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III Man-Machine Collaboration on a Shop Floor

Cyber-Human System

Curriculum Development
of Master's Degree Program in
Industrial Engineering for Thailand Sustainable Smart Industry

Discussion and Presentation

The relationship between Cyber-Physical Systems (CPSs) and Cyber-Human Systems (CHSs)

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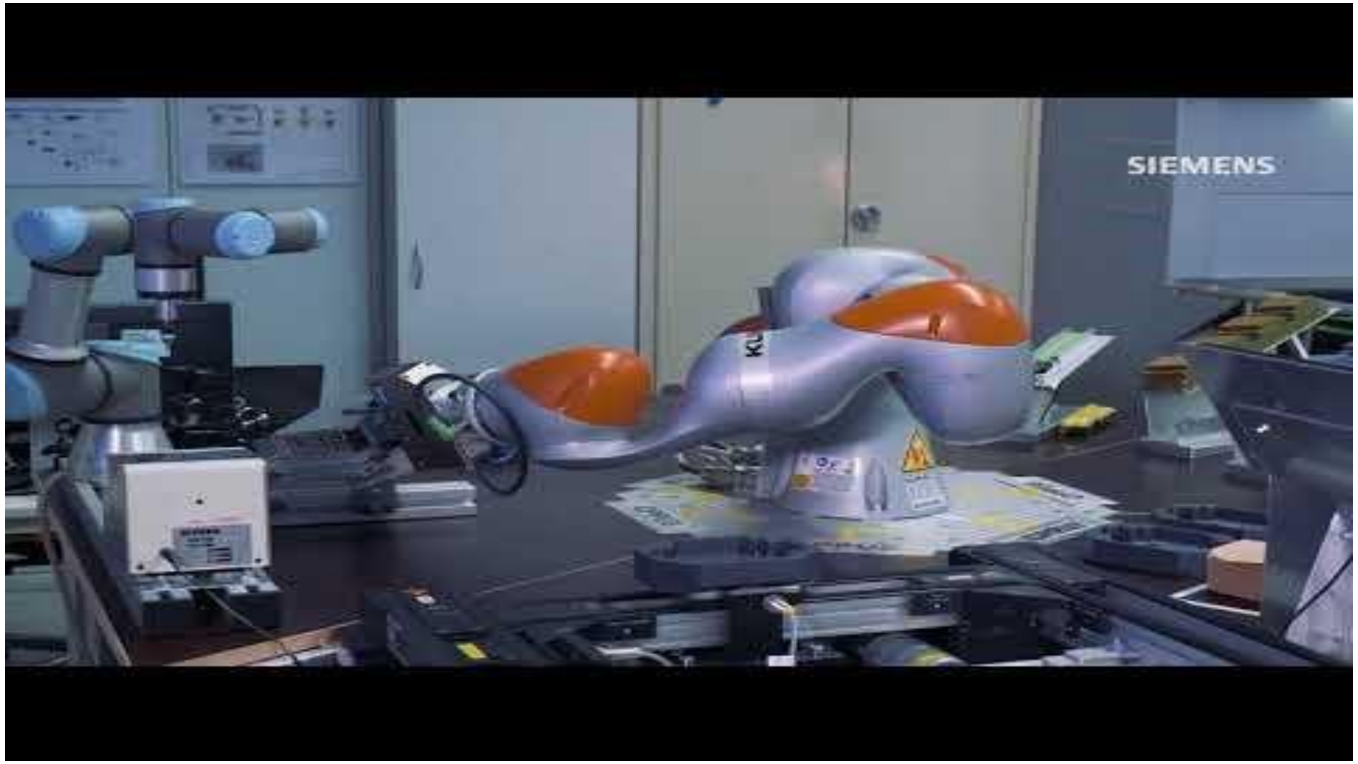
Cyber-Physical and Cyber-Human Systems

Cyber-physical Production Systems



Siemens(https://www.youtube.com/watch?v=wro3uoHR-ZY&t=3s)

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Cyber-Physical and Cyber-Human Systems (CHS)

CHS: BESK

Cyber Human Systems (https://www.youtube.com/watch?v=o0R2mi5sqxs)

CHS: Lumbar support exoskeleton

Cyber Human Systems (https://www.youtube.com/watch?v=czNjfAQZ5KA)

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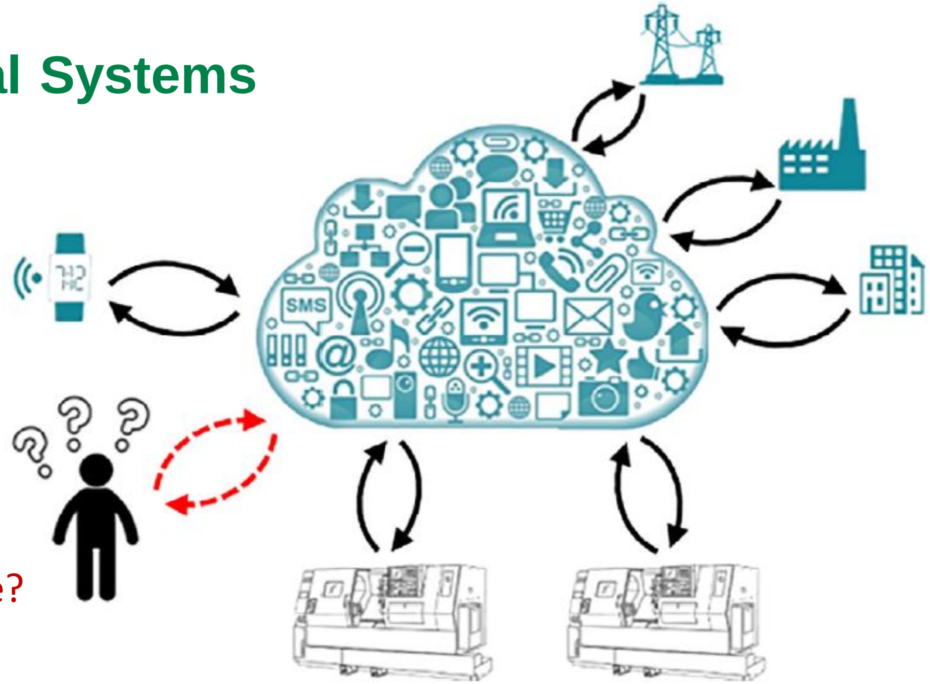
Cyber-Physical-Human Systems (CPHSs)

A complementary Cyber-Human Systems framework for Industry 4.0 Cyber-Physical Systems

Comparison with 5 Components of Cyber-Physical Systems

- Smart connection level
- Data-to-information conversion level
- Cyber level
- Cognition level
- Configuration level



The connected elements of modern Industry 4.0

(Krugh and Mears, 2019)

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Cyber-Physical and Cyber-Human Systems

5 components architecture for implementation of CPS and CHS

Cyber-Physical Systems

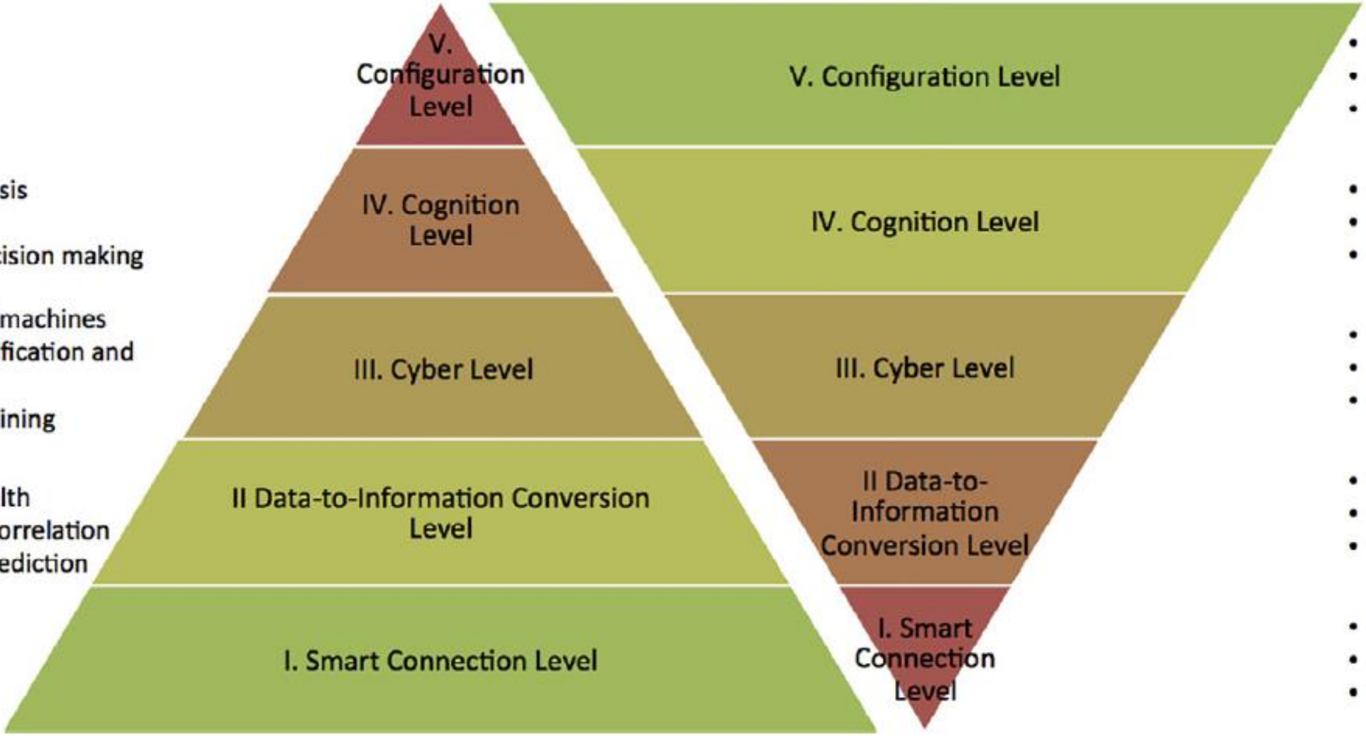
- Self-configure for resilience
- Self-adjust for variation
- Self-optimize for disturbance

- Integrated simulation and synthesis
- Remote visualization for human
- Collaborative diagnostics and decision making

- Twin model for components and machines
- Time machine for variation identification and memory
- Clustering for similarity in data mining

- Smart analytics for
    - Component machine health
    - Multi-dimensional data correlation
- Degradation and performance prediction

- Plug & Play
- Tether-free communication
- Sensor network



Cyber-Human Systems

- Self-configure for flexibility
- Recognize and adapt to variation
- Absorb disturbance

- Synthesis of known patterns with reality
- Visualization and understanding
- Collaborative decision making

- Twin model for individual human workers
- Recognition of variation over time
- Recognition of patterns and classes

- Analytics for human readiness monitoring
- Converting data to information
- Identifying state changes

- Plug & Play people...
- Communication integrated to infrastructure
- Sensing in the data stream

(Krugh and Mears, 2019)

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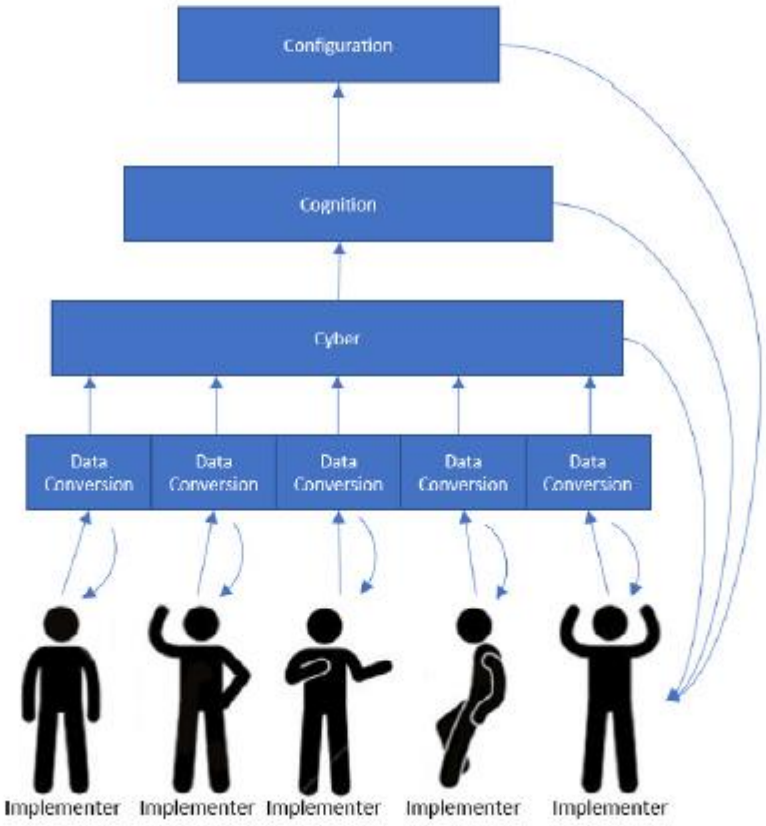
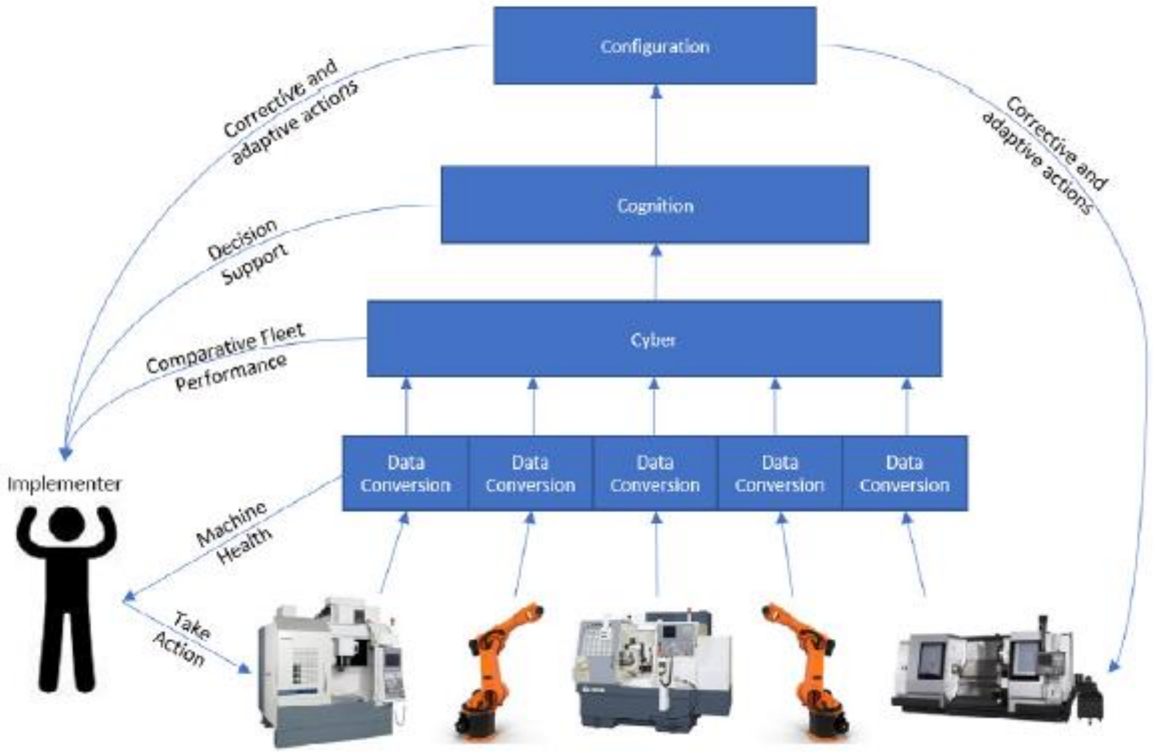
Cyber-Physical and Cyber-Human Systems

Information flow of CHS and CPS



CHS



CPS

(Krugh and Mears, 2019)

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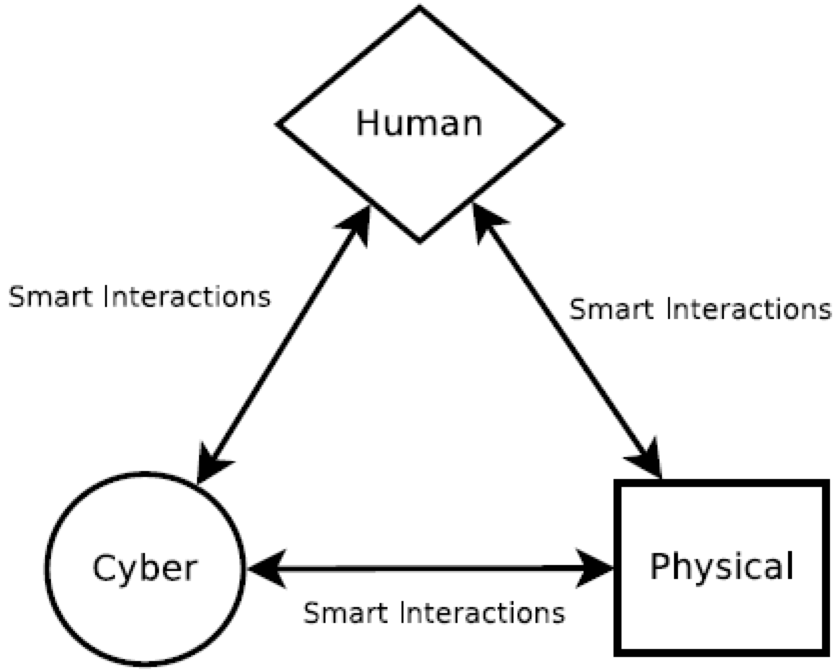
Cyber-Physical-Human Systems (CPHSs)

Three dimensions of Cyber-Physical-Human Systems



Lorena, 2017: http://lcastaneda.com/research/cphs/

- Physical dimension:

  Comprises all resources connected to the system through sensors and actuators

- Cyber dimension:

  Describes all computational, networking and cloud infrastructures that communicate resources' data, processes and software.

- Human dimension:

  Describes the human elements, as well as their situations based on their goals and context.

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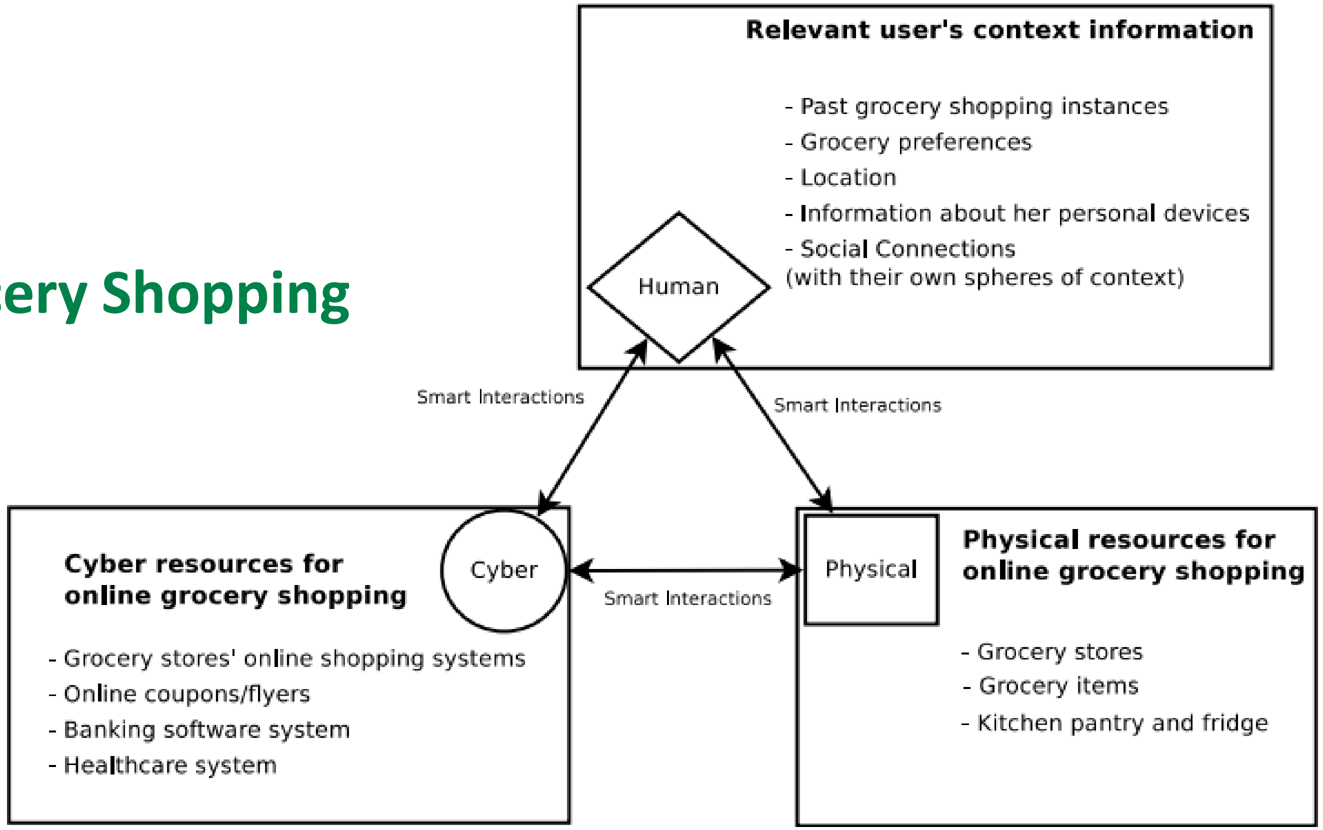
Cyber-Physical-Human Systems (CPHSs)

User-Centric Smart Cyber-Physical-Human Applications

Case Study of Online Grocery Shopping



(Lorena, 2017)

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User-Centric Smart Cyber-Physical-Human Applications

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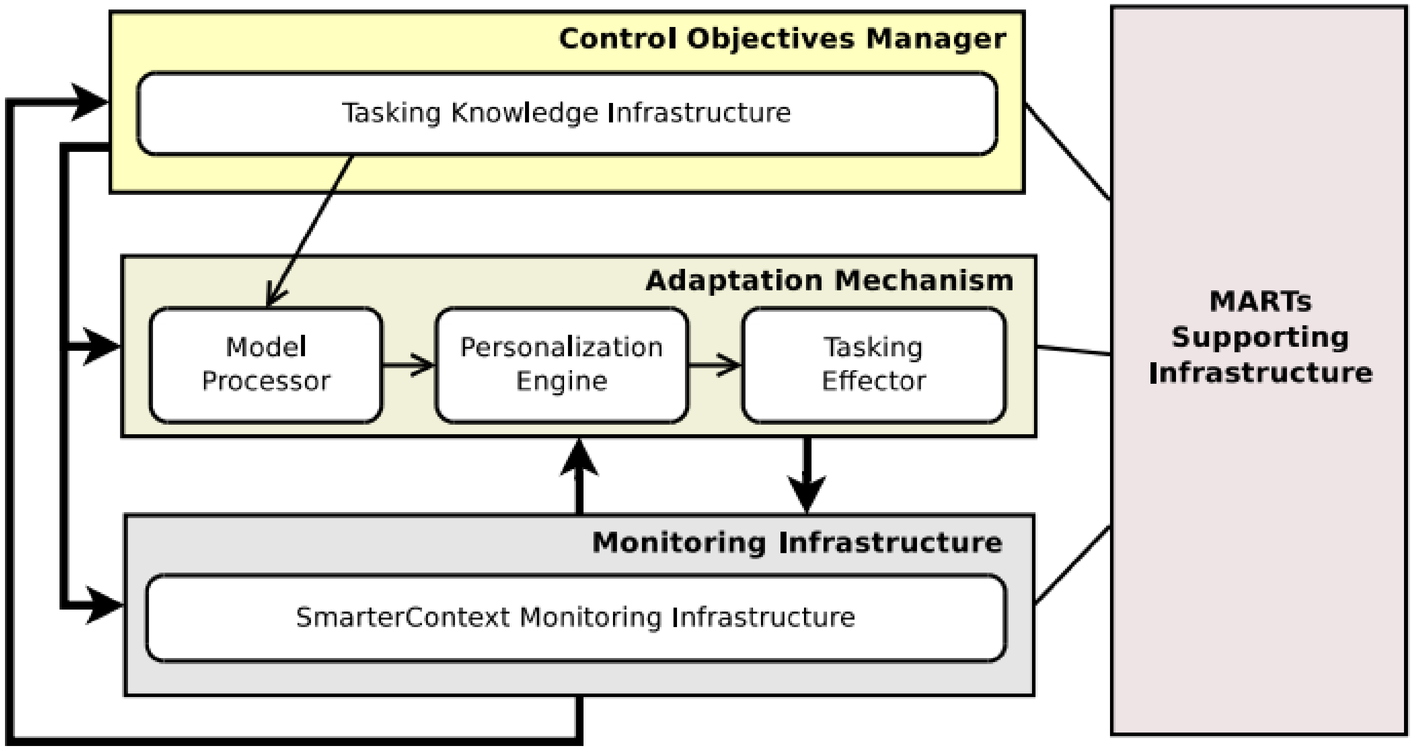

User-Centric Smart Application architecture

(Lorena, 2017)

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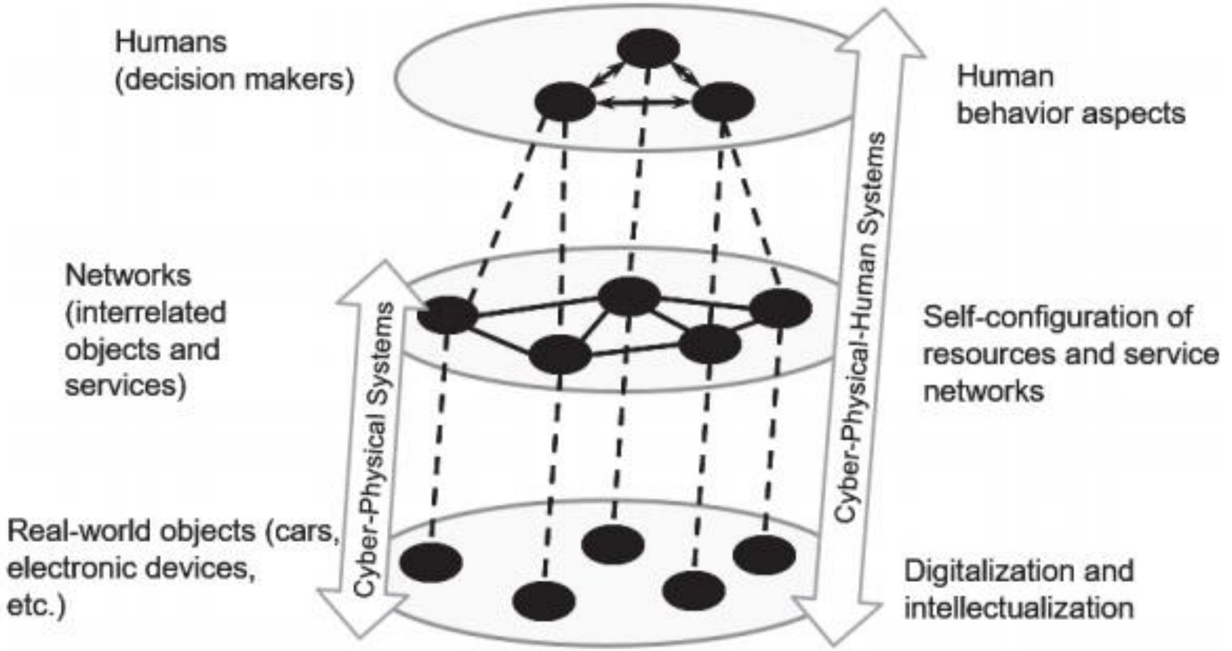
Cyber-Physical-Human Systems (CPHSs)

CPHS Applications: Case Study of Car-Based e-Tourism

Cyber-Physical and Cyber-Human Systems



(Smirnov et al., 2017)

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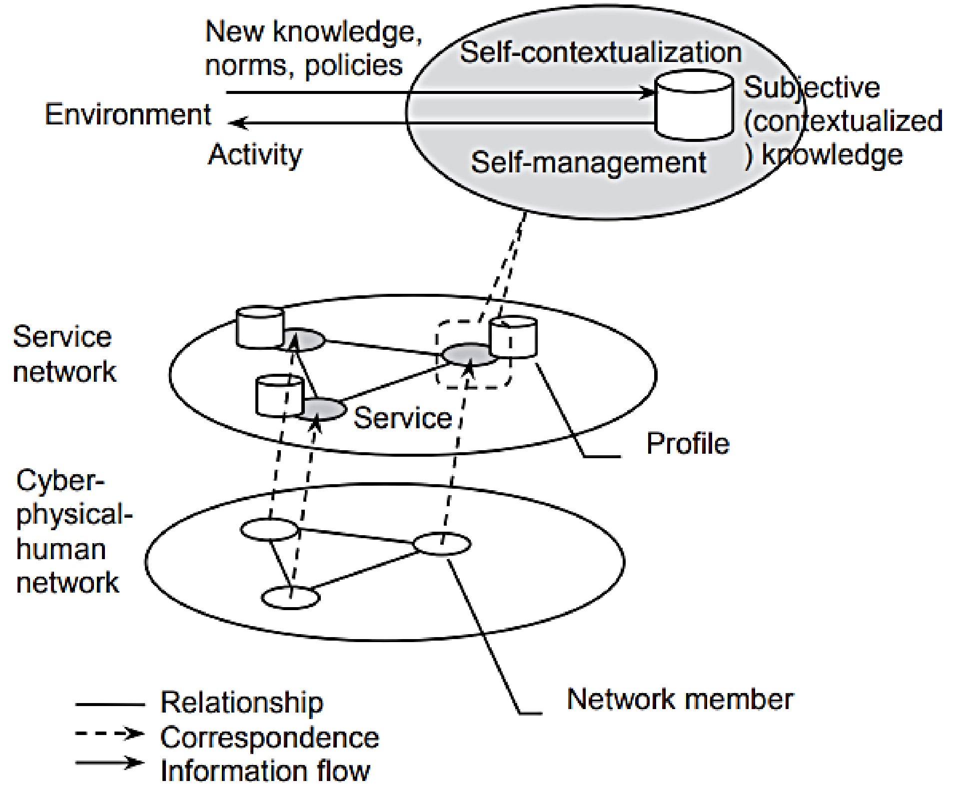
Cyber-Physical-Human Systems (CPHSs)

CPHS Applications: Case Study of Car-Based e-Tourism

Cyber-physical-human system configuration approach



(Smirnov et al., 2017)

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Cyber-Physical-Human Systems (CPHSs)

CPHS Applications: Case Study of Car-Based e-Tourism

Aspects of Car-Based e-Tourism system

Situational awareness:

Infomobility support is supposed to be context-dependent and the situation is changing continuously

Context information components

- ✓ Tourist location
- ✓ Co-travelers
- ✓ Preferences (both explicit and tacit)
- ✓ Schedule restrictions
- ✓ Weather
- ✓ Traffic
- ✓ Attraction occupancy and opening hour

(Smirnov et al., 2017)

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Cyber-Physical-Human Systems (CPHSs)

CPHS Applications: Case Study of Car-Based e-Tourism

Aspects of Car-Based e-Tourism system

Behavioral awareness:

Efficient infomobile information support has to be proactive, what assumes predicting human actions.

Behavior patterns

- ✓ **Context:** autumn, the temperature is relatively low, no rain
- ✓ **Antecedent:** a new forecast with rain soon has become available
- ✓ **Possible behavior:** continue to the attraction
- ✓ **Preferred behavior:** continue to the attraction
- ✓ **Consequence:** low evaluation of the attraction in the given context

(Smirnov et al., 2017)

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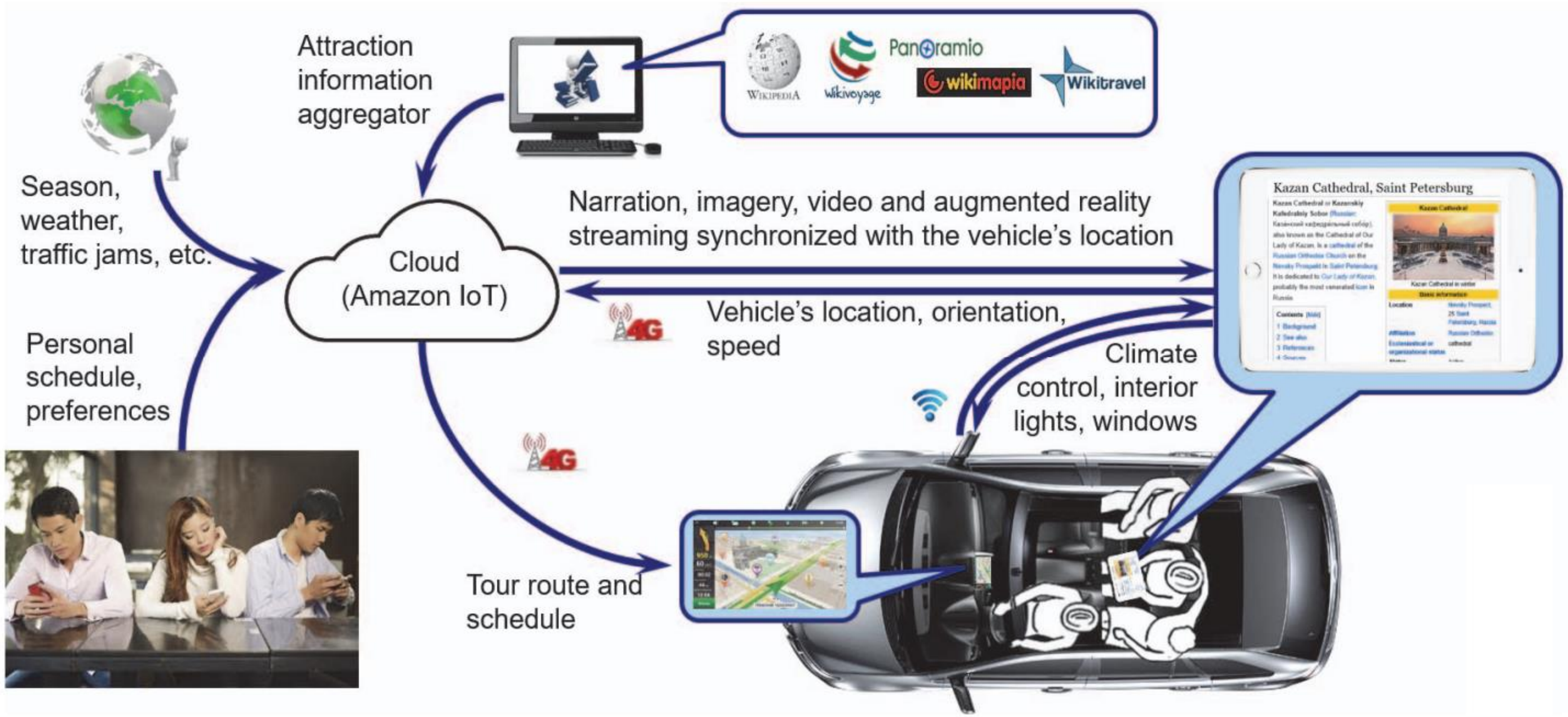
Cyber-Physical-Human Systems (CPHSs)

CPHS Applications: Case Study of Car-Based e-Tourism



(Smirnov et al., 2017)

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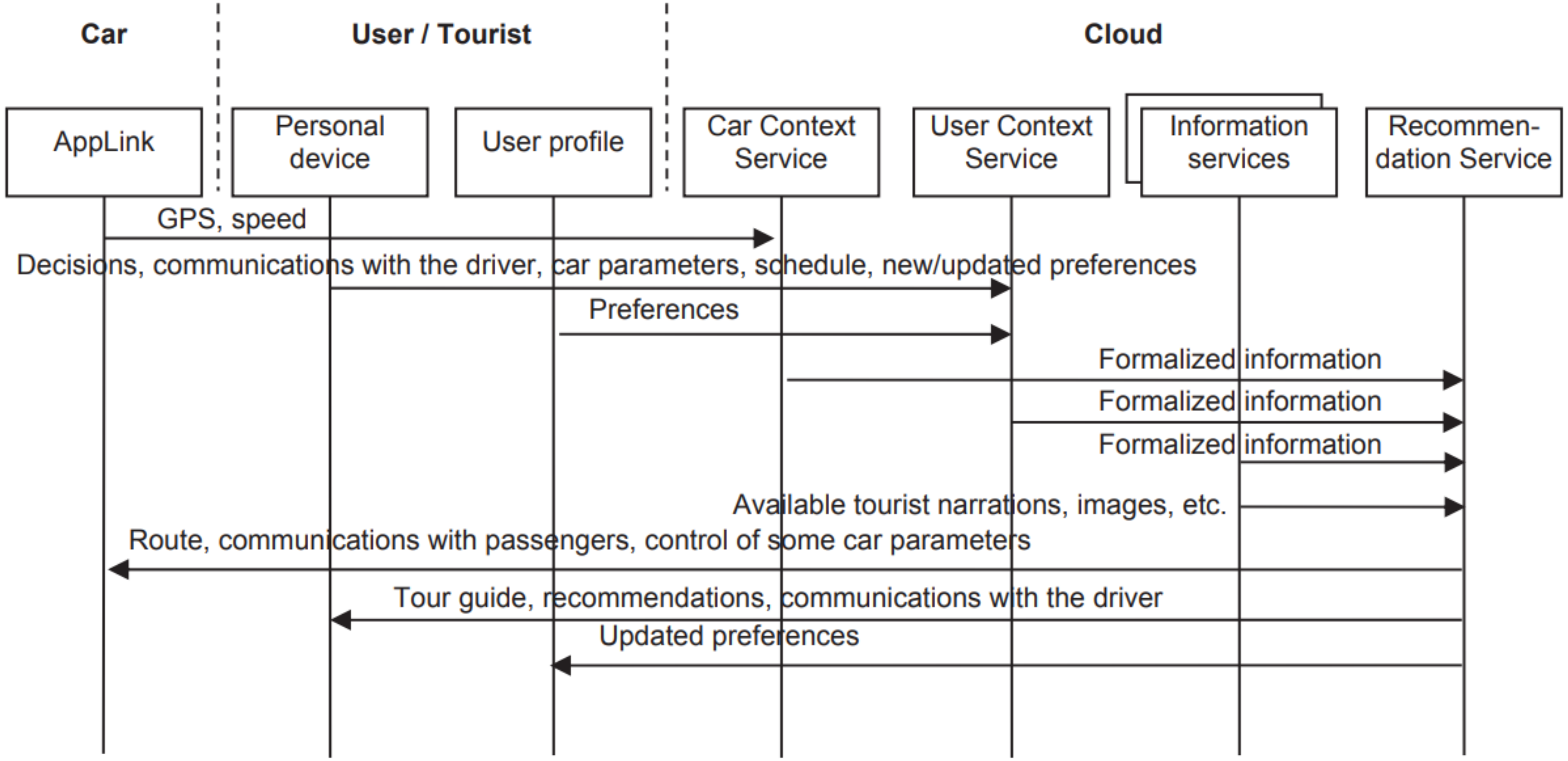
Cyber-Physical-Human Systems (CPHSs)

CPHS Applications: Case Study of Car-Based e-Tourism

Service interaction



(Smirnov et al., 2017)

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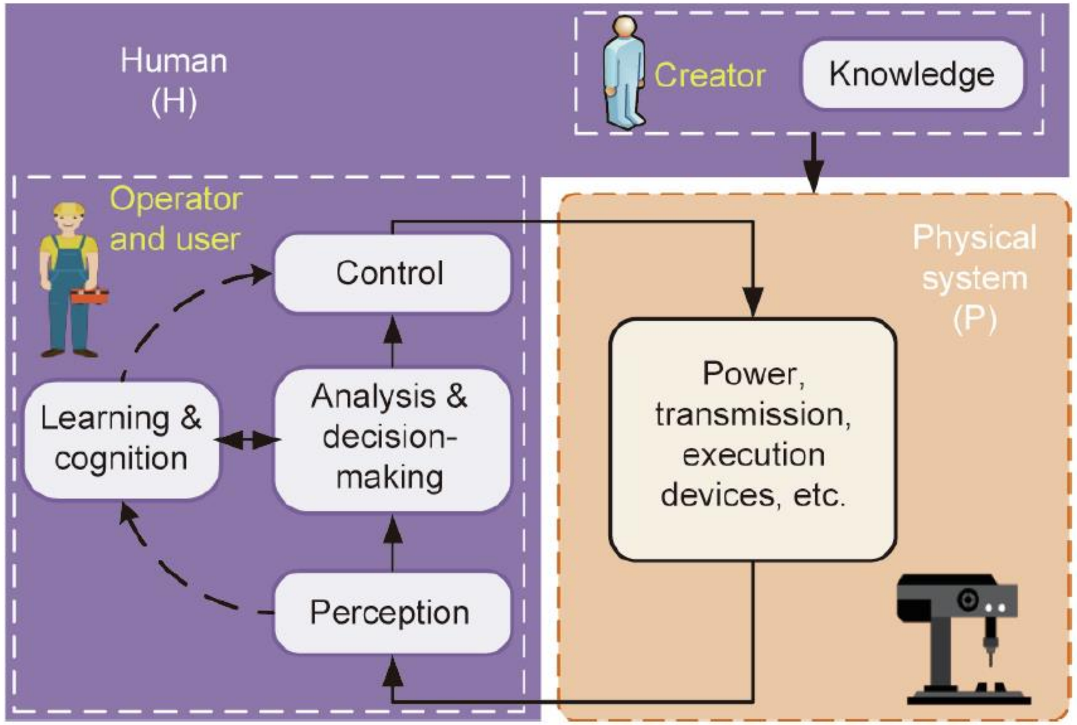
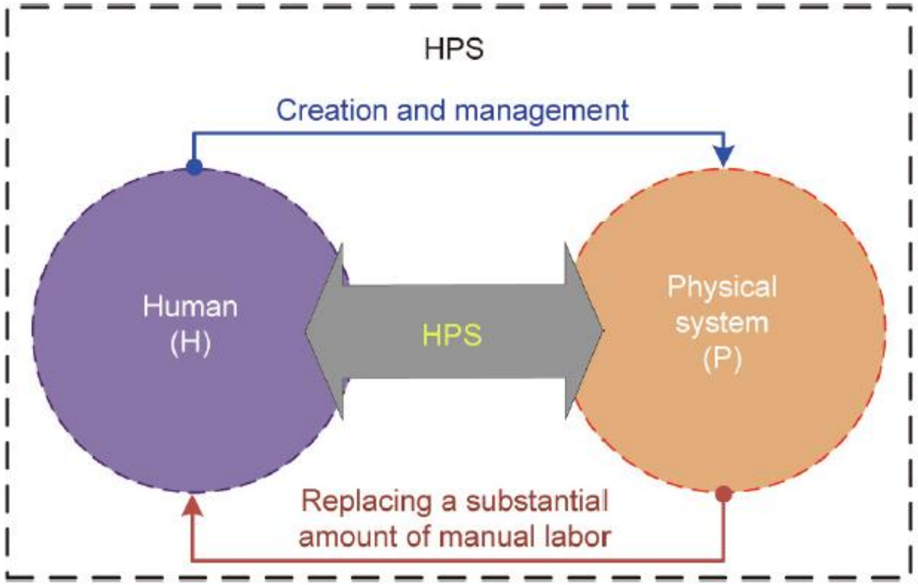
Human–Cyber–Physical Systems (HCPSs)

Evolution of HCPSs : Traditional manufacturing

Human–physical systems



Schematic of an Human–physical systems



(Ji et al, 2019)

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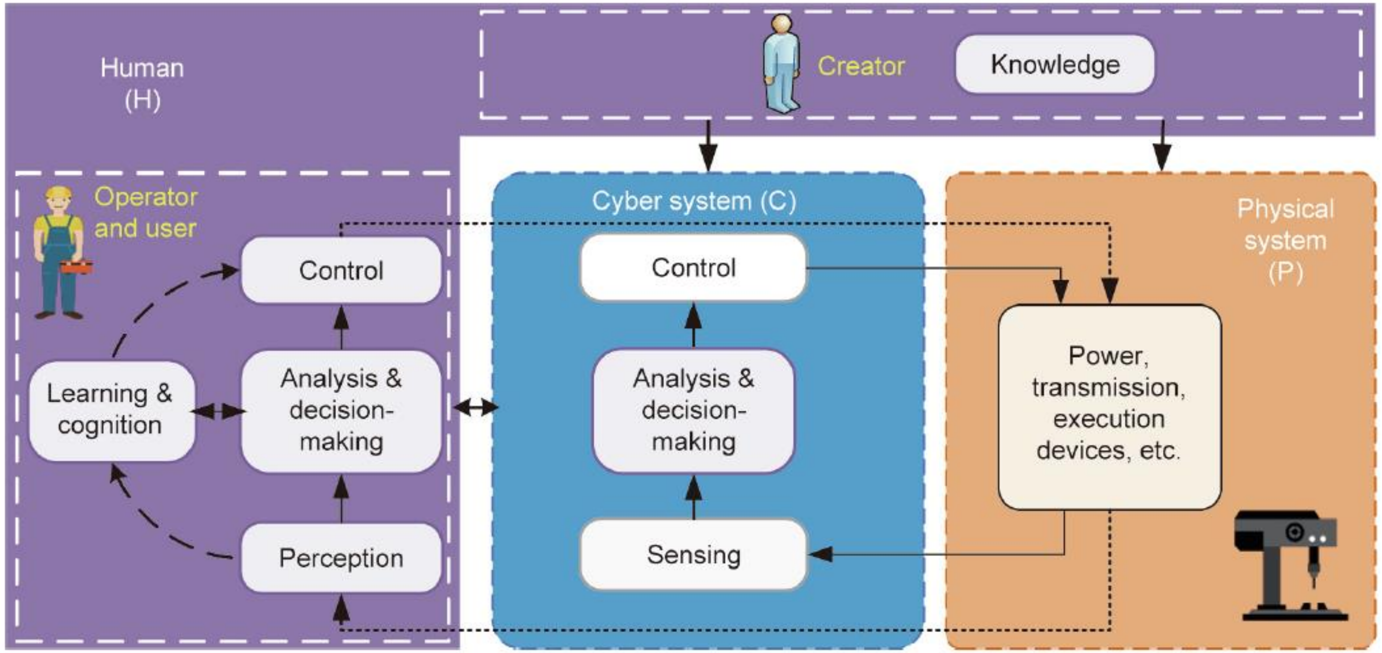
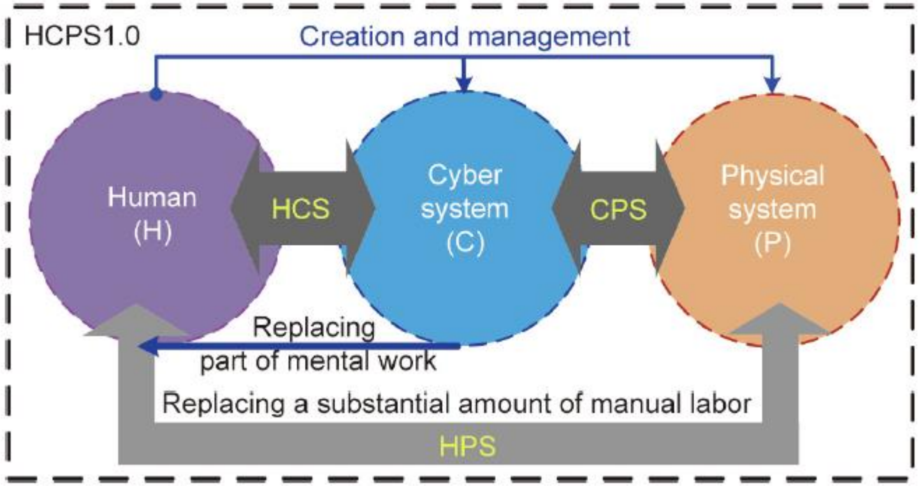
Human–Cyber–Physical Systems (HCPSs)

Evolution of HCPSs : Digital manufacturing

HCPS1.0



HCPS1.0



(Ji et al, 2019)

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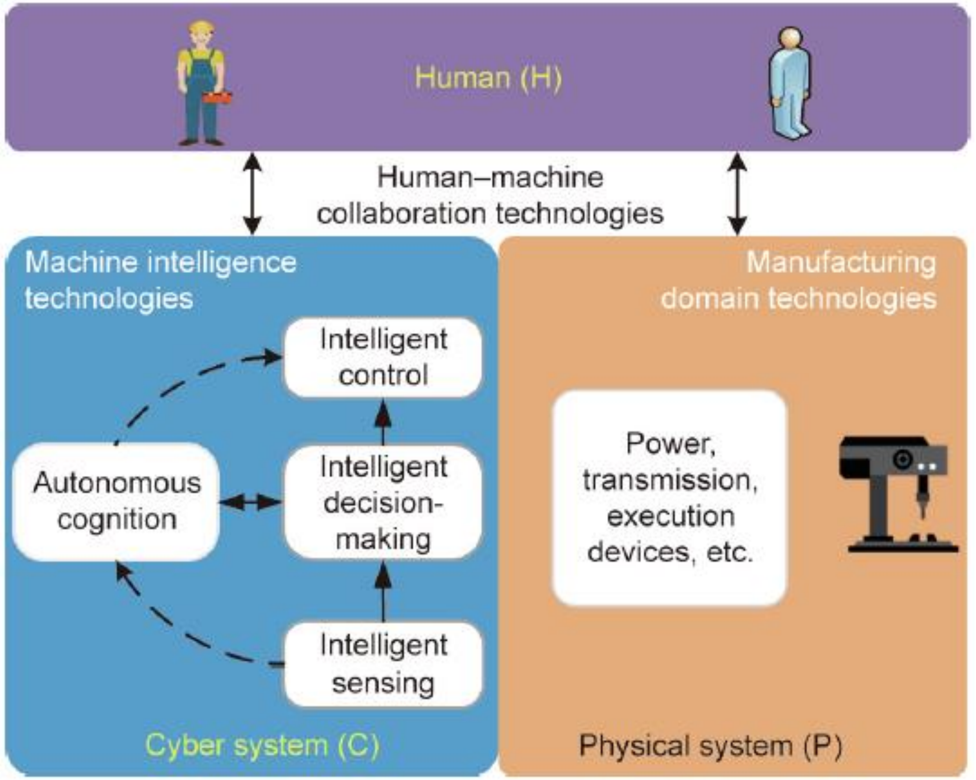
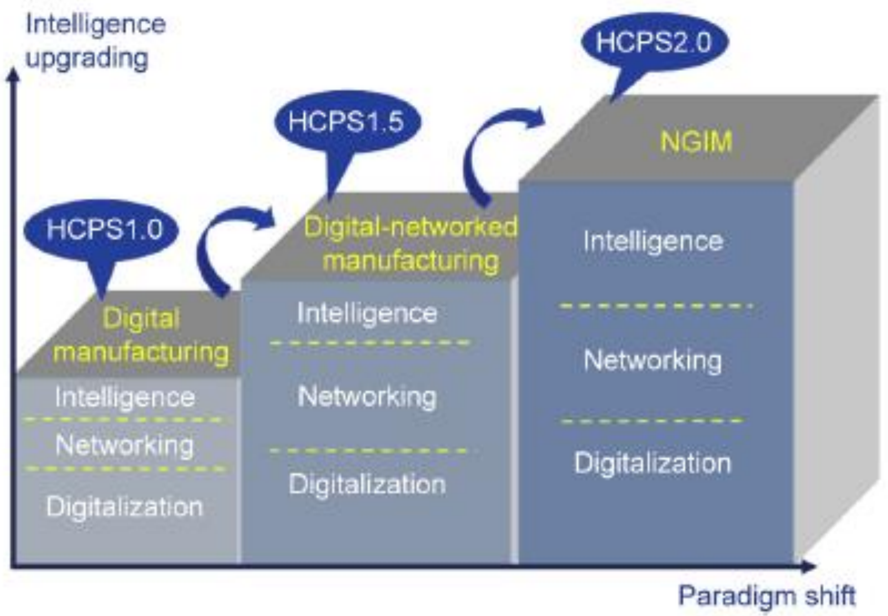
Human–Cyber–Physical Systems (HCPSs)

Evolution of HCPSs : Digital manufacturing

HCPS2.0



3 basic paradigms of intelligent manufacturing



(Ji et al, 2019)

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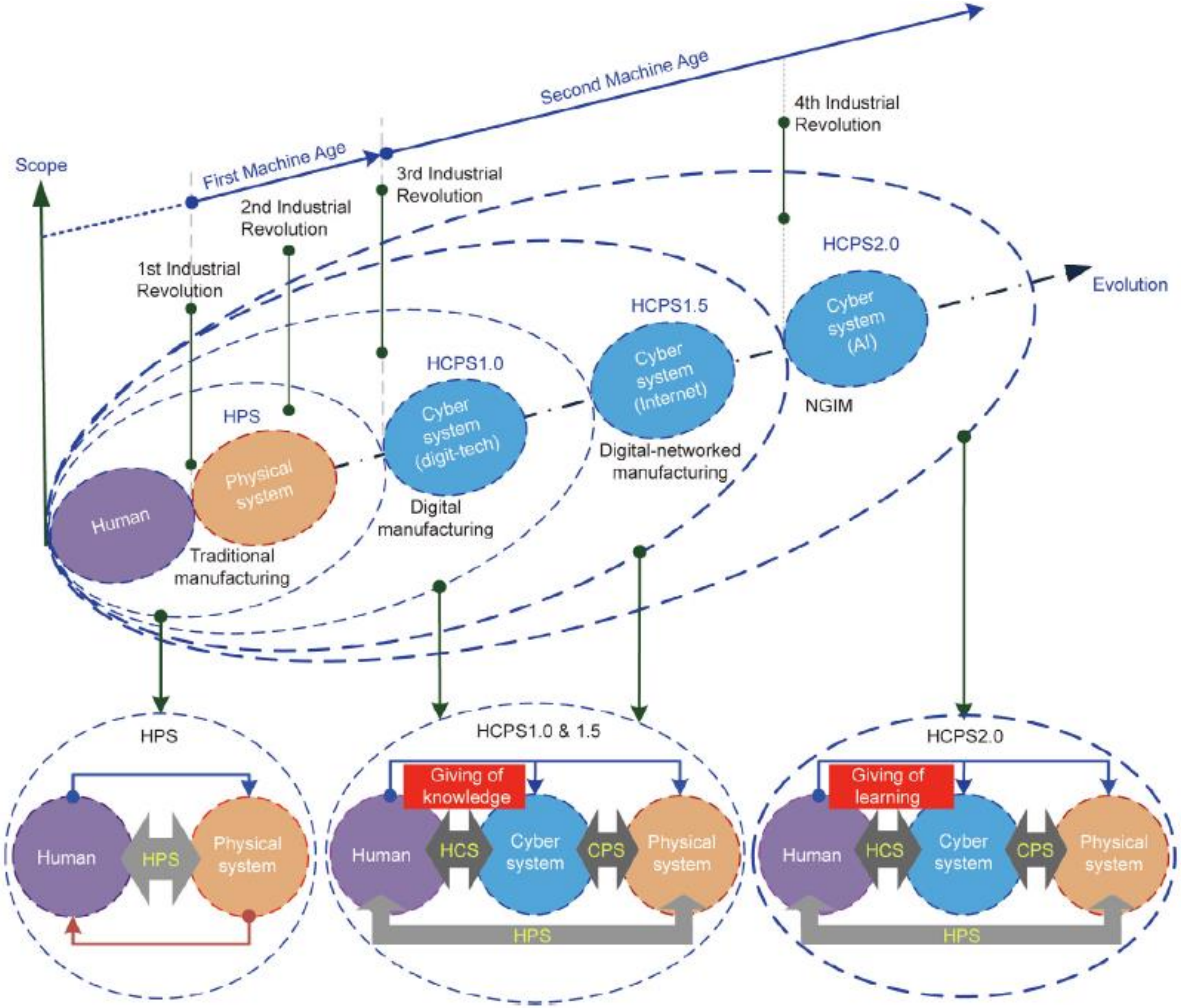
Evolution of HCPS-based intelligent manufacturing



(Ji et al, 2019)

Technical framework of HCPS2.0 for NGIM

- Overall architecture of HCPS2.0
  - The value dimension of intelligent manufacturing and the functional properties of the HCPS
  - The technical dimension of intelligent manufacturing and the technical properties of HCPS
- Key technologies of unit-level HCPS2.0
  - Manufacturing domain technologies
  - Machine intelligence technologies: Intelligent sensing, Autonomous cognition, Intelligent decision-making and Intelligent control
  - Human–machine collaboration technologies

Note: NGIM (Next Generation Instant Messaging)

(Ji et al, 2019)

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Major challenges in HCPS2.0 for NGIM

- System modeling: In-depth integration of mathematical modeling and big-data-driven intelligent modeling
  - In big data intelligent modeling
  - In hybrid modeling
- Knowledge engineering: In-depth integration of manufacturing technology (root technology) and intelligent technology (enabling technology)
  - A challenge in manufacturing domain technology
  - Challenges in intelligent technology
  - In-depth integration of manufacturing technology and intelligent technology

Note: NGIM (Next Generation Instant Messaging)

(Ji et al, 2019)

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Major challenges in HCPS2.0 for NGIM

- **Human–machine symbiosis:** In-depth integration of humans and CPSs (intelligent machines)
  - How can the effective division of work and cooperation between humans and intelligent machines be better achieved?
  - How can human–machine hybrid-augmented intelligence be achieved?
  - How can safety, privacy, ethical, and other issues that may be introduced by AI and intelligent manufacturing be addressed?

Note: NGIM (Next Generation Instant Messaging)

(Ji et al, 2019)

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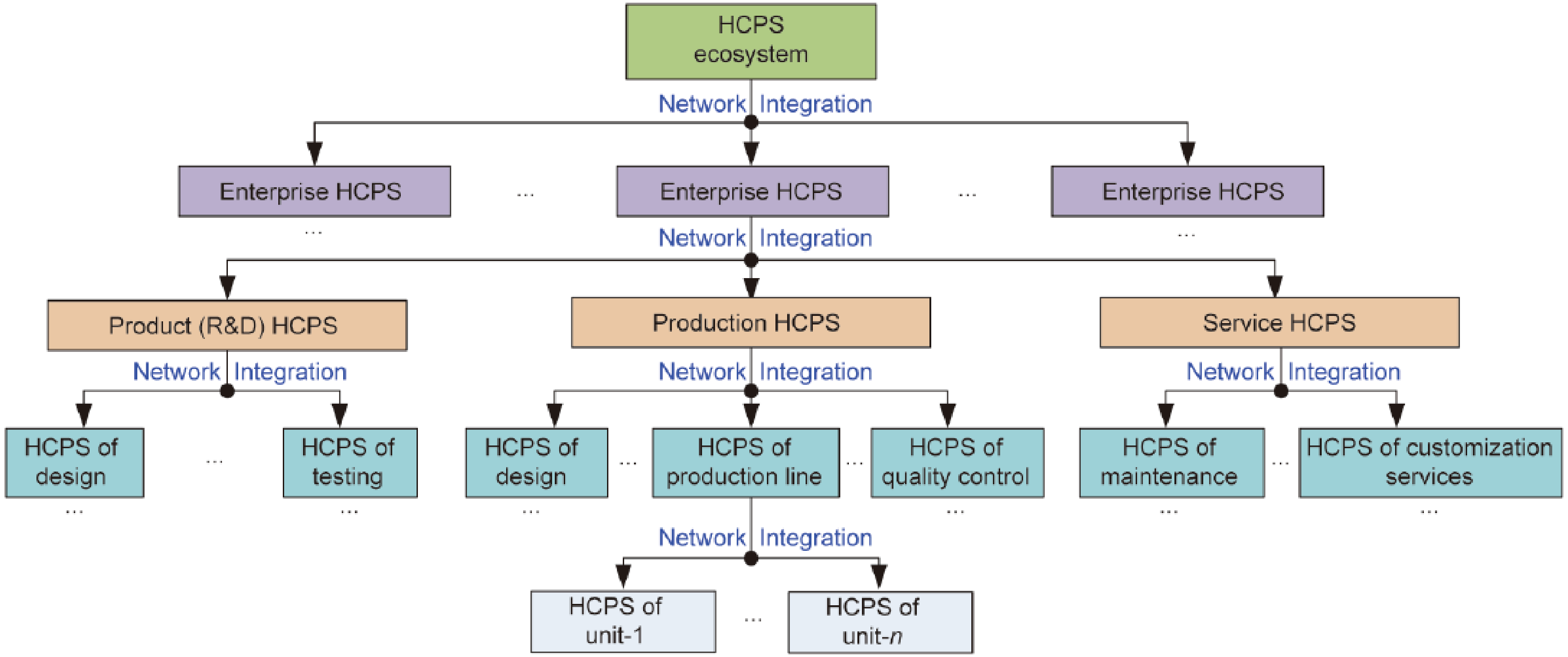
Human–Cyber–Physical Systems (HCPSs)

Hierarchical levels of HCPS2.0 for NGIM



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(Ji et al, 2019)

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Human–Cyber–Physical Systems (HCPSs)

Unit-level HCPS2.0 and intelligent machine tools

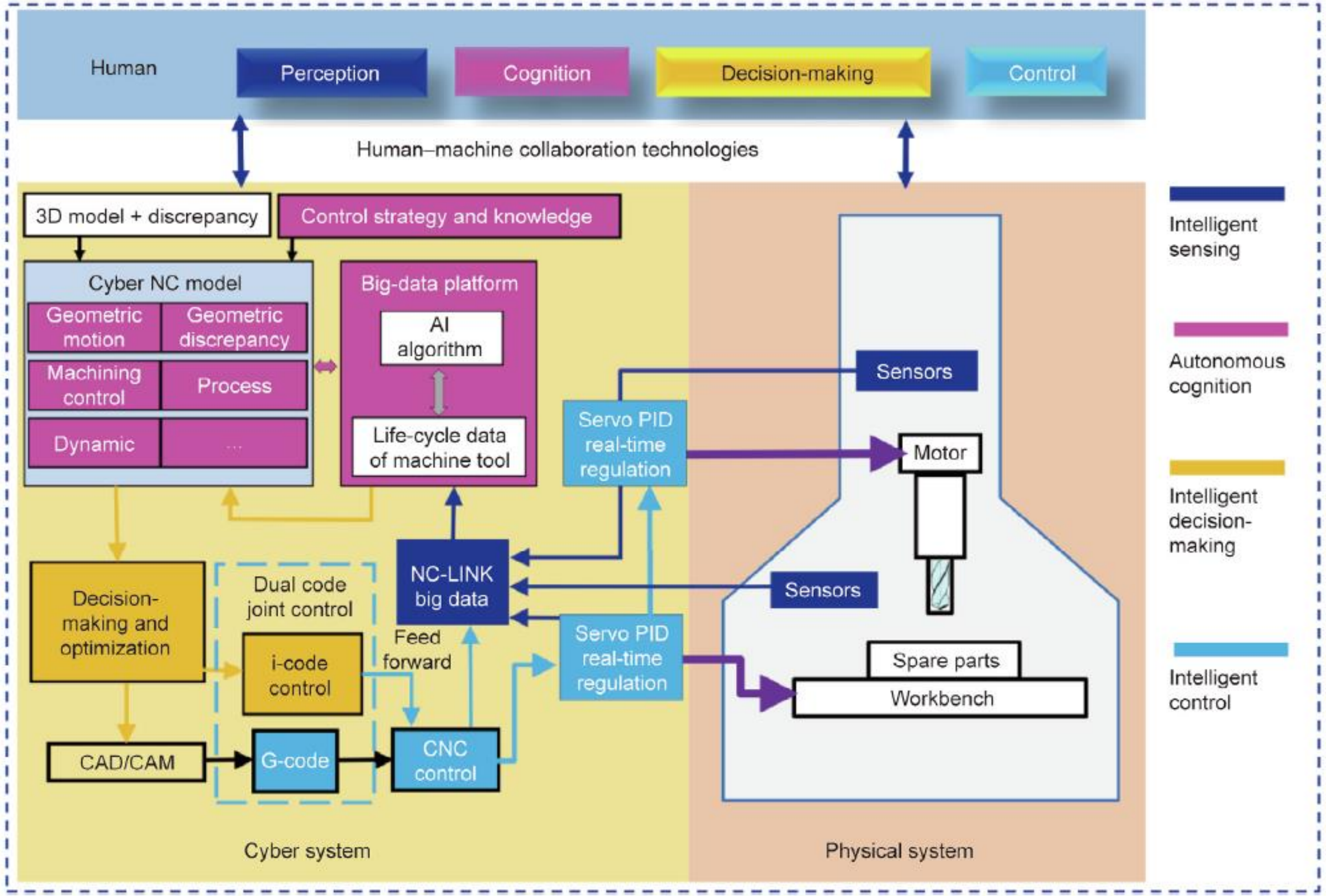
CAD: computer-aided design;

CAM: computer-aided manufacturing;

NC: numerical control;

PID: proportional–integral–derivative.

i-code: intelligent code,



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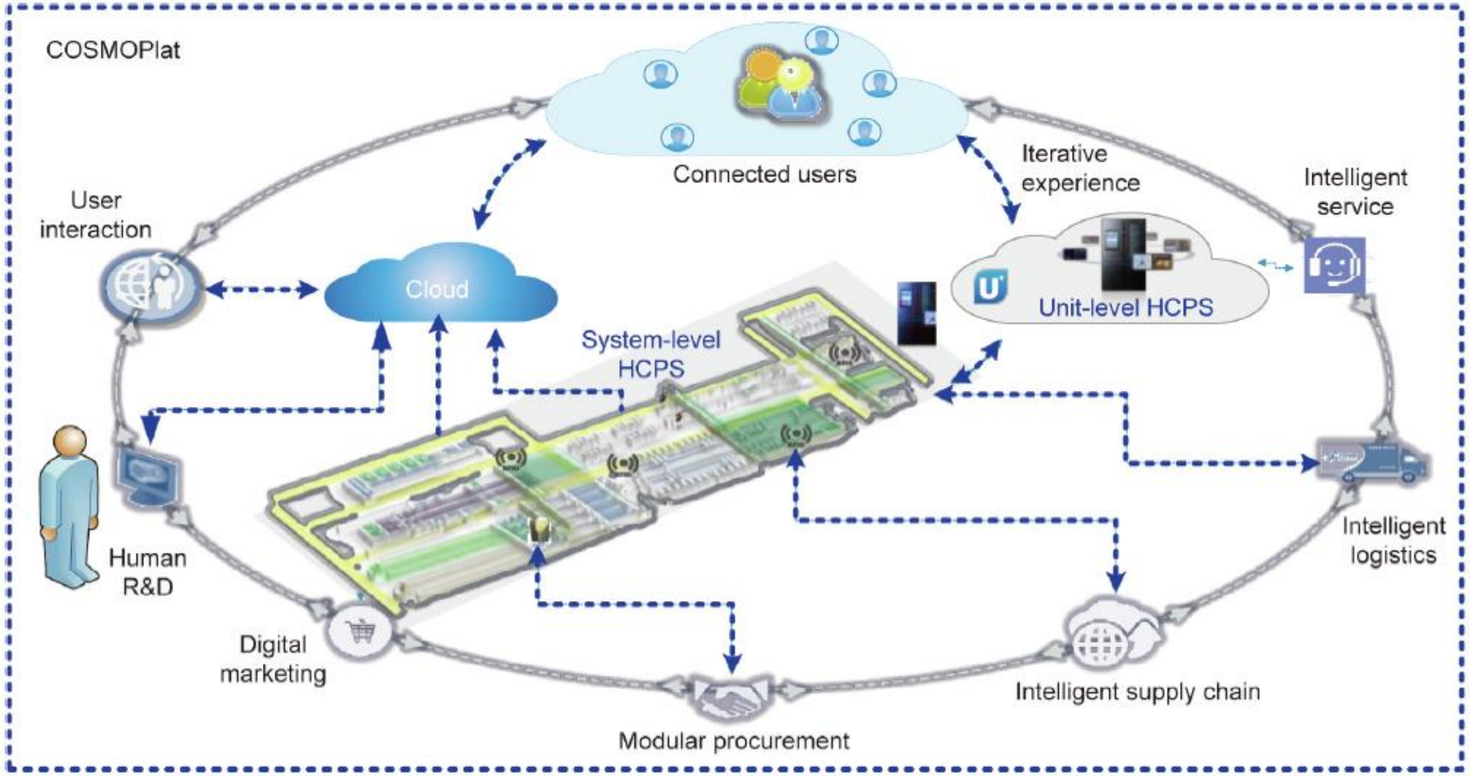
Human–Cyber–Physical Systems (HCPSs)

Hierarchical levels of HCPS2.0 for NGIM



System-level HCPS in the COSMOPlat

Note: NGIM (Next Generation Instant Messaging)

(Ji et al, 2019)

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Think

Why Cyber-Physical-Human System is important ?

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