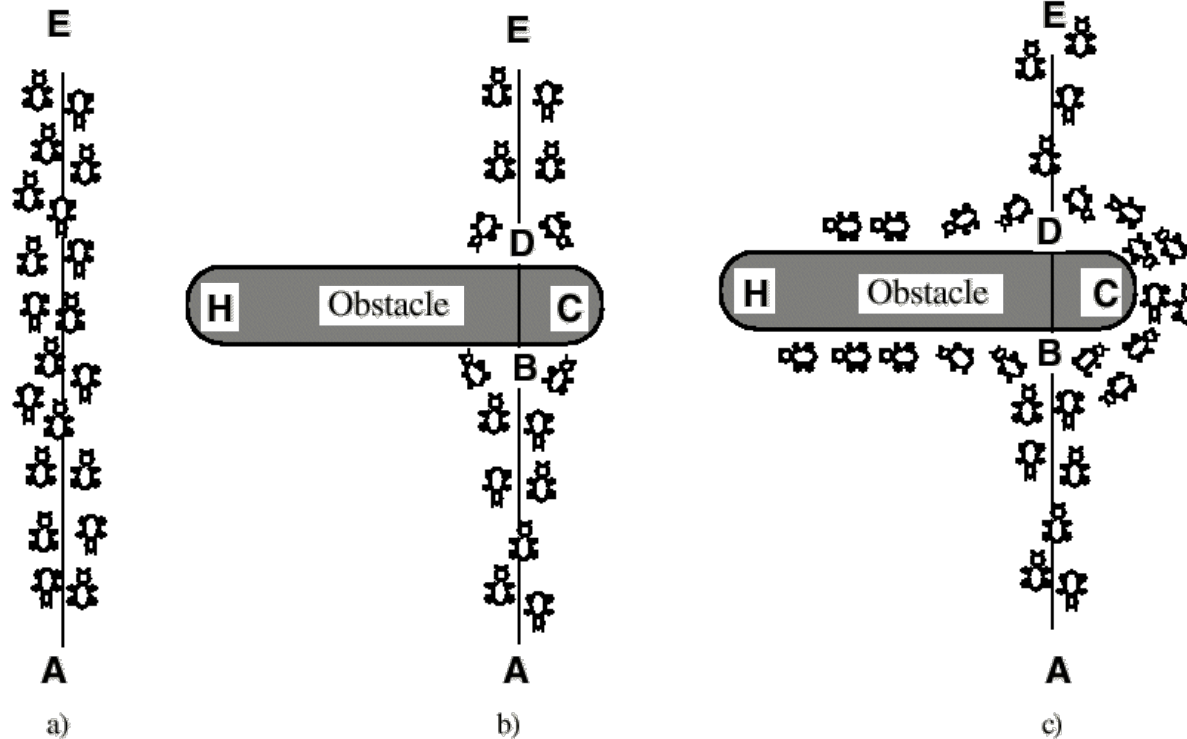
Observation:

☐   Pheromones ensure that in the long run the shortest detour dominates

Stigmergy: Ant Mill

So What?

- Such a behavior would be not acceptable for a CPS system even if they are confronted with **unexpected circumstances (rare events)**.

- If even "Nature" come up with designed solutions that fail (even it filtered for ages), how could we envision to be more successful?

- But there is also a solution in nature:

  reflection/**adaptation** on itself (**self-awareness**)

My Game Changing and Controversial Topic ...

➔ Often CPS **requires** the capability of **self-awareness** to be able handle such problems due to unexpected circumstances

- Models must be able to evolve (**runtime models**)

- Systems must **reflect** on itself (**self-aware** of goals)

- Systems must **adapt**/self-adapt/learn

➔ many results for CPS are no longer applicable as they do not cover reflection/adaptation (design, verification, ...)
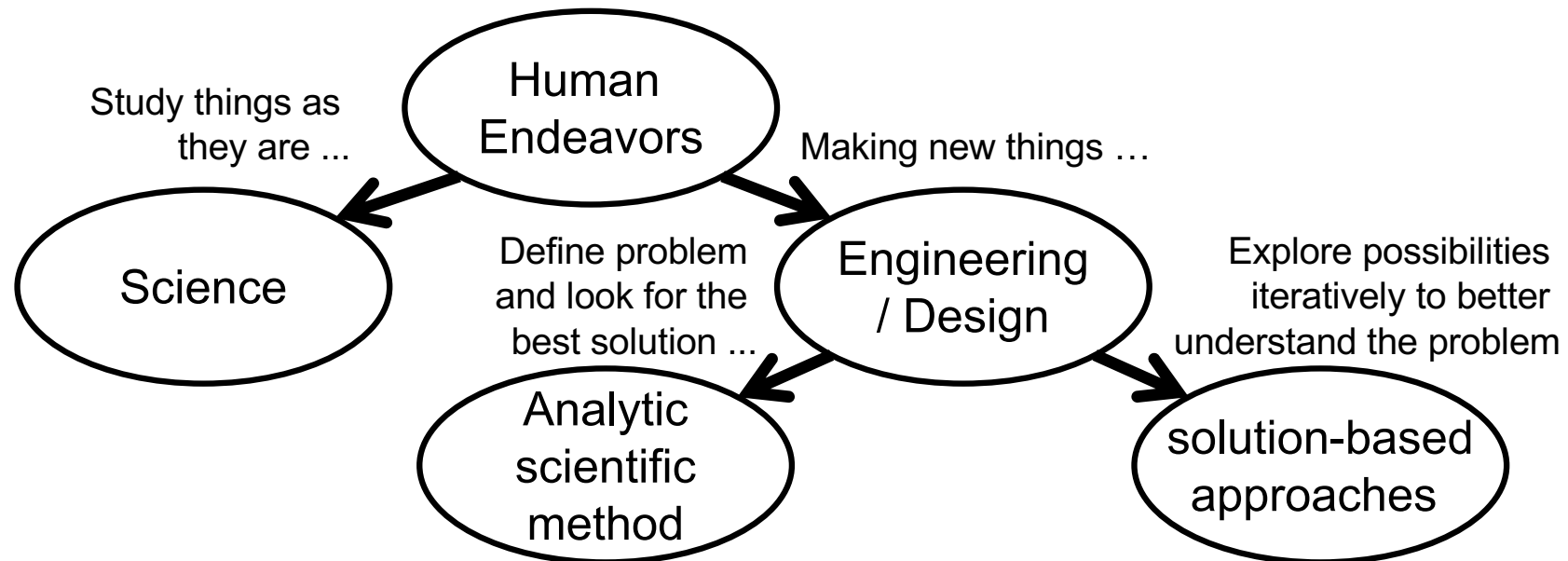
➔ many **design-time activities** must accompanied by **run-time activities** (design, verification, ...)

➔ **reflection/adaptation** will make the overall design easier long term (by separation via reflection levels).

FINE

One more Controversial Topic …

Study things as they are …

Human Endeavors

Making new things …

Science

Define problem and look for the best solution …

Engineering / Design

Explore possibilities iteratively to better understand the problem

Analytic scientific method

solution-based approaches

Well-defined problems have specific goals, clearly defined solution paths, and clear expected solutions.

➔ Engineering becomes an optimization problem

Ill-defined problems are those that do not have clear goals, solution paths, or expected solution.

Wicked problems are ill-defined problems that are not understood until after the formulation of a solution [7]

➔ Engineering becomes an iterative search problem

➔ The computation and physical domain are different concerning their engineering!