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Delft University of Technology

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# New age, new systems, new services and new challenges for students and teachers of industrial design engineering

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2

# Today's lecture ...

... is a personal view on:

- Influencing trends
- Effects on products
- New design challenges
- Reflection on projects
- Prepare your future

# Setting the stage for discussion ...

# Traditional customer durables

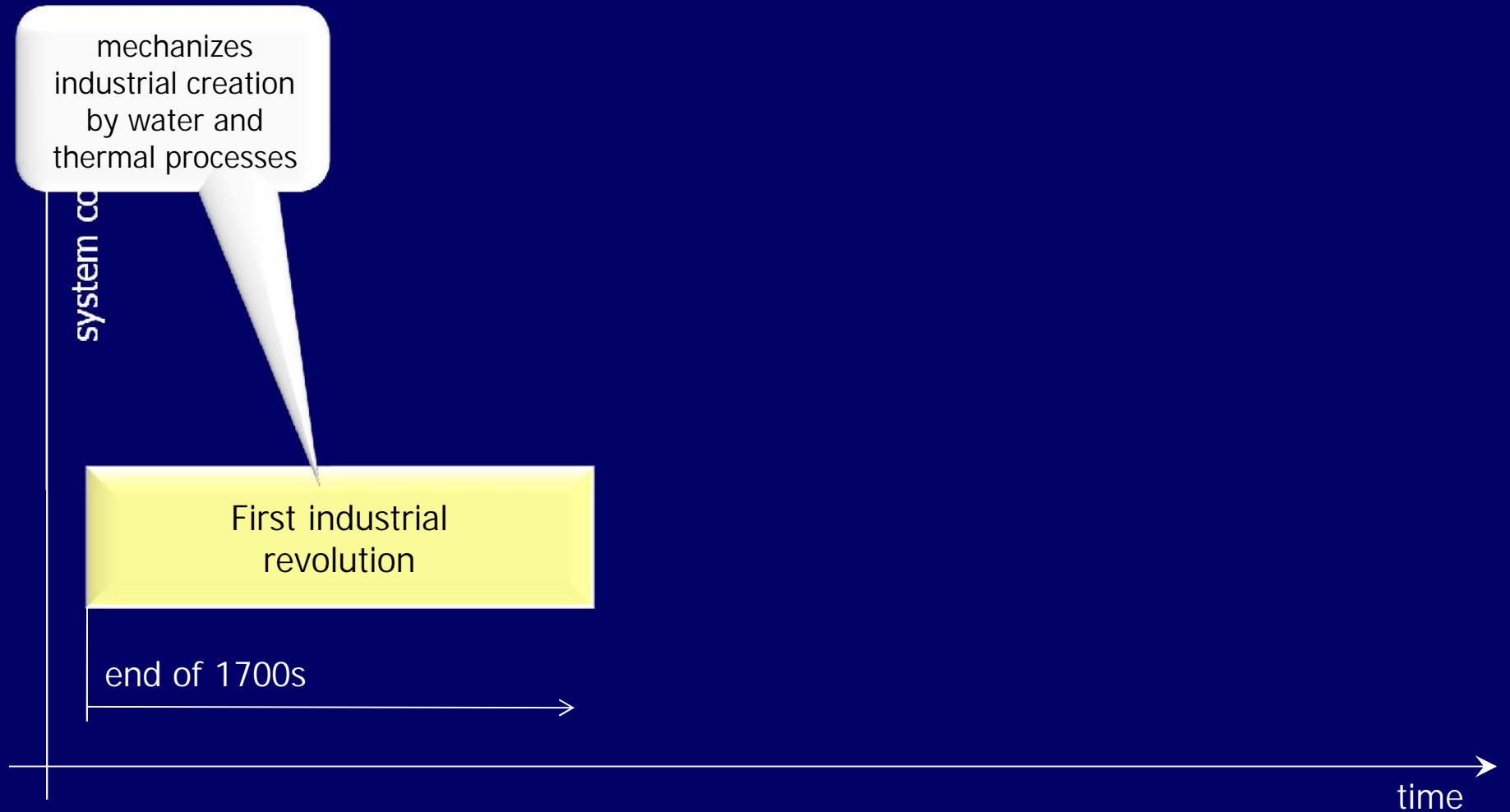


But the change is just around the corner ...

# Accelerating industrial revolutions

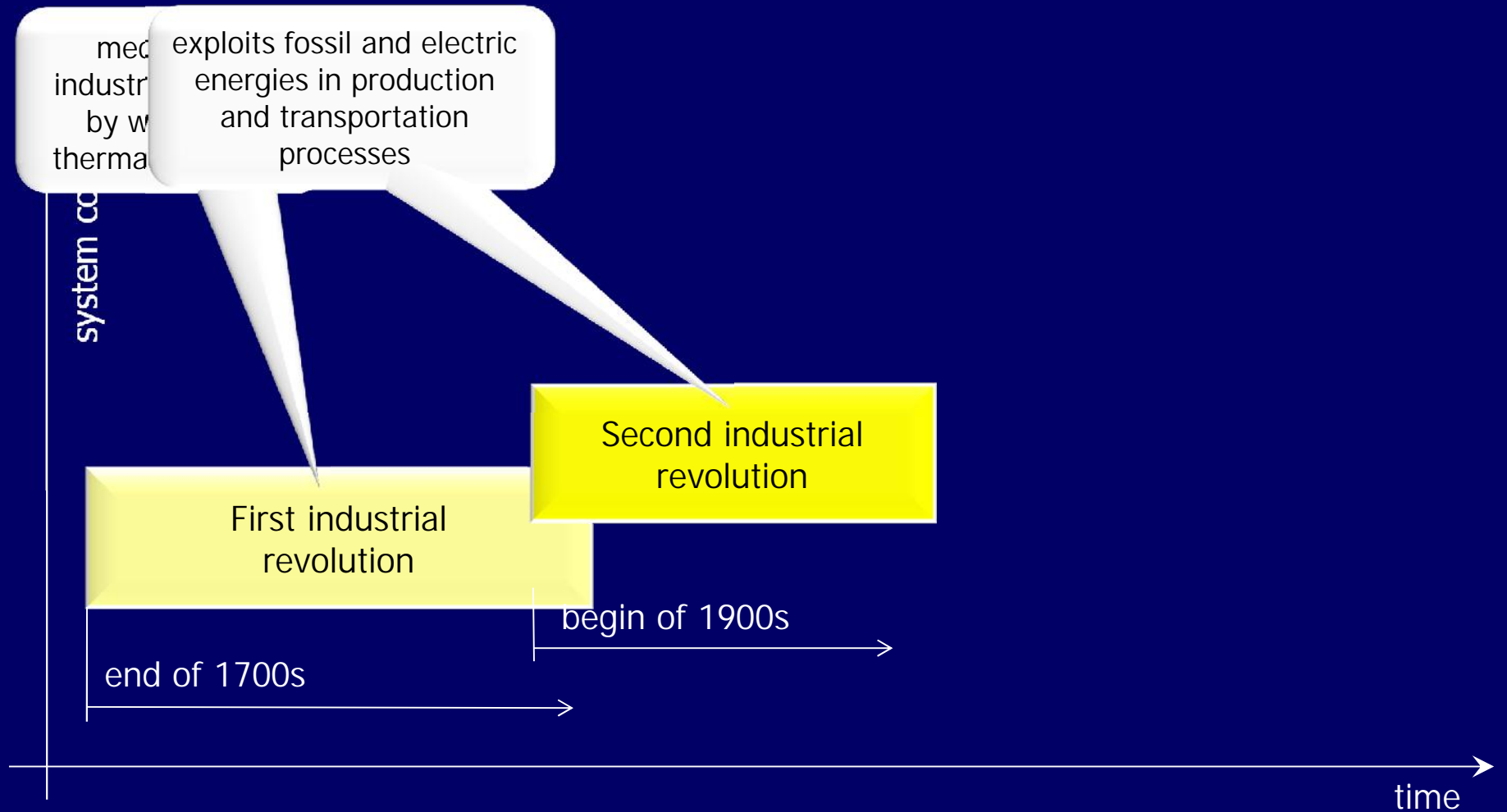


# Accelerating industrial revolutions

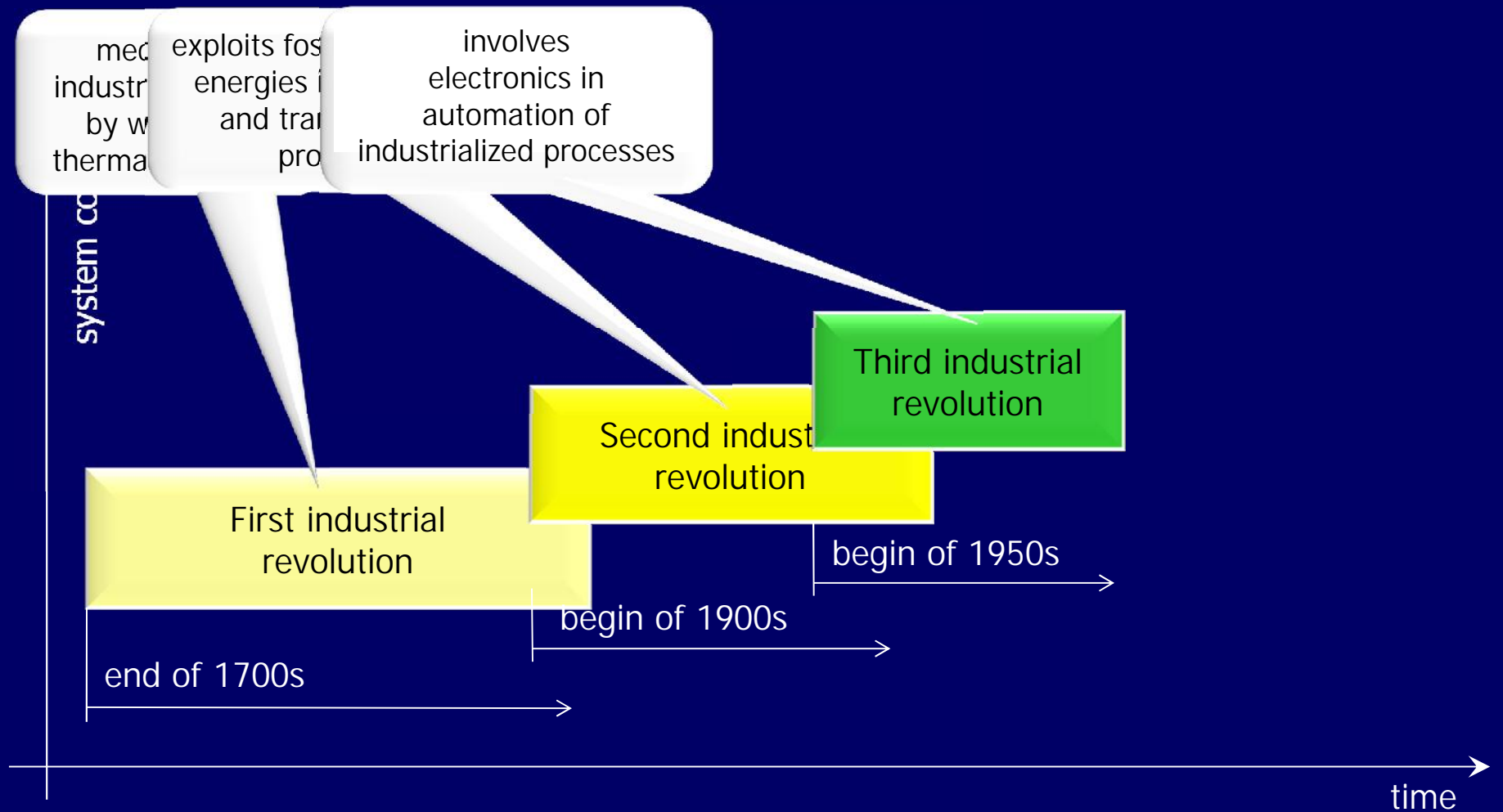




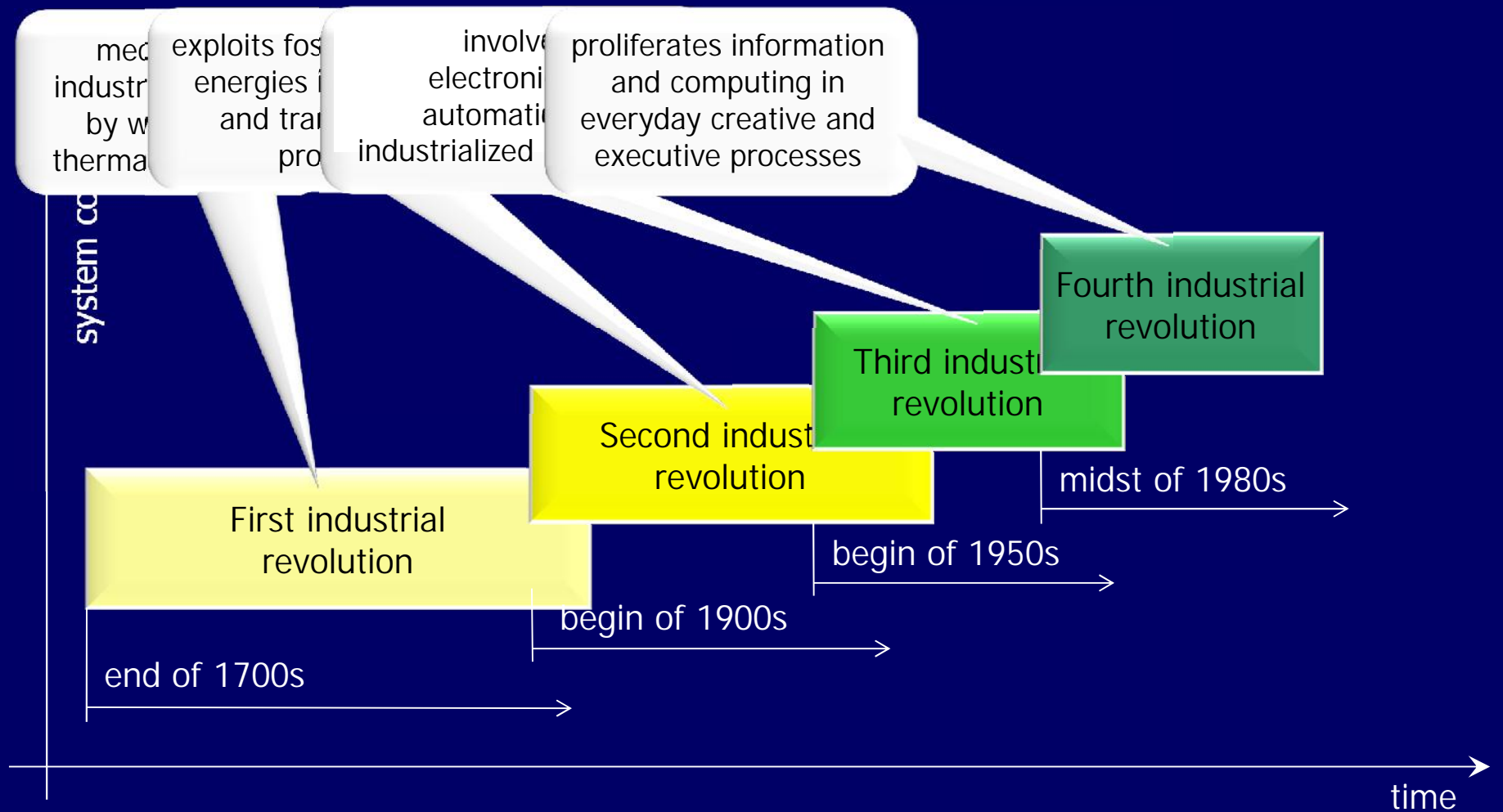
# Accelerating industrial revolutions



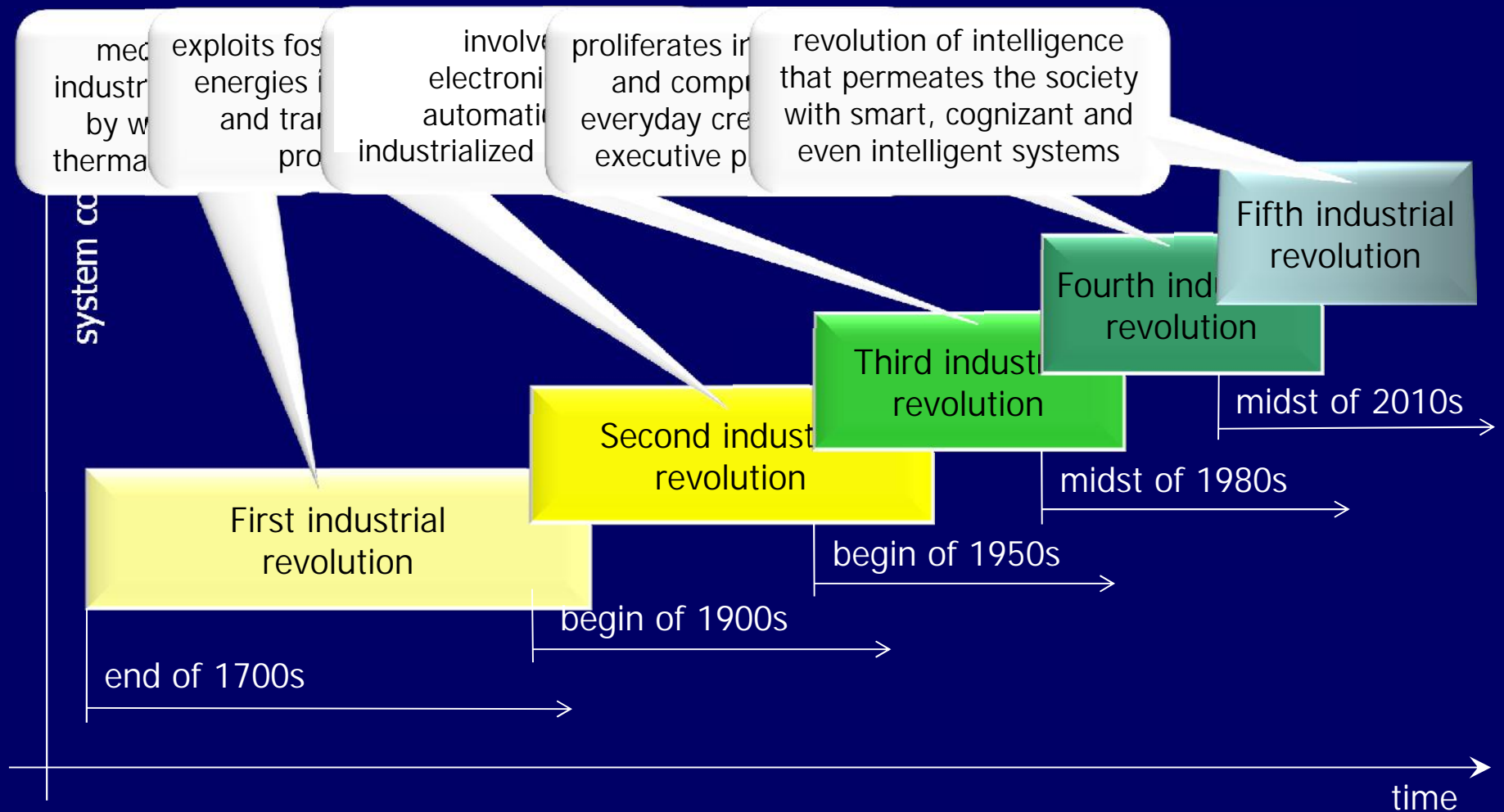
# Accelerating industrial revolutions



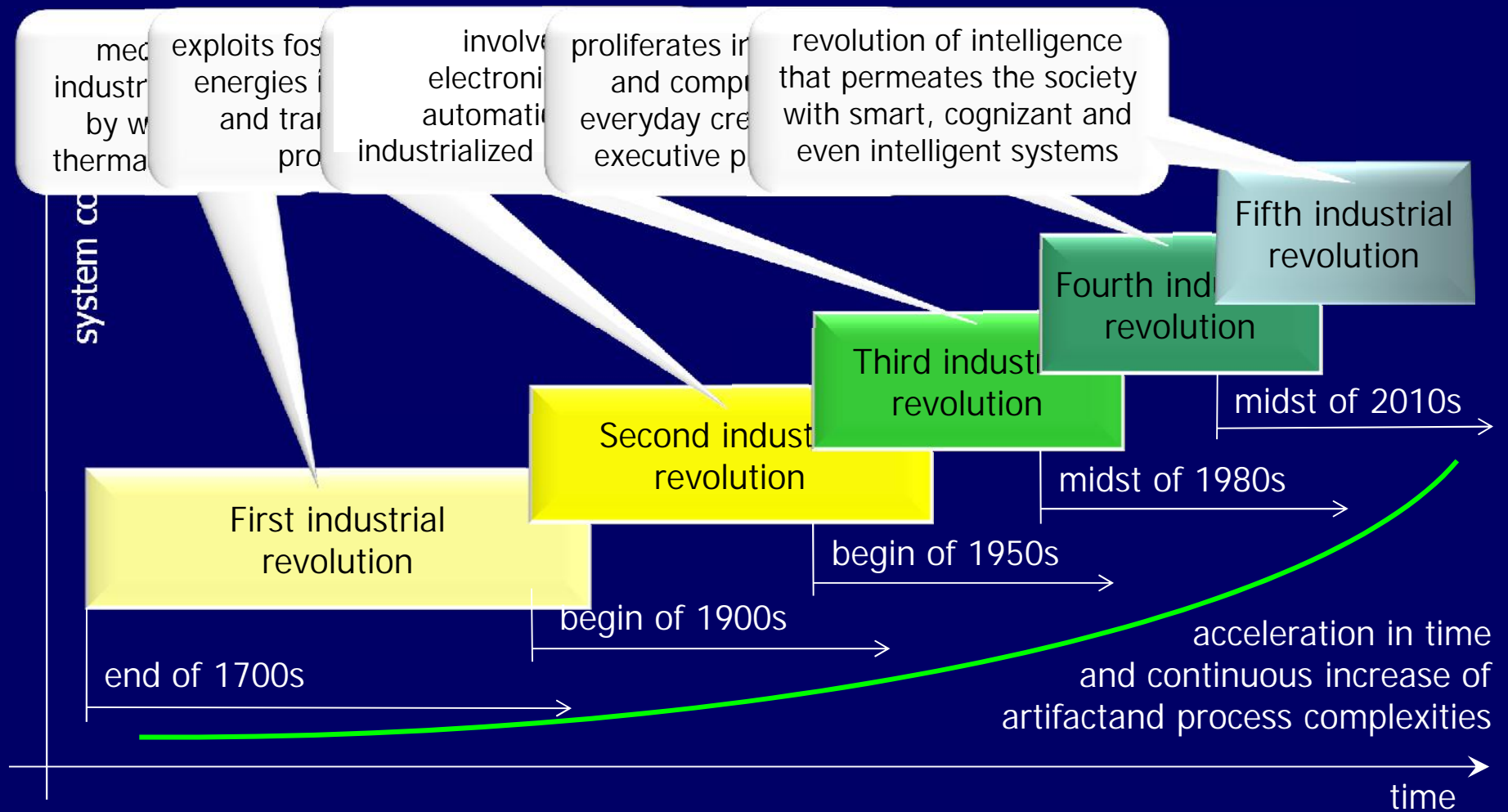
# Accelerating industrial revolutions



# Accelerating industrial revolutions



# Accelerating industrial revolutions



What is the most influential factor nowadays?

# Changing computing paradigms (1)

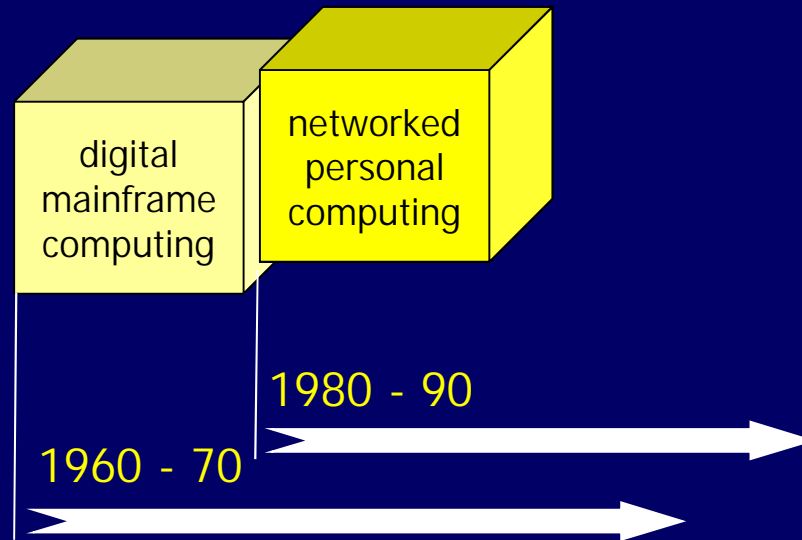


digital  
mainframe  
computing

1960 - 70

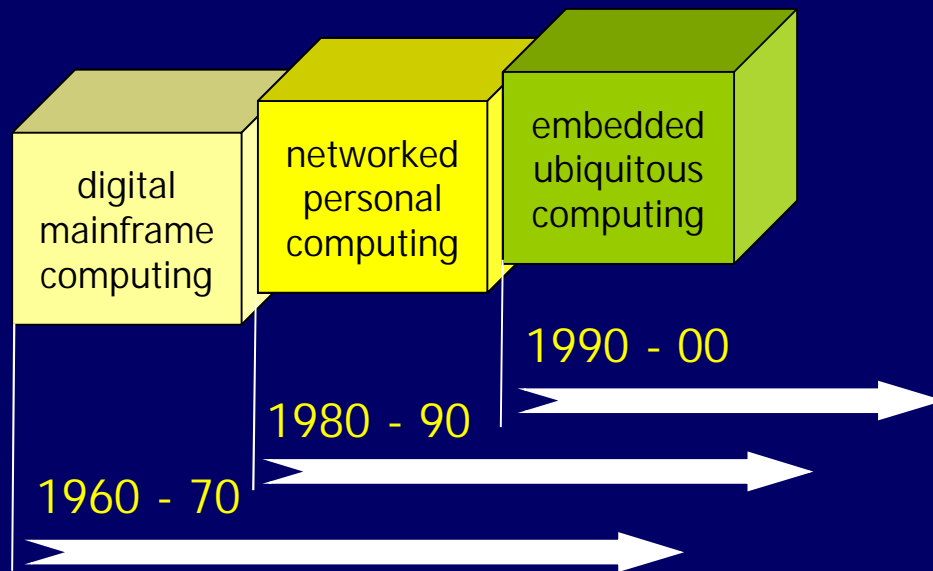


# Changing computing paradigms (2)

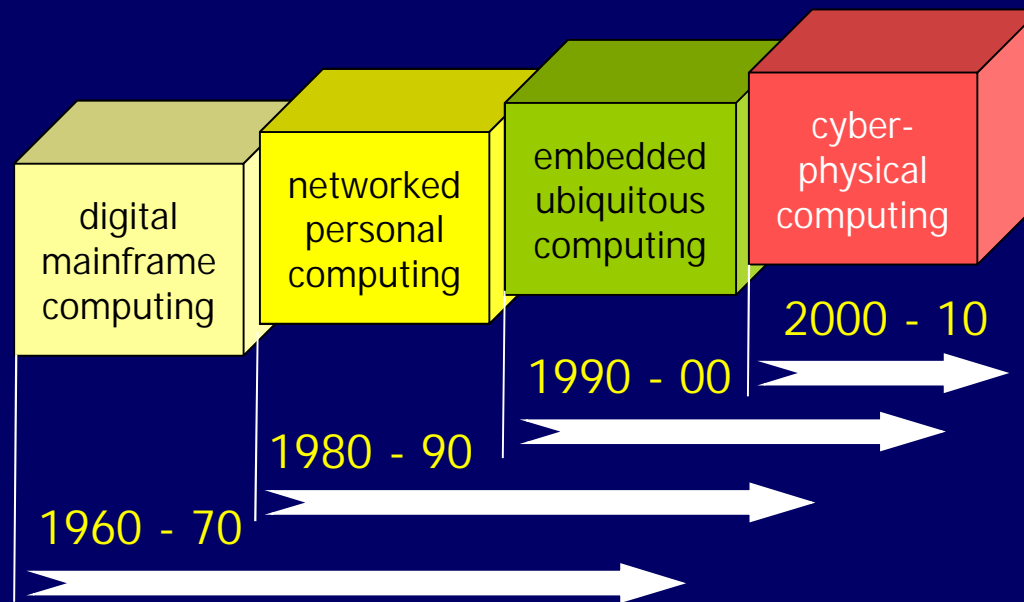




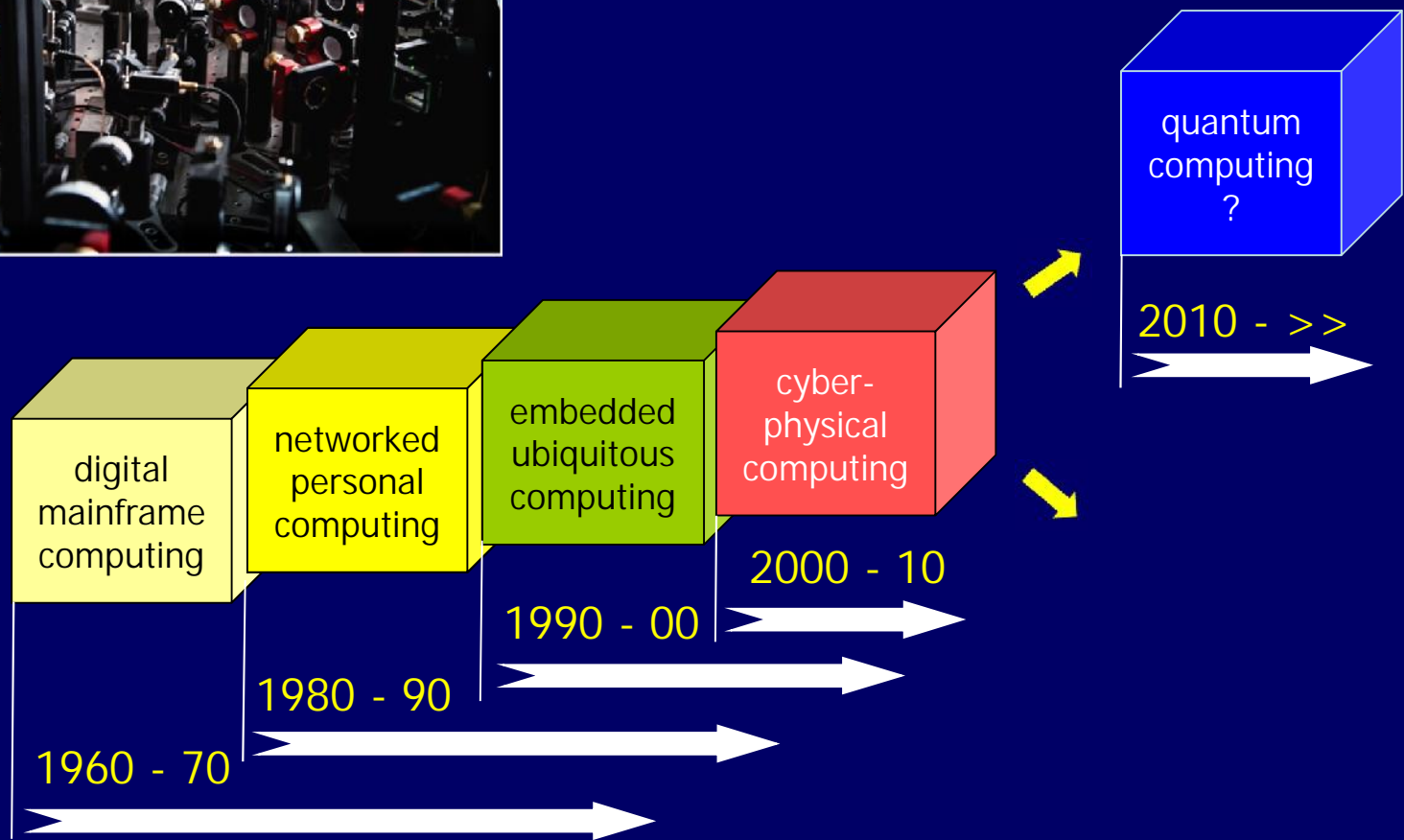
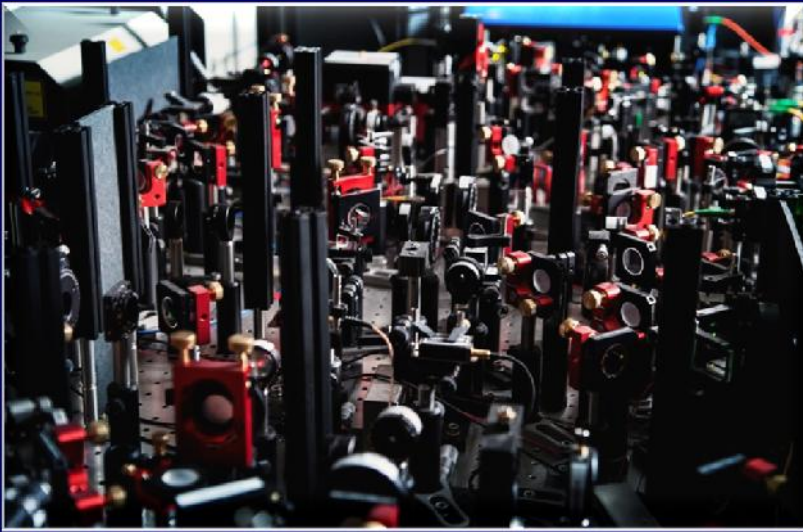
# Changing computing paradigms (3)



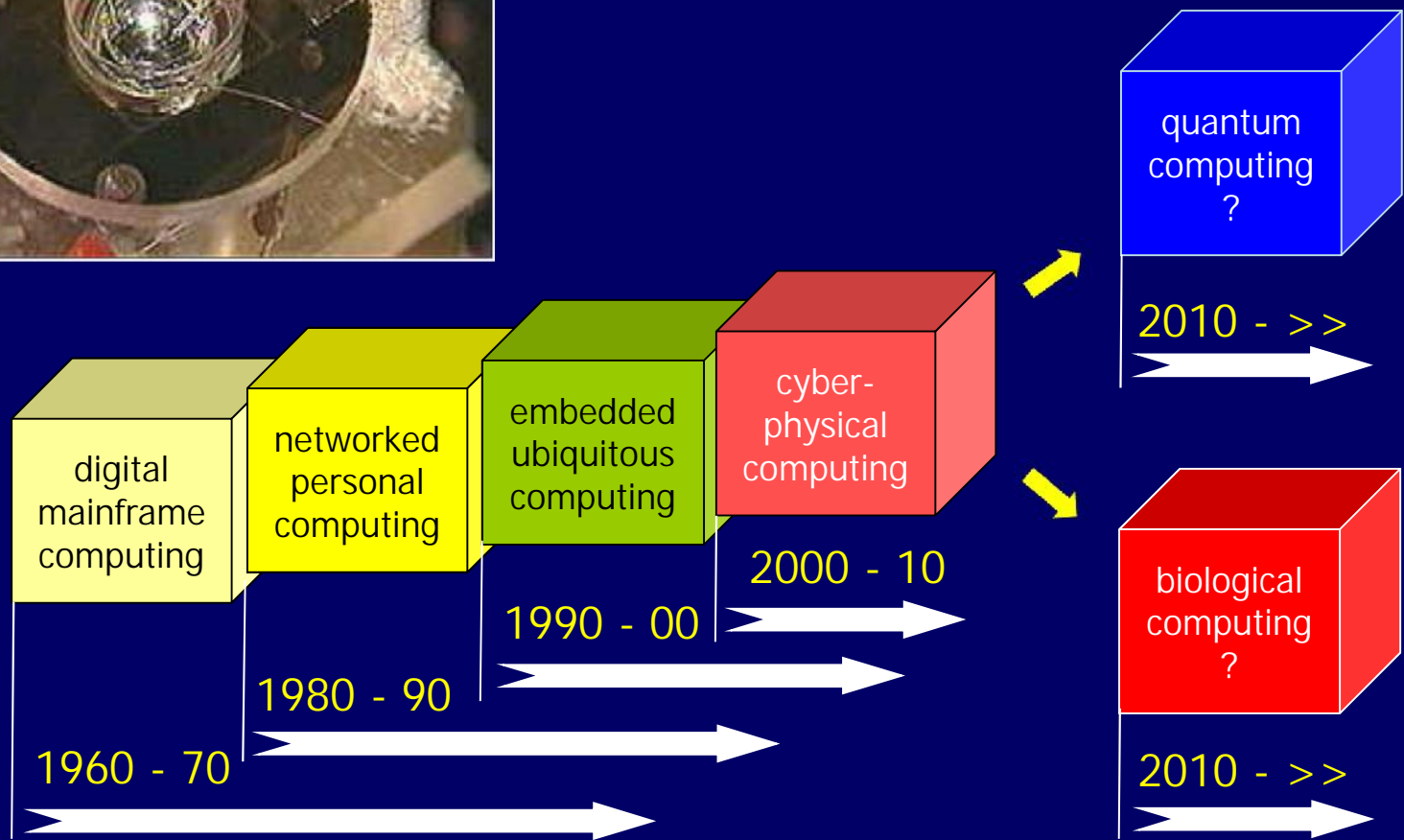
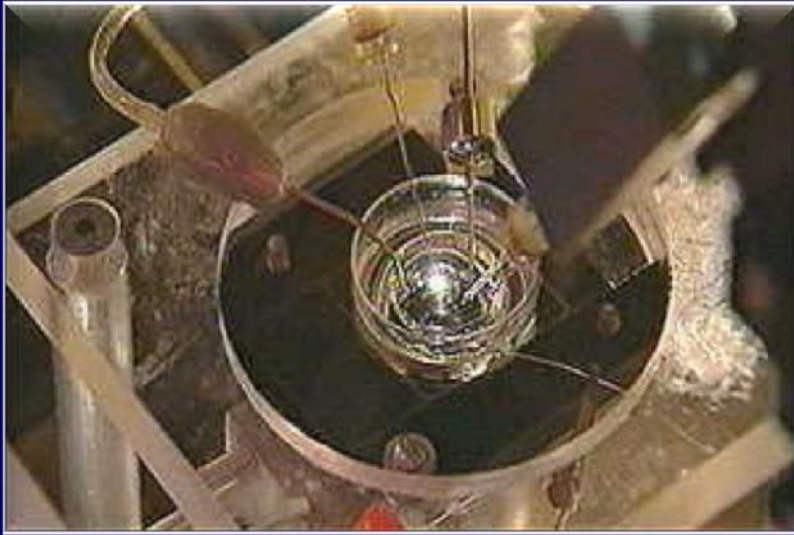
# Changing computing paradigms (4)



# Changing computing paradigms (5)

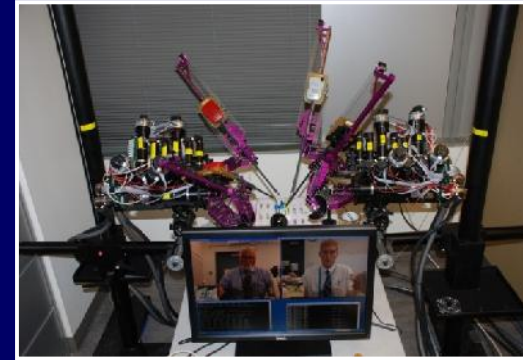


# Changing computing paradigms (6)



And these influence everything around us!

# Shifting paradigms of systems

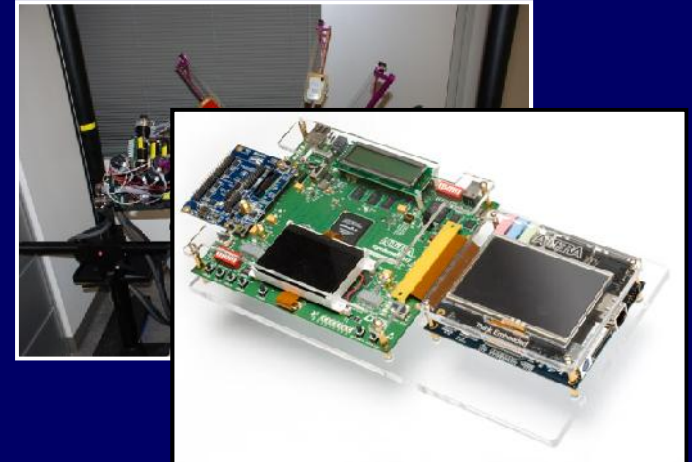


advanced  
mechatronics  
systems

# Shifting paradigms of systems

embedded  
systems

ed  
ronics  
systems

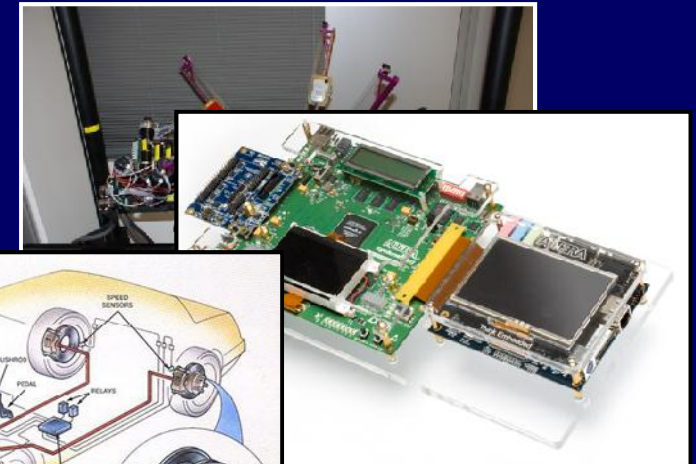
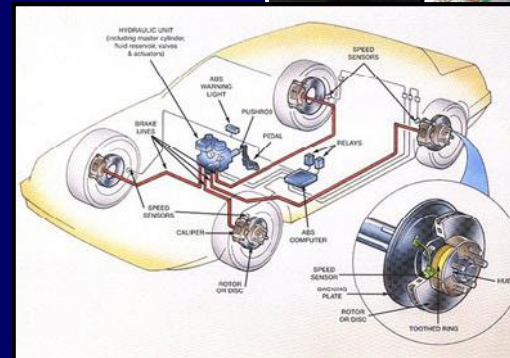


# Shifting paradigms of systems

embedded  
systems

distributed  
real-time  
systems

centralized  
systems



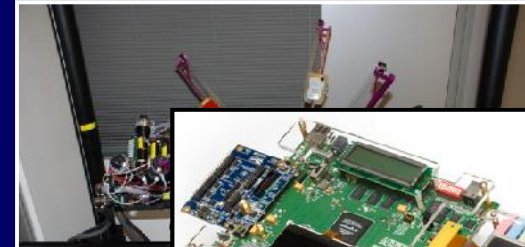
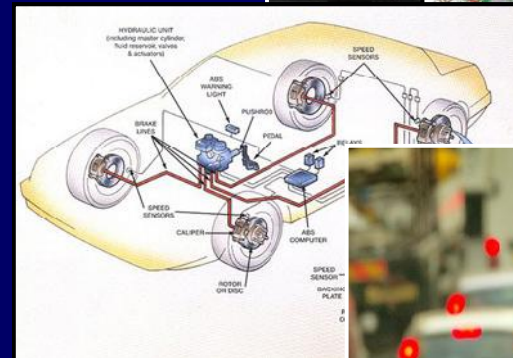


# Shifting paradigms of systems

embedded  
systems

distributed  
real-time  
systems

networked  
agent-based  
systems



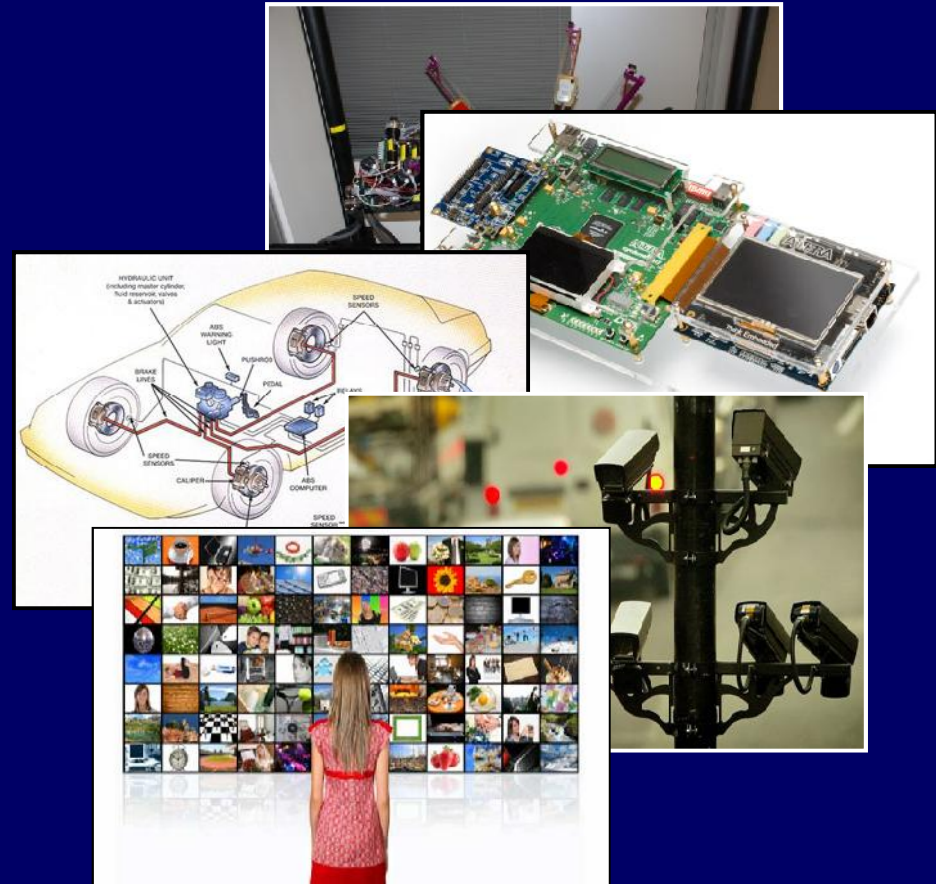
# Shifting paradigms of systems

embedded systems

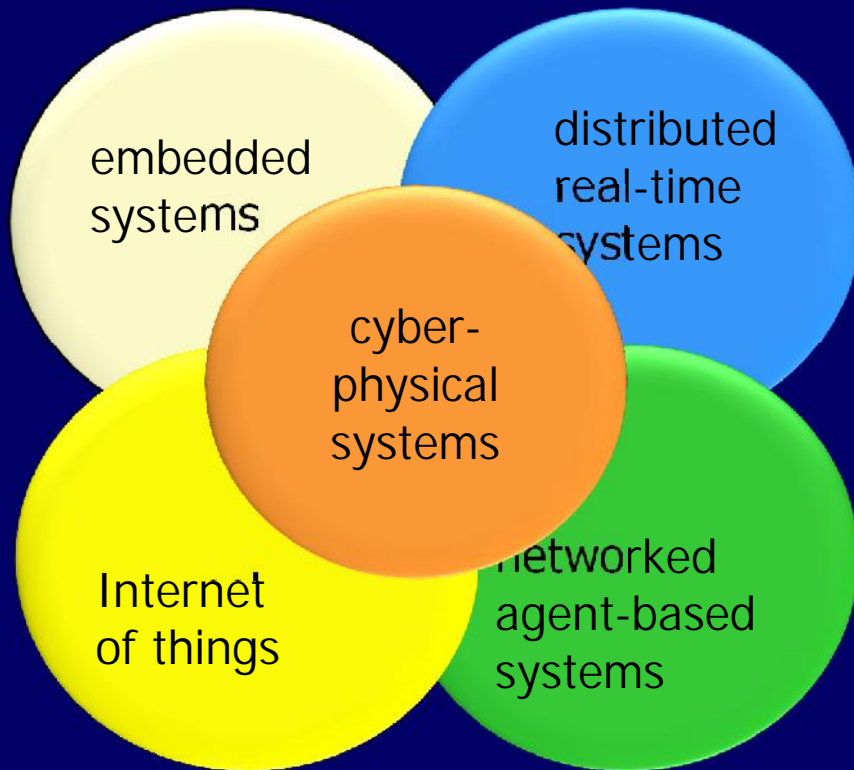
distributed real-time systems

Internet of things

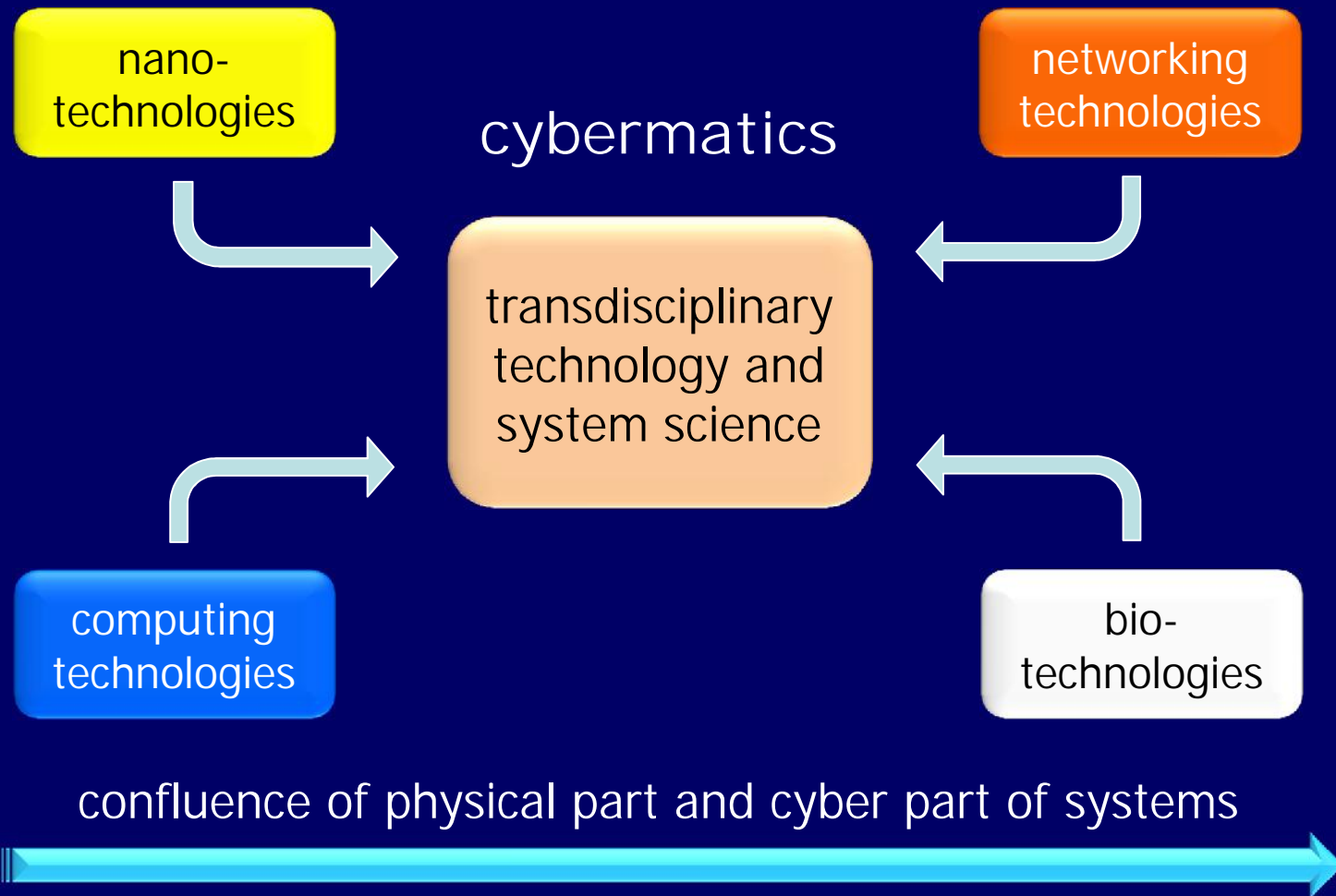
networked agent-based systems



# Shifting paradigms of systems



# Implication on system development




# A comprehensive real life example

movie is linked here

What is to be known about cyber-physical systems?

# Getting to the center of research ...



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## Future of all technologies - The Cloud Cyber Physical Systems


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**Abstract:** Modern society relies on a web of physical network infrastructures, such as power stations, telecommunication systems. Thanks to technological advances, these infrastructures have become increasingly dependent on each other and have emerged as interdependent networks. While interdependency enables to build systems that are larger, stronger, and more resilient, it is also observed that interdependent systems tend to be more fragile against failures, natural hazards and attacks. It is important to develop the science for interdependent Networks, which serves as the foundation to better understand the interactions among individual networks and propel significant advances therein, such as the Internet, power grid, social networks, and the economy to name just a few. This paper aims at presenting our future research outlook oriented towards understanding device security and to cyber physical systems and some challenges related to cyber physical systems.

**Keywords:** Cyber Physical Systems, cloud computing.

### I. Introduction

As computers and communication bandwidth become ever-faster and ever-cheaper, computing and communication capabilities will be embedded in all types of objects and structures in the physical environment. Applications with enormous societal impact and economic benefit will be created by harnessing these capabilities in time and across space. We refer to systems that bridge the cyber-world of computing and communications with the physical world as cyber-physical systems. Cyber-physical systems (CPS) are



## CYBER-PHYSICAL-SOCIAL SYSTEMS

Editor: Daniel Zeng, University of Arizona, zeng@email.arizona.edu

# Physical-Cyber-Social Computing: An Early 21st Century Approach

Amit Sheth, Pramod Anantharam, and Cory Henson, *Kno.e.sis Center, Wright State University*

**T**echnology plays an increasingly important role in facilitating and improving personal and social activities, engagements, decision making, interaction with physical and social worlds, insight generation, and just about anything that humans, as intelligent beings, seek to do. We've used the term *computing for human experience* (CHE)<sup>1</sup> to capture technology's human-centric role. CHE emphasizes the unobtrusive, supportive, and assistive part technology plays in improving

PCS computing requires that we move away from traditional data processing to multitier computation along the data-information-knowledge-wisdom (DIKW) dimension, which supports reasoning to convert data into abstractions that are more familiar, accessible, and understandable to humans. We illustrate PCS computing for healthcare with a focus on semantic perception,<sup>3</sup> which converts low-level, heterogeneous, multimodal, and contextually relevant data into higher-level abstractions that can provide insights and assist humans

# A generic definition

- Cyber-physical systems:
  - manifest as smart networked **multi-actor** systems
  - are enabled by cyber-physical computing
  - are examples of synergistic/compositional systemsand are characterized by
  - deep **diffusion** into real-life physical processes
  - multiple sensing-reasoning-adapting-actuating loops
  - dynamic resource and service provisioning
  - applications in human/social/industrial contexts



# Examples of CPSs



Air traffic control system



Automated logistics system



Robotized military combat system

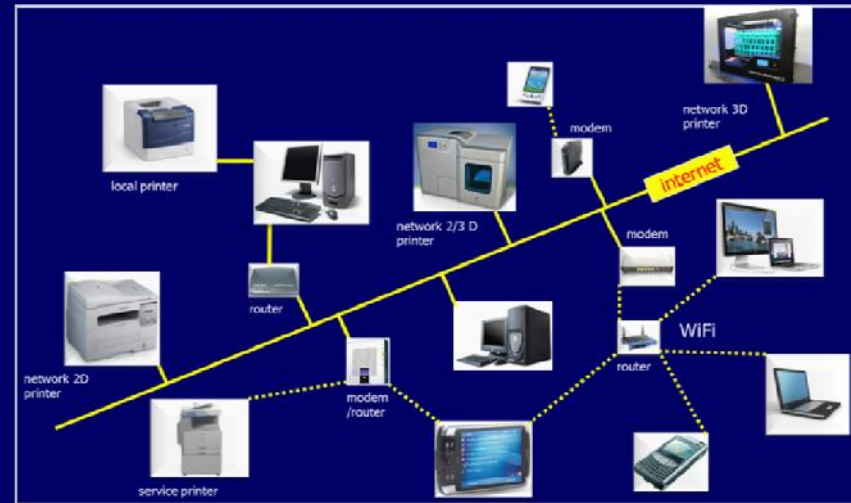


Smart electric grid system

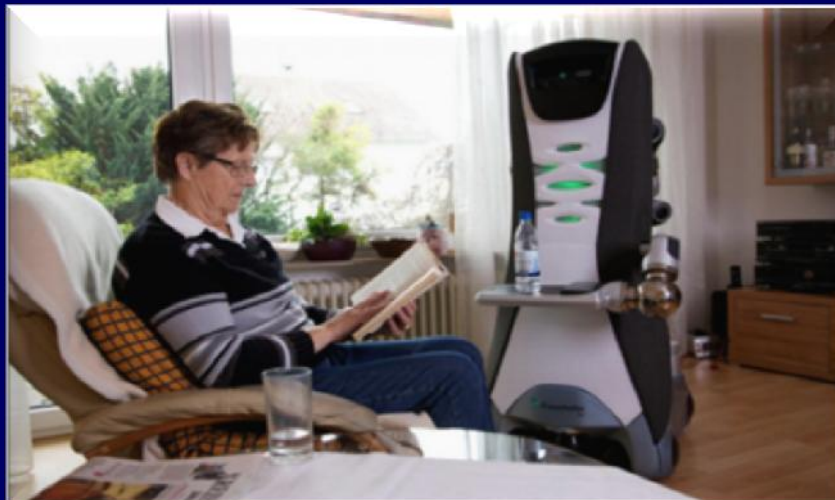
# Other examples of CPSs



Self-driving car-fleet system



Follow-me 2D/3D printing system



Caregiving assistive robotics system



Stroke rehabilitation assisting system

# Penetration into real life processes

- System control is synthesized based on information obtained in run-time and real time from existent real-life processes



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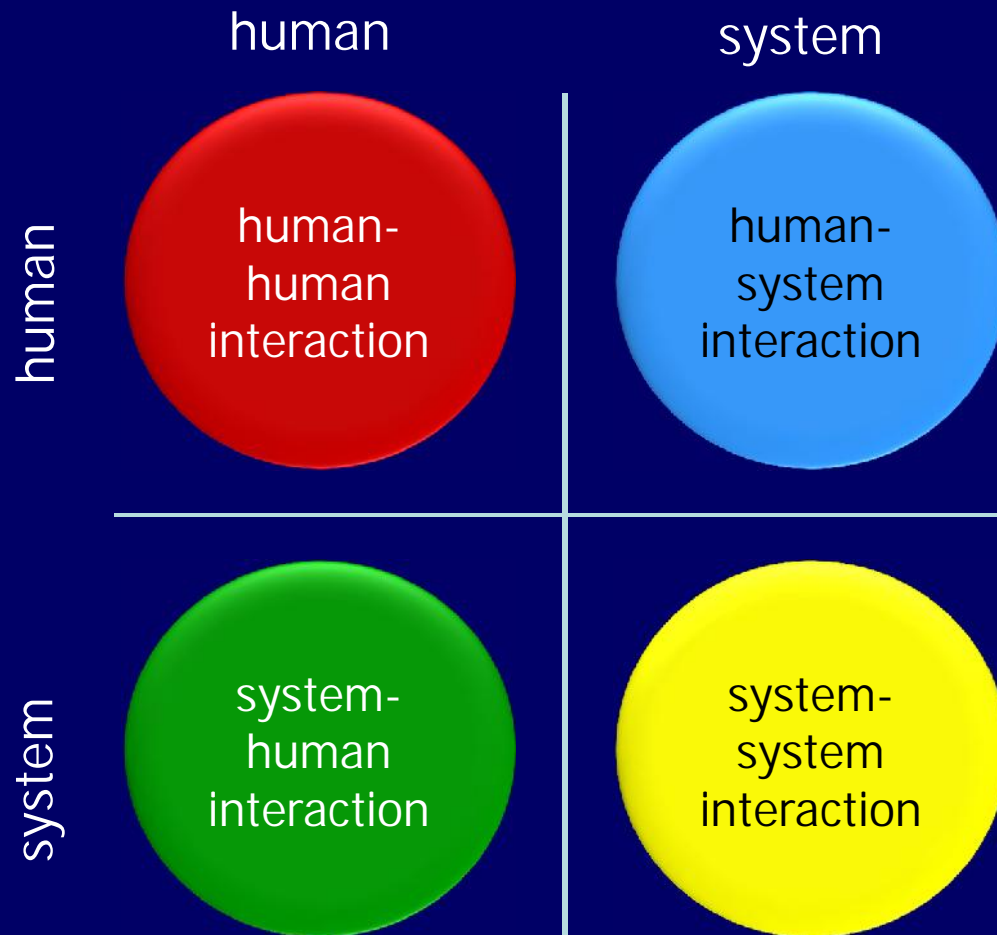


- RTC enables CPSs to adapt (sense, reason, learn, actuate, organize, evolve, reproduce) dynamically and reliably

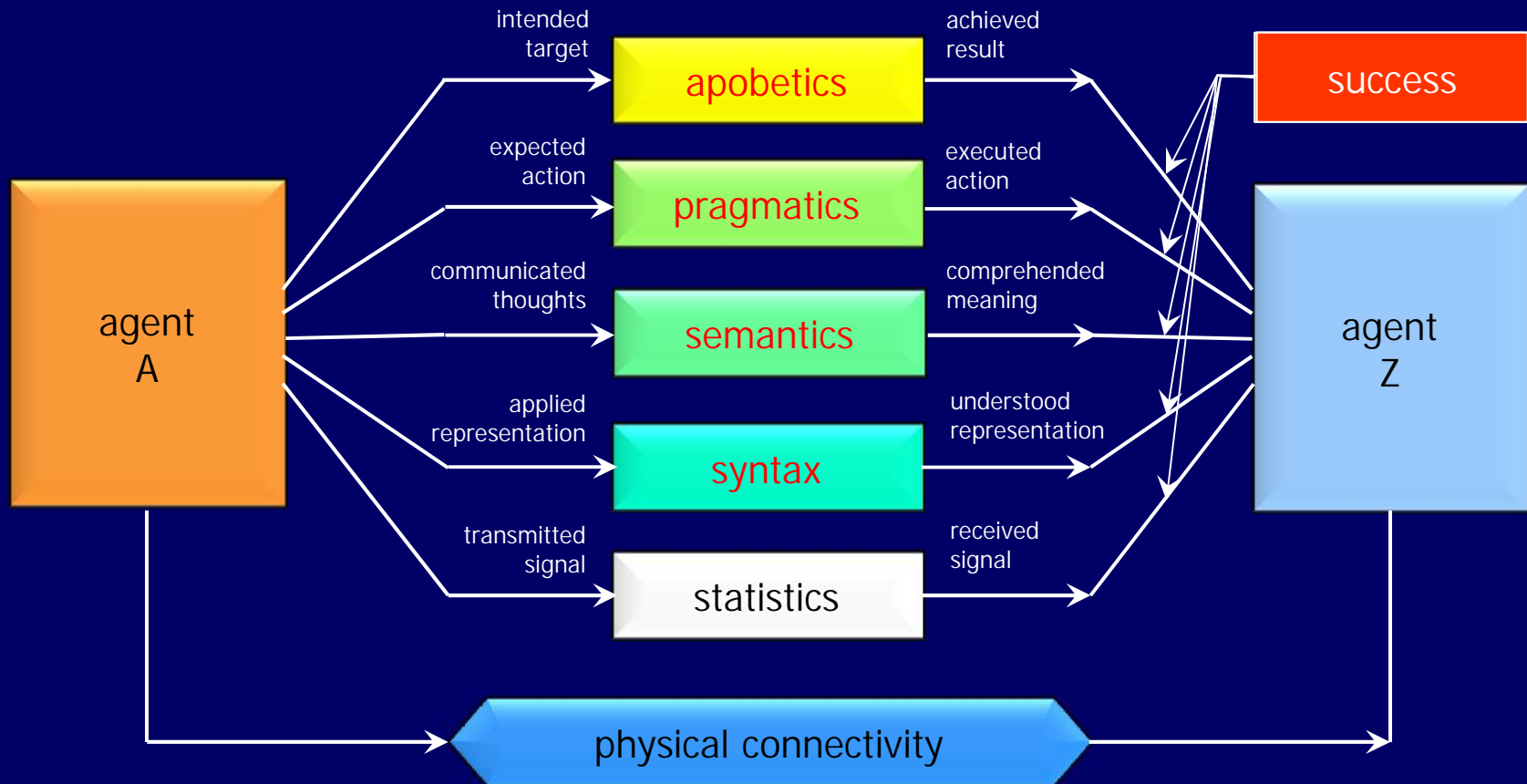
# Advanced reasoning model on interaction

Who is taking the initiative to achieve the objective?

The level of interaction also plays an important role



# Levels of interaction





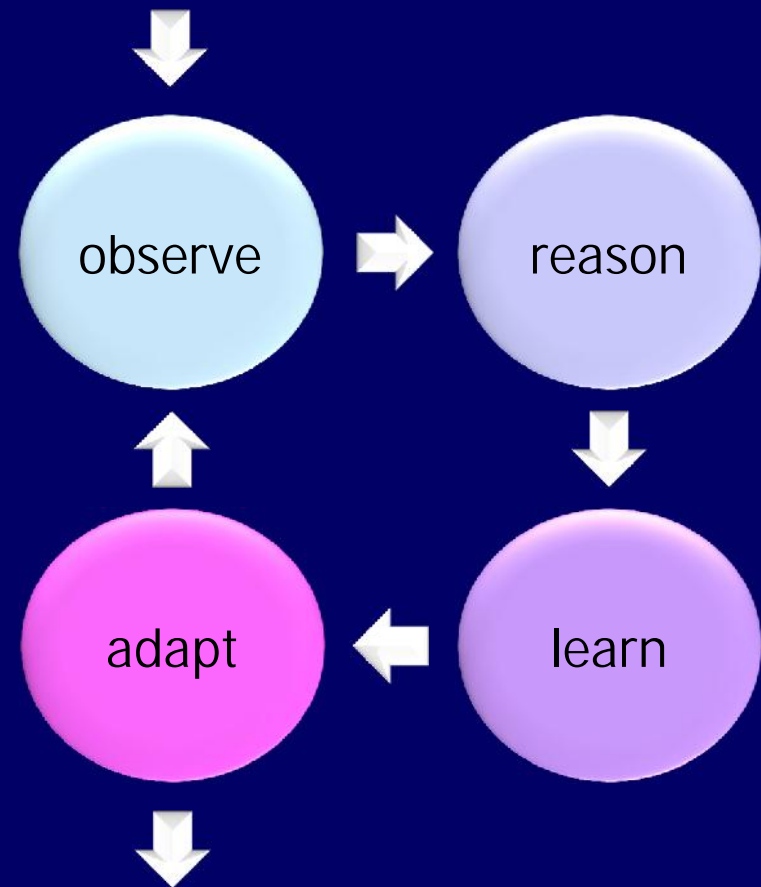
These all come together here ...

movie is linked here

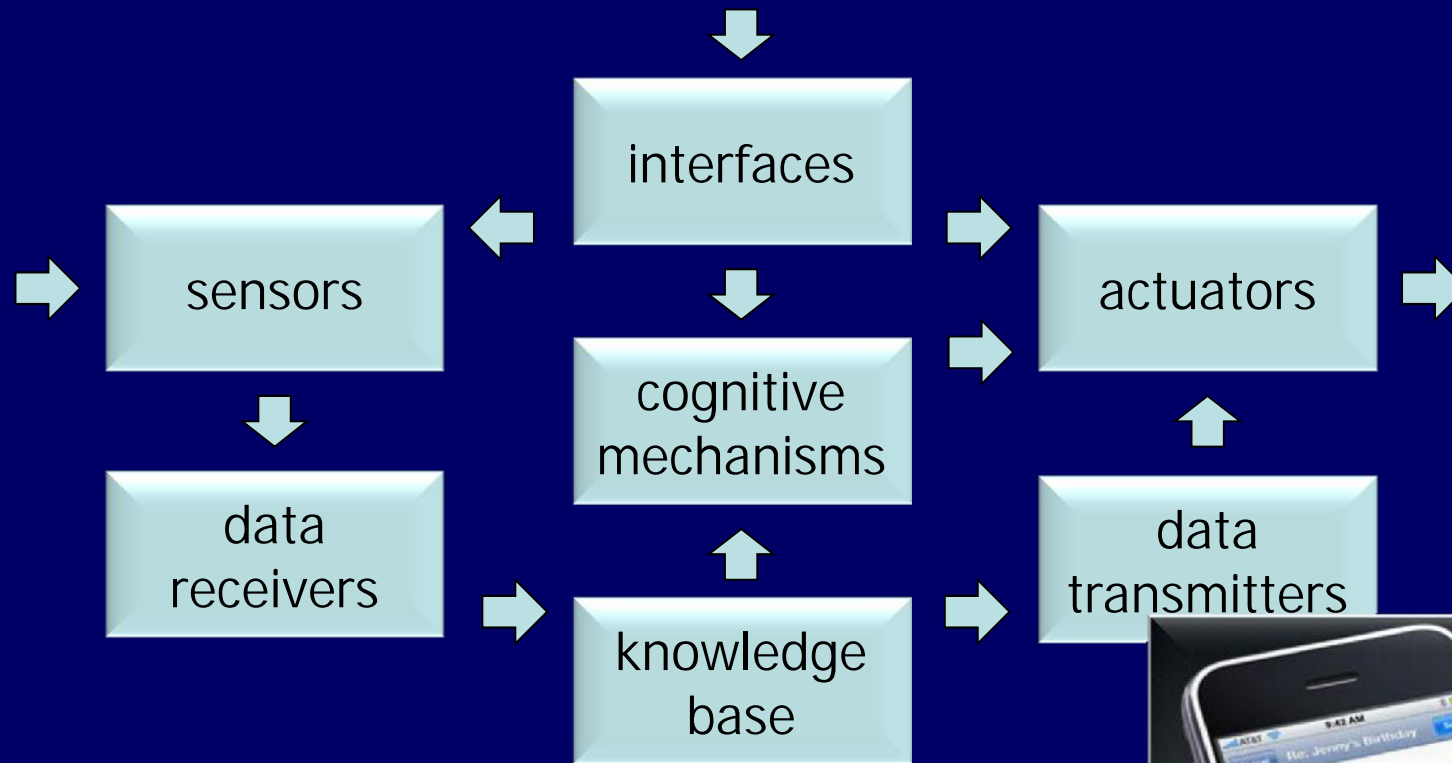
Smart products and serviced will be in the focus

## Can you imagine ...

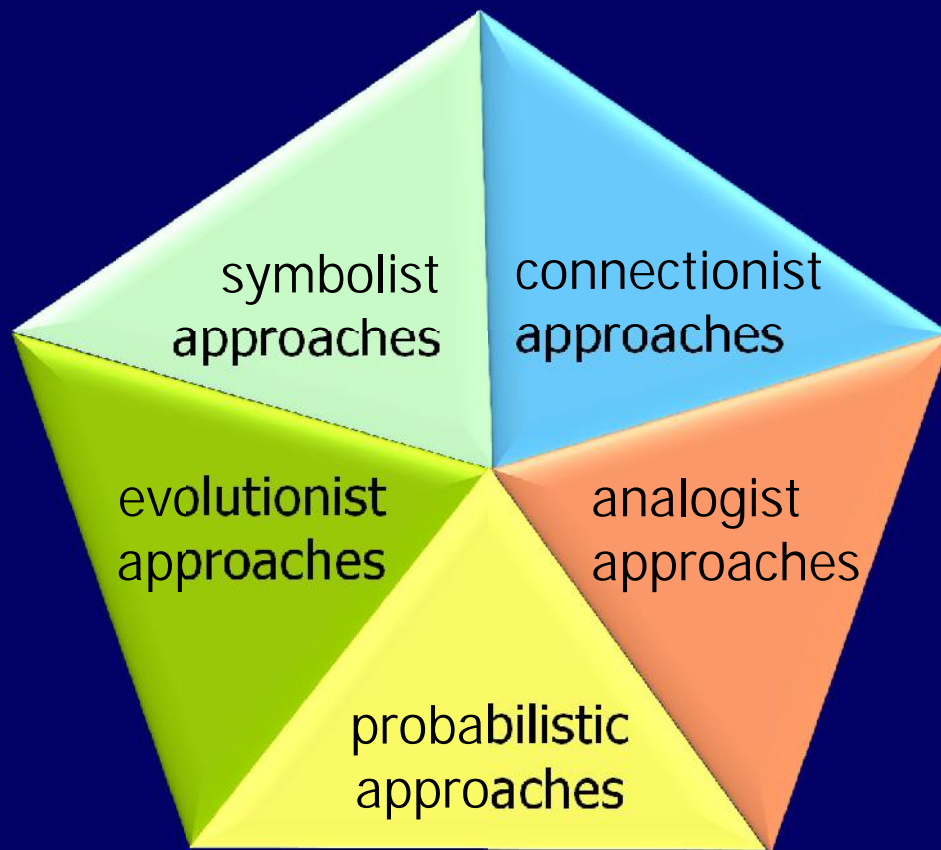
- .... a computer-controlled system in which information processing is not (or is not completely) preprogrammed like in your desktop, laptop, tablet or smartphone?
- What this system needs to do?
- It would be like an open finite reasoning automaton



# Classical model of smart systems



# Five approaches to reproducing intelligence



- **Symbolist approaches:**
  - Production rule-based
  - Logical inferencing
- **Connectionist approaches:**
  - Semantic network-based
  - Artificial neural networks
- **Analogist approaches:**
  - Case-based reasoning
  - Natural analogy-based
- **Probabilistic approaches:**
  - Bayesian reasoning
  - Fuzzy reasoning
- **Evolutionist approaches:**
  - Genetic algorithms
  - Bio-mimicry techniques

# Characteristics of smart products

- **Personalization**  
Customization according to the needs of the stakeholders
- **Awareness**  
Consideration of objectives, states, constraints and contexts
- **Situatedness**  
Recognition of situational and community contexts
- **Adaptiveness**  
Changing behavior according to objectives and conditions
- **Connectedness**  
Ability to communicate, integrate, bundle with other products
- **Proactivity**  
Anticipation of stakeholders' plan and intentions

# Two representative graduation projects

# A cyber-physical educational solution (1)

**AUGMENTED ASTRONOMY**

The mystery and beauty of the cosmos have been the subject of our interest for ages, but light pollution and complex tools have made us lose touch with the splendour of the universe. This project was initiated to find a solution to this problem. The answer was found in combining binoculars with augmented reality technology that makes it possible to add a digital overlay to the natural view through the binoculars.

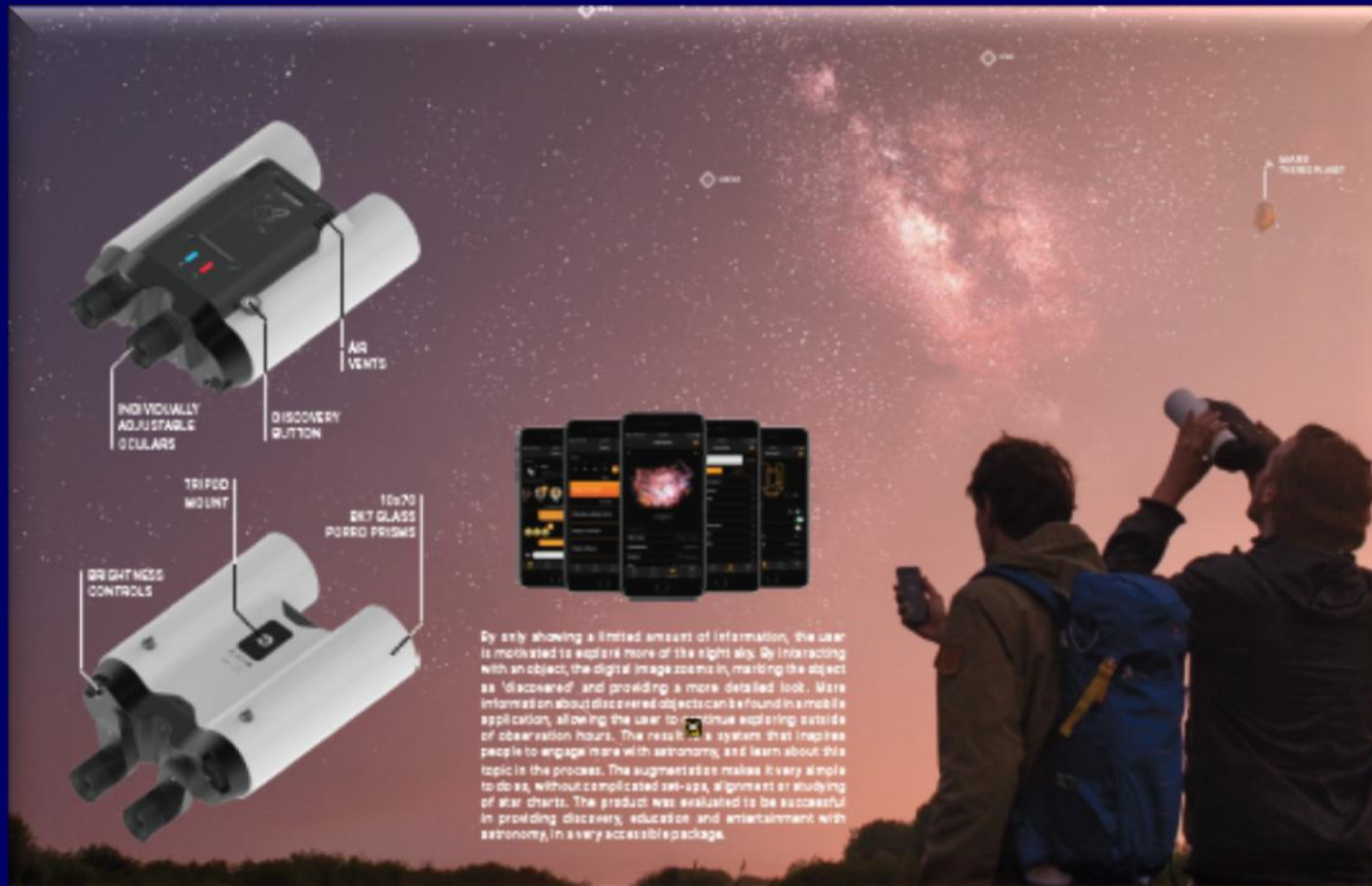
Binoculars provide a wide field-of-view, ideally suited to explore the night sky. Most binoculars, however, can't gather enough light or provide the magnification required to see a lot of detail. The inclusion of a digital aspect allows for the astronomical observation experience to be lifted to the next level, making astronomy more accessible, inspiring and fun.

The challenge in this project is found in the multidisciplinary combination of various scientific disciplines, such as astronomy, optical engineering, information technology and user experience design. All of these aspects must work together to create a positive user experience, which revolves around promoting discovery, education and entertainment. The developed system uses beam splitters and projectors to overlay digital content on the natural view. By using the product's orientation and location, the system can correctly augment planets, moons, certain stars, nebulae, galaxies and many more celestial objects.

The diagram illustrates the interdisciplinary nature of the project, showing a central question mark in a circle labeled 'ASTRONOMY'. This is connected by a dashed line to a series of icons representing 'INFORMATION TECHNOLOGY', 'OPTICAL ENGINEERING', and 'USER EXPERIENCE DESIGN'. The background features a starry sky with labels for 'SATURN', 'ANDROMEDA GALAXY', and 'FURNACE GALAXY'.



# A cyber-physical educational solution (2)



# A cyber-physical measuring solution (1)



# A cyber-physical measuring solution (2)



What is the main take away?

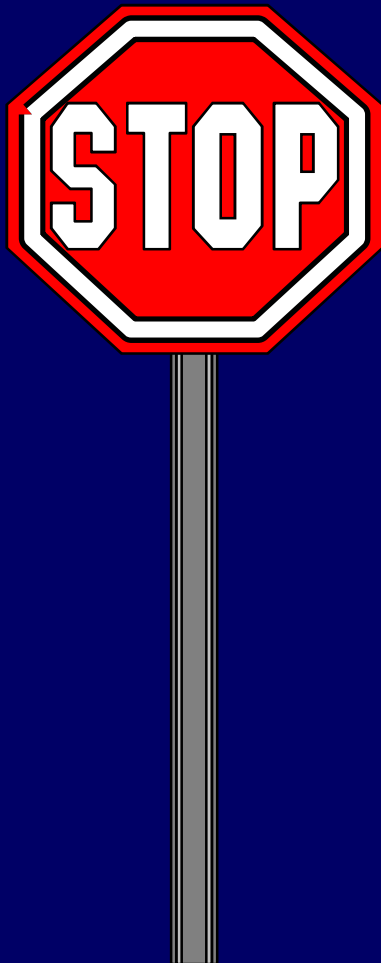
# More attention to systems and services

- Everything is becoming a (human-in-the-loop) **system** and they should be designed skilfully and purposefully
- Future industrial design engineers need to **focus on services** rather than only on materialized artifacts
- Cyber-physical systems are one important family of engineered systems of **high potential future impacts**
- Their significance comes from the fact that they can **penetrate into real life processes** and change them
- They offer **new functional opportunities** for product/service designers

# Novel requirements for the future

After completing your studies you are supposed to be able to:

- monitor human, social, business, technological and industrial **trends in a holistic framework**
- bring **social demands** and **technological affordances** together into triggering relationships
- conceptualize **smart artifactual systems and services** in various socialized and personalized application contexts
- develop and/or apply purposeful **reasoning and learning mechanisms** for aware and adaptive systems/services
- apply **data analytics and forecasting methods** to predict expected behavior, use, misuse of products and services



Thank you  
for your kind attention!

Let us now discuss the  
questions!

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