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Welcome!



SDPS 2023

TOWARDS A SUPRA-DISCIPLINARY DESIGN AND PROCESS SCIENCE

Workshop Session: Intellectualized Cyber-physical Systems

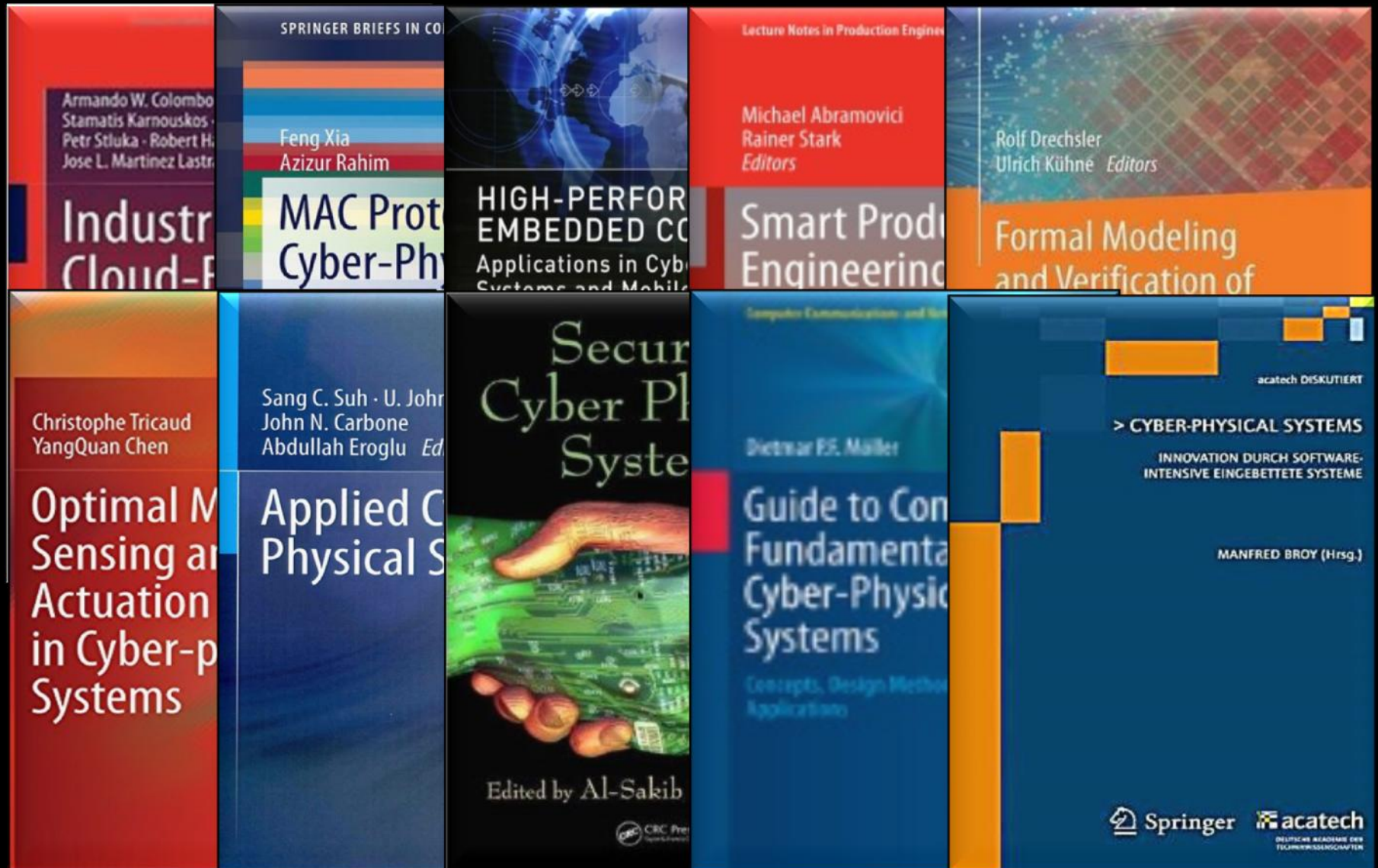
INTELLECTUALIZATION OF CYBER-PHYSICAL SYSTEMS

Position statement by:

Prof. em. Dr. Imre Horváth



A discipline in rapid development



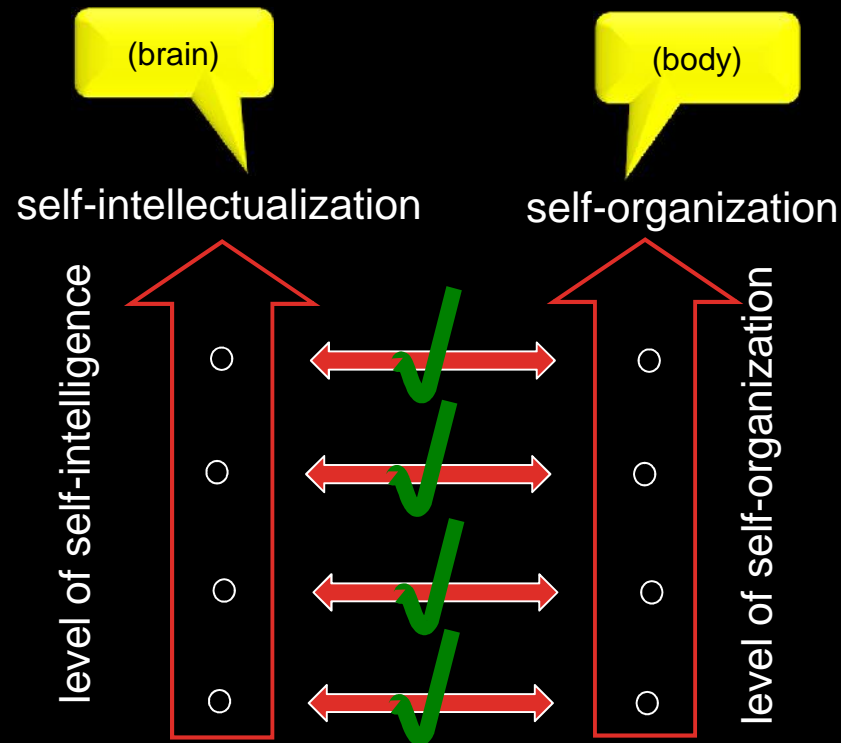
How are CPSs defined?

- **Augmentative definitions:**
express in which sense CPSs are more than other comparable traditional systems
- **Descriptive definitions:**
bring a large number of experienced common characteristics of CPSs into an exact holistic formulation in a specific context
- **Normative definitions:**
intend to capture a minimal set of criteria that specific CPSs implementations should meet in order to be regarded as such
- **Predictive definitions:**
include systems science abstractions or projections to forecast distinguishing characteristics of future (next-generation) CPSs
- **Symbolic definitions:**
create canonical models/constructs to capture the essence using logical, mathematical, and information technological means

What are CPSs for us?

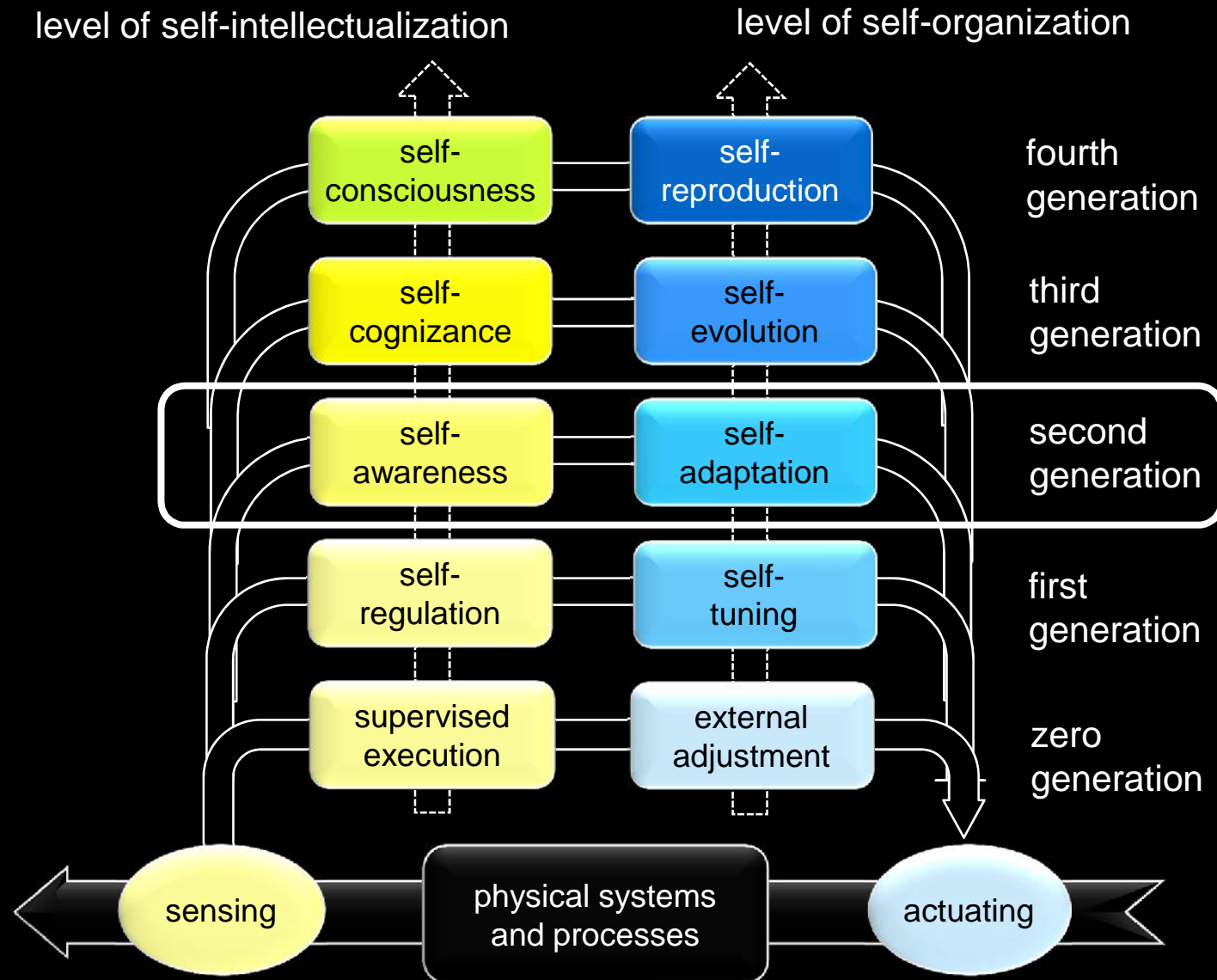
- Distinguishing characteristics of CPSs were defined as:
 - Smart **multi-actor networked** systems
 - Enabled by **cyber-physical computing**
 - Deep **diffusion** in physical processes
 - Sensing-reasoning-adapting-actuating **loop**
 - Model of future **intellectualized** systems
 - **Resource** and **service** provisioning
 - Application in **human/social contexts**
- These are neither **all-or-none**, nor **perpetual** characteristics
- Assumption has been that CPSs develop through paradigmatic **generations**
- Two **basic enablers** cause the difference among them

Analogical argumentation



- **Consciousness** is not considered to be addressable on the current state of progress as the basis of system intellectualization
- **Autonomism** is regarded as a derivative of self-intelligence and self-organization

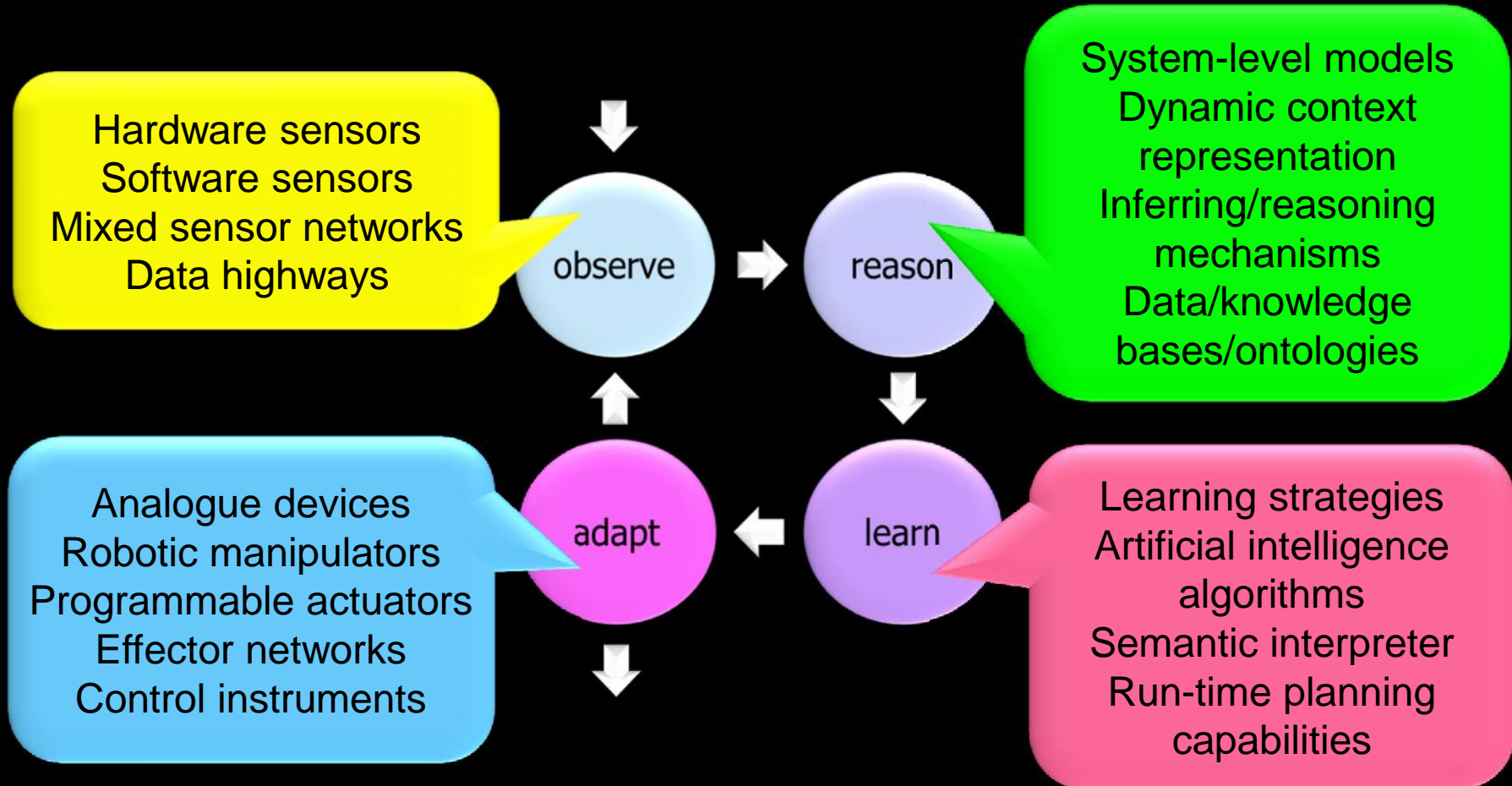
Generations of cyber-physical systems



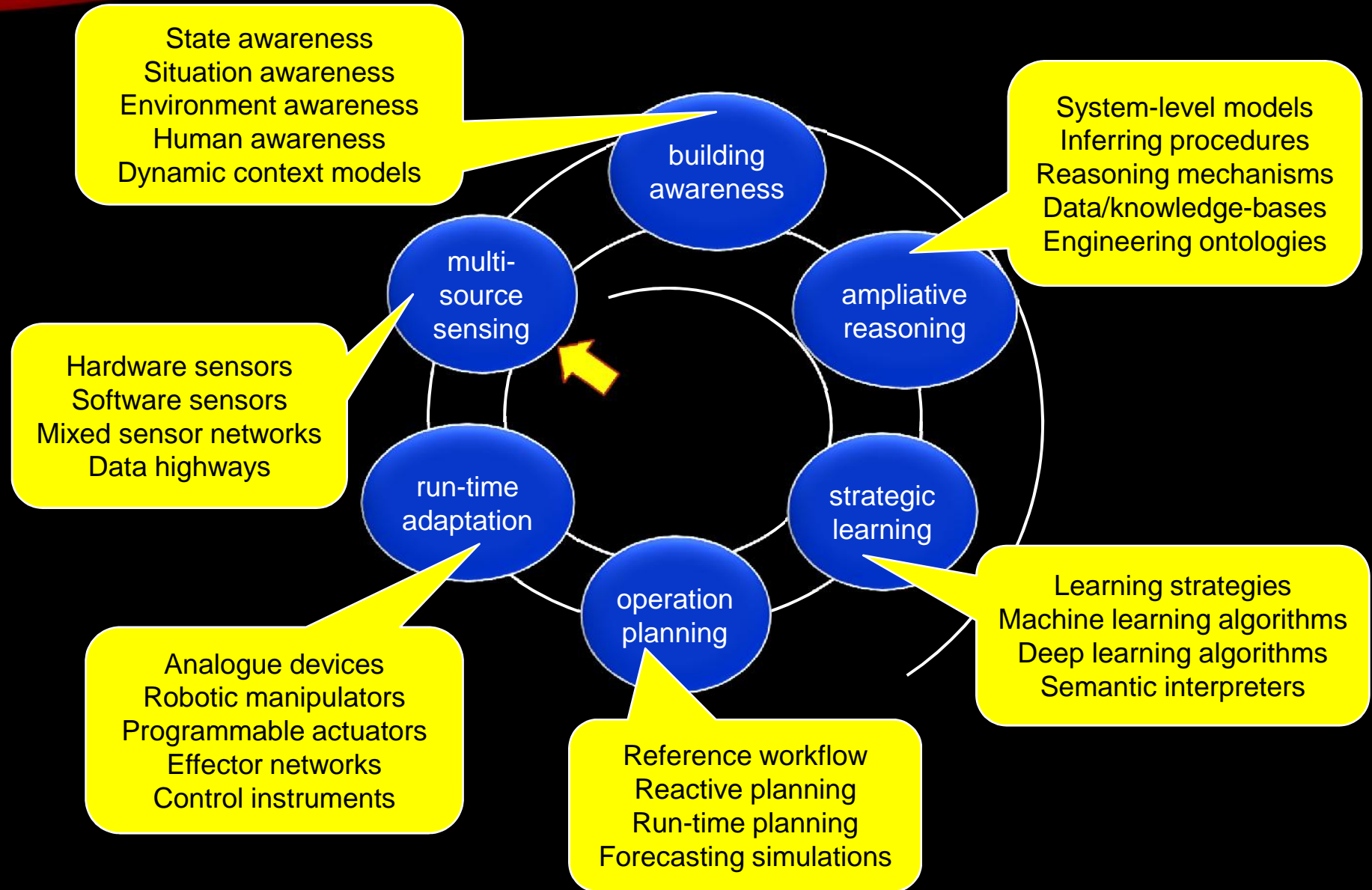
Characteristics of smart systems

- **Connectedness**
Ability to communicate, integrate, and bundling
- **Proactivity**
Anticipation of stakeholders' plan and intentions
- **Awareness**
Considering objectives, states, constraints, contexts
- **Situatedness**
Recognition of situational and community contexts
- **Personalization**
Customization according to the stakeholders' needs
- **Adaptiveness**
Rendering behavior to objectives and conditions

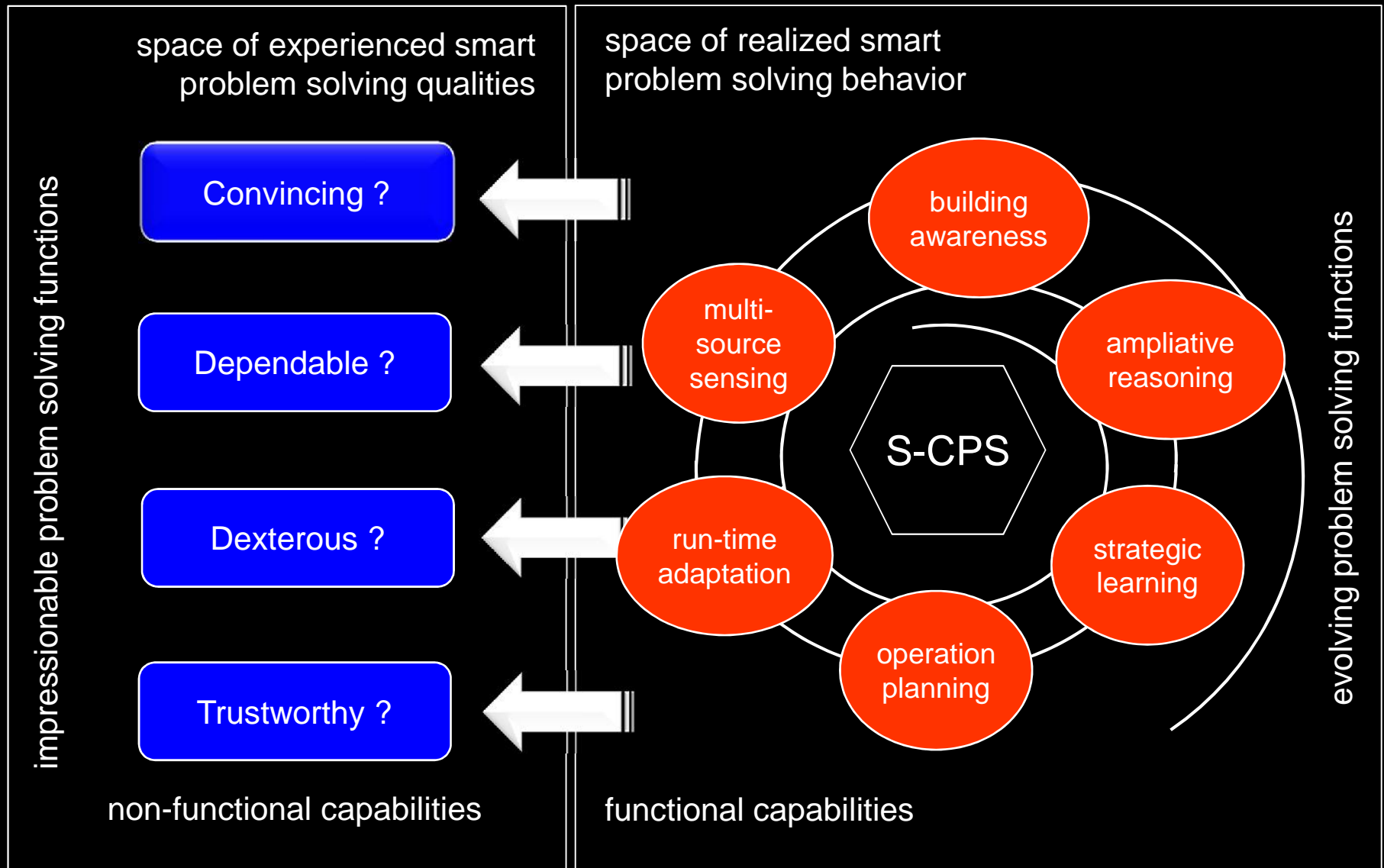
Operational view on system smartness



Computational view on system smartness



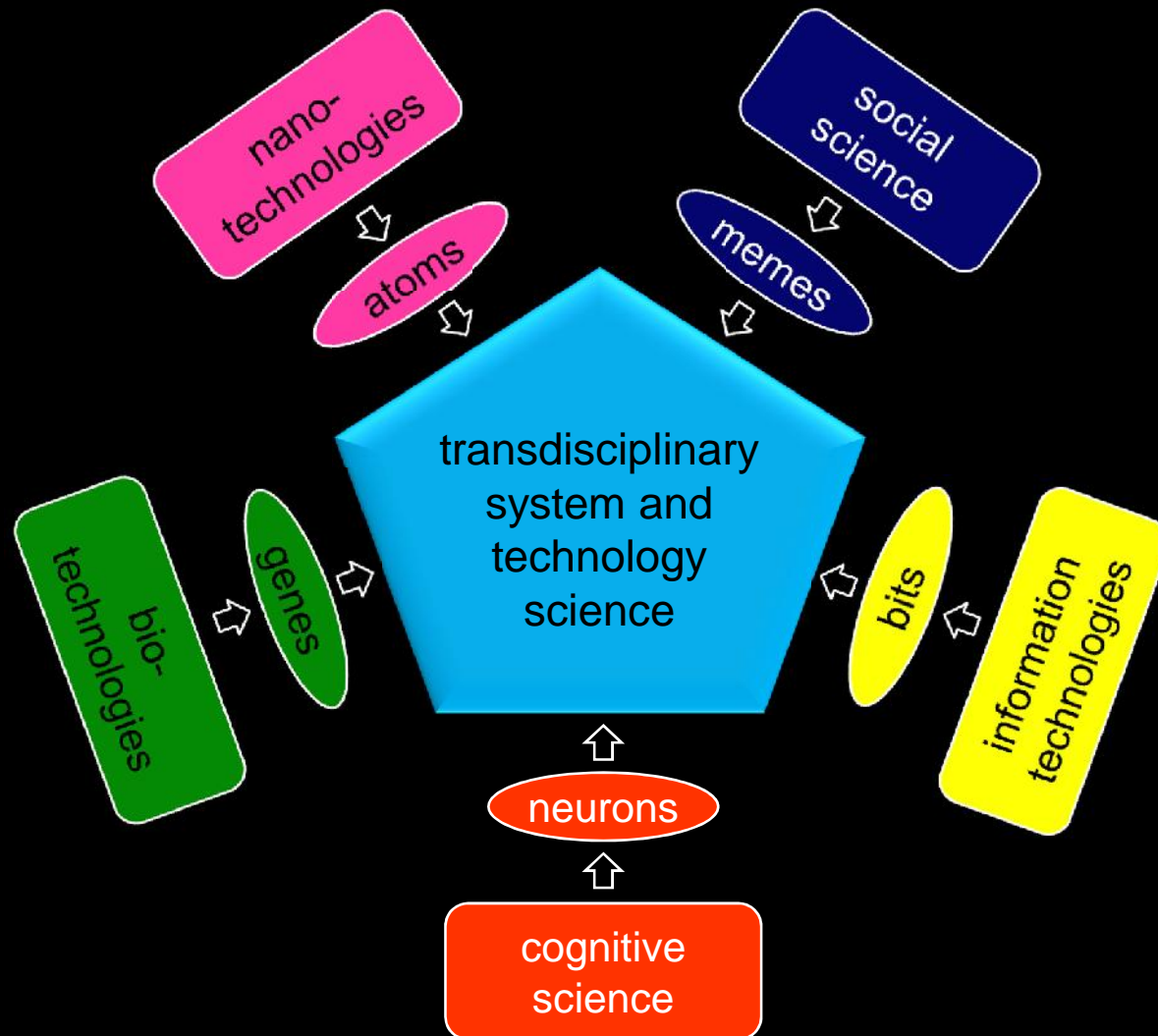
Dual-space of smartness



Challenges of smart CPS

- System operation cannot be **completely defined** in the design phase
- System is characterised by an **emergent behaviour** which in turn entails the need for smart operation
- **Smart operation** needs self-reasoning, self-learning, self-adaptation and self-evolution
- The challenge is to develop the needed **contemplation mechanisms** and harmonize them on system level
- What it means is that a **focused research** is needed in a concrete case of cyber-physical system development
- **Tailored problem solving intellect** is needed and expected from cognitive engineering and artificial general intelligence

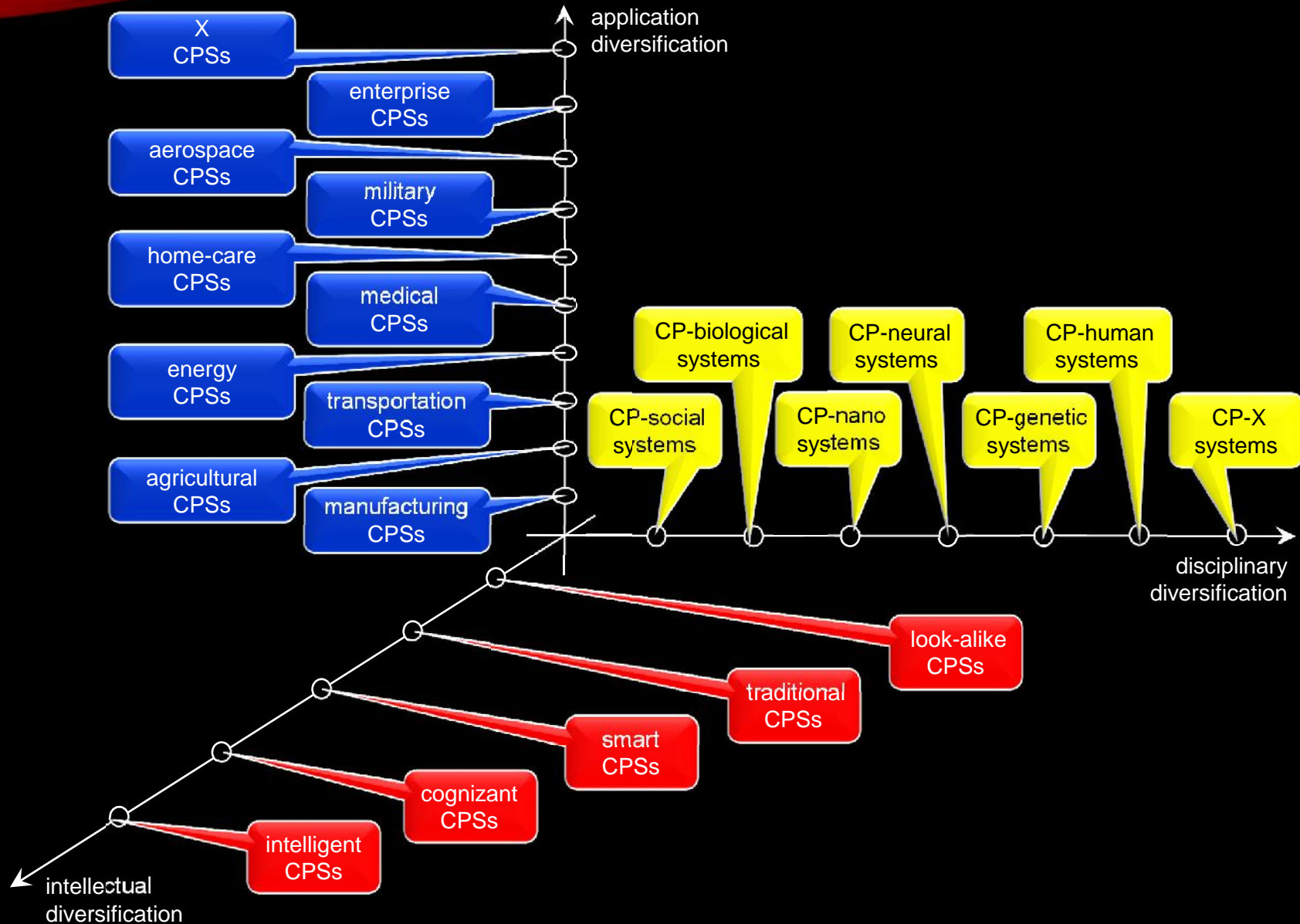
A rapidly advancing phenomenon



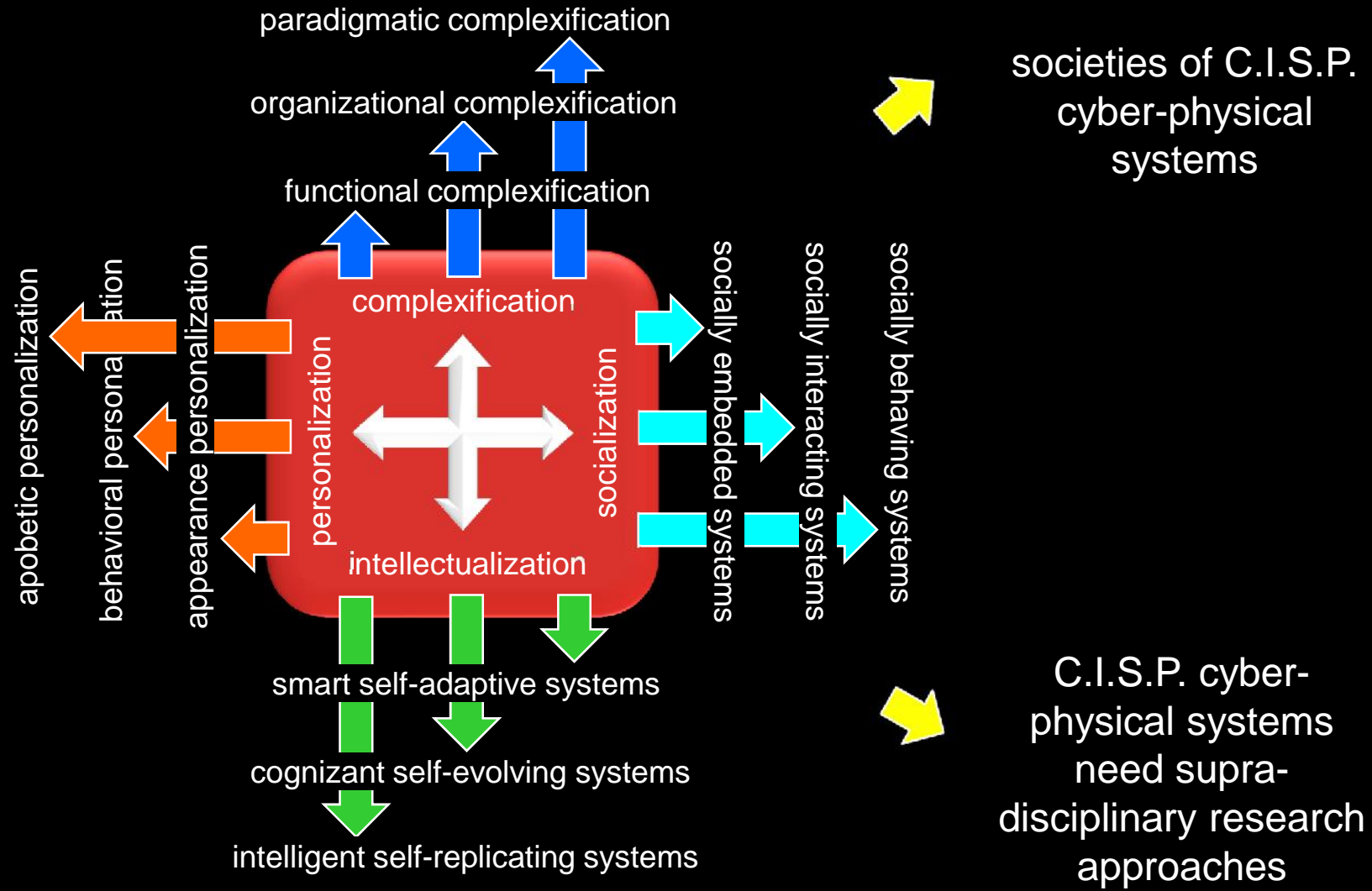
B.A.N.G.M.
technological
integration

Contributes
to changing
the nature of
CPSs

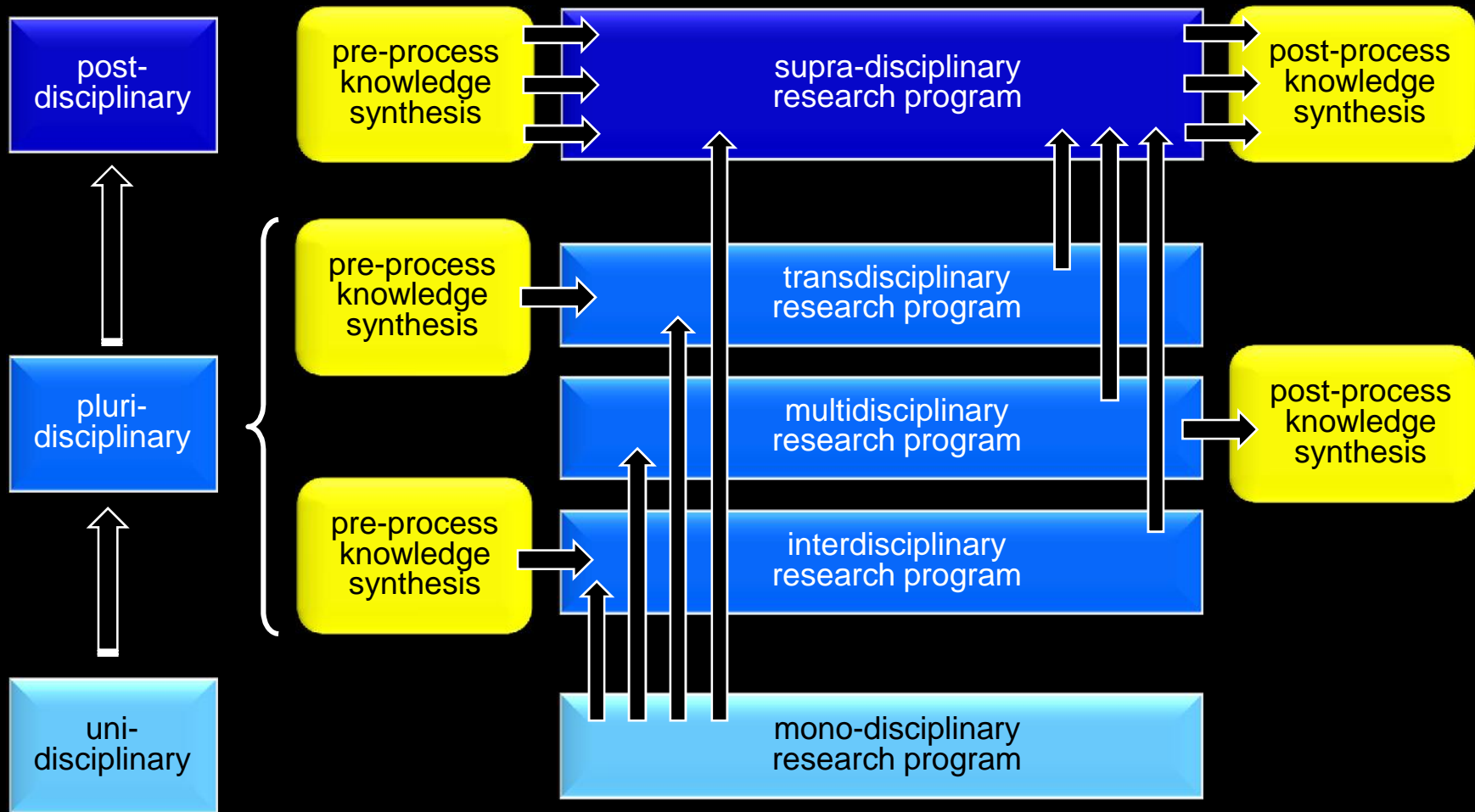
Dimensions of diversification



Overall trends of evolution



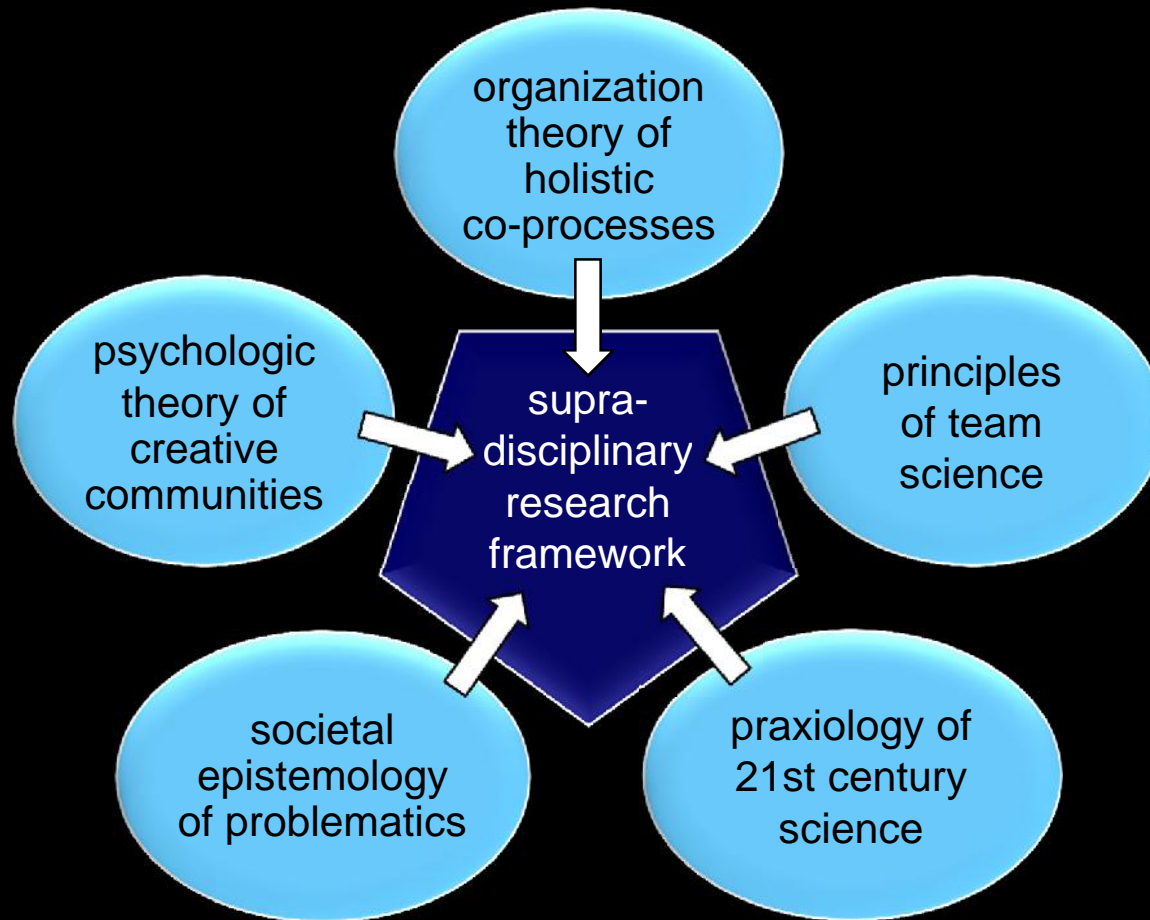
Supra-disciplinary research landscape



Sample research tasks

- In the context of conceptualization/design of **smart cyber-physical systems**, such problematics/phenomena can be:
 - exploring social demands for smart CPSs in the light of the current technological affordances
 - exploring application opportunities for a society/family of smart CPSs
 - ideation of next generation home-care servicing smart CPSs with alternative cost profiles
 - aggregation and distribution of synthetic system knowledge from and to a fleet of smart CPSs
 - intellect resource warehouses and upgrade mechanisms for self-evolving smart CPSs
 - complex solutions for transferable smart cyber-physical-social-human systems
- and so forth.

Influential factors



Some preliminary questions

- Intellectualization is the major game changer in the field of CPSs, beyond complexification, socialization, and personalization
 - What is the essence of the growing intellectualization of CPSs and what is its trajectory?
 - Is achieving human-type intelligence a necessity for I*CPSs in a longer term?
 - What are fundamental issues of designing, implementation, and application of socialized and personalized I*CPSs?
 - What problem solving knowledge, reasoning mechanisms, and cognitive technologies can I*CPSs use and for what?
 - What way will I*CPSs be integrated into the fabric of society and industry?
 - What will the relationship I*CPSs with humans and other systems be like and how will it evolve?

Panelists



Bedir Tekinerdogan



Zuhail Erden



Mey Goh



Stefano Borgo

intellectualized
cyber-physical systems



Martin Törngren



Imre Horváth



Duncan A. Coulter

Position statements

- Intellectualized cyber-physical systems: Just in time! I.H.
- Interacting with intelligent CPSs: How to make sense of smart agents ontologically? S.B.
- What were you thinking? – The need for explicitly explicable AI systems D.C.
- Are the cyber-physical systems only “cyber-physical”? Z.E.
- Human - The missing link in CPS? M.G.
- From complexity to intelligence: Multi-paradigm modeling for next-generation CPS T.B.
- Responsible deployment of trustworthy CPS as part of socio-technical systems M.T.



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