Knowledge Management 4.0 VO

Priv.-Doz. Dr.-Ing. Fazel Ansari

March 7, 2023

THIS IS DAY ONE

OVERVIEW OF THE COURSE

About Me

A Mechanical Engineer who made a Journey in Computer Science and Management

Education

- Habilitation (venia docendi) in Industrial Engineering, TU Wien, 2021
- Ph.D. in Computer Science (Summa cum laude), Universität Siegen, 2014

Areas of Research Interests

- Human-Centered Cyber Physical Production Systems
- Knowledge Management in Industry 4.0: Human- and Machine Factors in Smart and Learning Factories
- Knowledge-Based Maintenance (Predictive and Prescriptive Maintenance)
- Industrial AI – Application of Semantic Modeling, Text Mining and Predictive Data Analytic in Manufacturing Systems and Production Processes

TU WIEN

INSTITUTE OF MANAGEMENT SCIENCE
Research Group of Production and Maintenance Management

Fraunhofer AUSTRIA

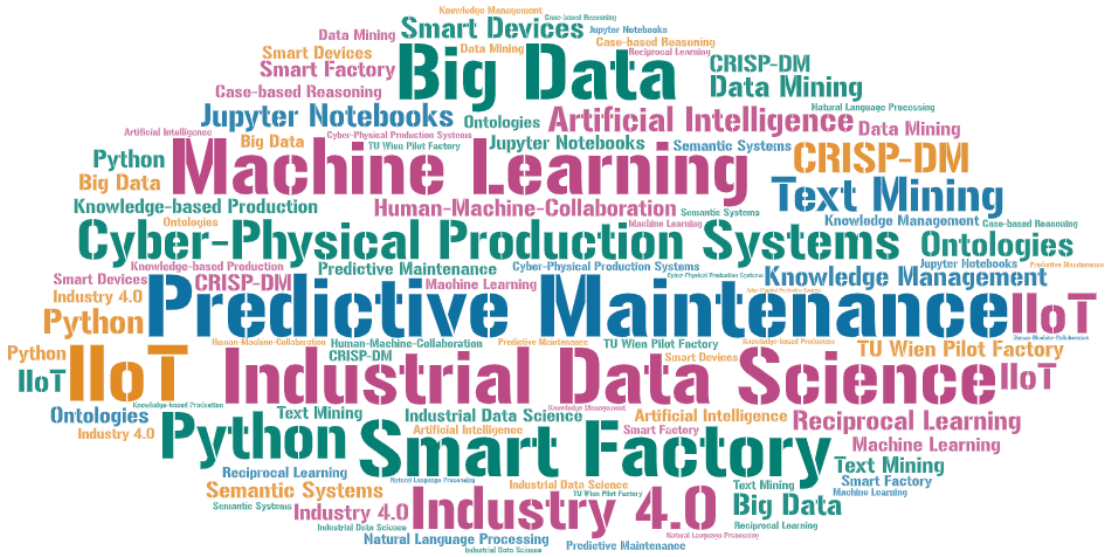
Research Group of “Production and Maintenance Management” invites you to join

330.267 – VO: Knowledge Management 4.0 (Bombardier Hörsaal)

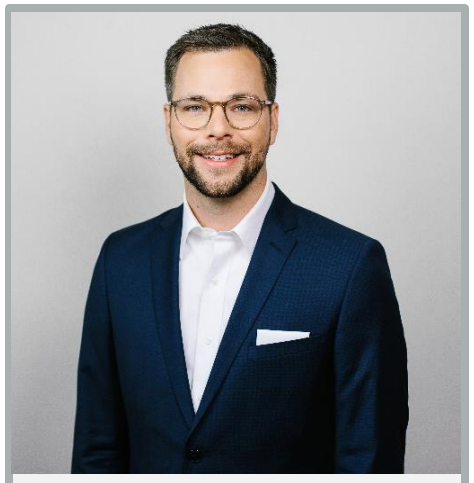
330.282 – UE: Industrial Data Science (HS 2)

Gain Insight Into to the Topics of:

Priv.-Doz. Dr.-Ing.
Fazel Ansari
Head of Research Group
fazel.ansari@tuwien.ac.at



Dipl.-Ing.
Theresa Madreiter
Text Analyst
theresa.madreiter@tuwien.ac.at



Dipl.-Ing.
Linus Kohl
Big Data Engineer
linus.kohl@tuwien.ac.at

Theoretical, practice-oriented and interactive lecture and exercise sessions!

Summer Semester 2023: Thursdays, **2pm-6pm**

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Overview of the Course

Lecture (VO)

330.267 Knowledge Management 4.0

- Related studying programs:
  - 066 482 Mechanical Engineering - Management
  - 066 926 Business Informatics
- 2023 Summer Semester, VO, 2.0 Hours per week, 3.0 Credit points
- Language: English
- Exam:
  - Type: Written (Combination of open format and multiple choices)
  - Date & Time: See TISS
  - Place: Bombardier Hörsaal + + HS 2
  - Course registration is compulsory at TISS

Overview of the Course

Exercise (UE)

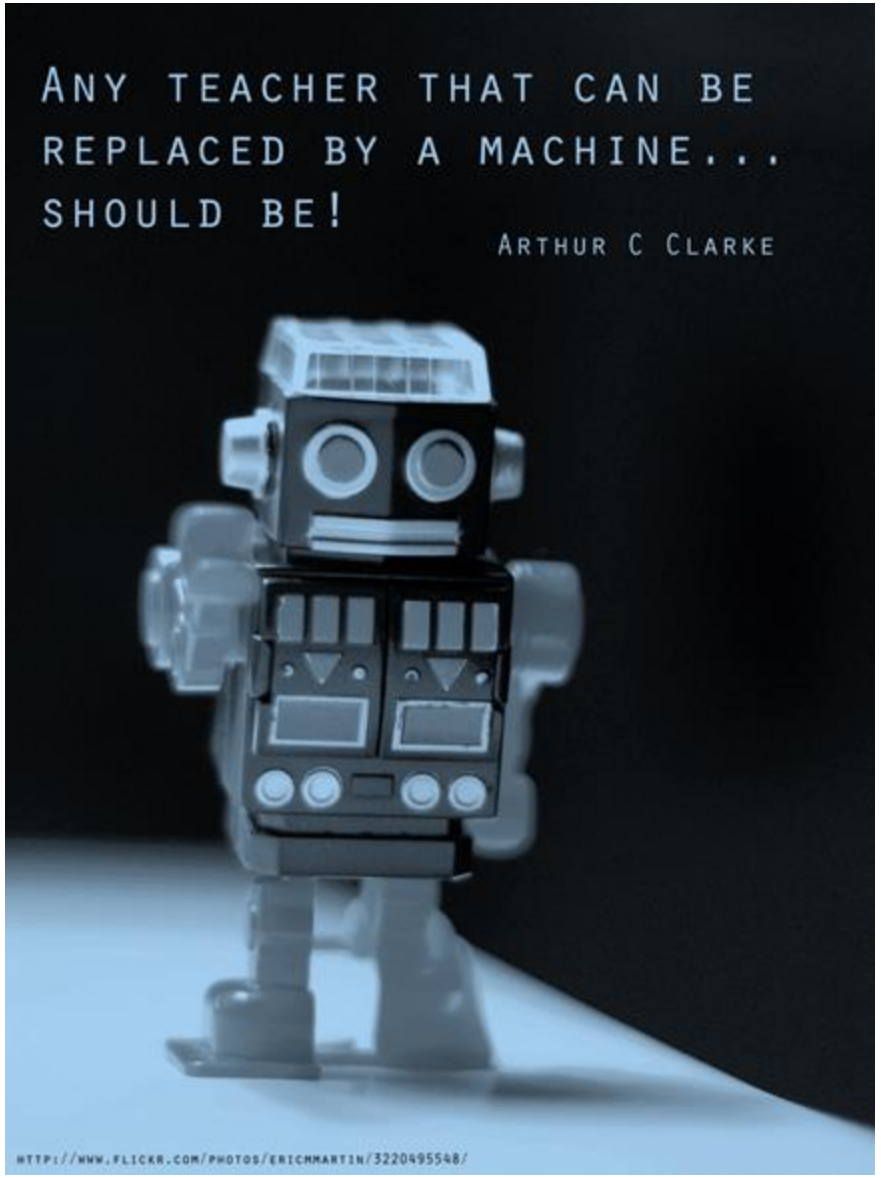
330.282 Industrial Data Science

- Related studying programs:
  - 066 482 Mechanical Engineering - Management
  - 066 926 Business Informatics
- 2023 Summer Semester, VO, 1.0 Hour per week, 2.0 Credit points
- Topic: Industrial Data Science (Programming and Modeling with Python & Protégé)
- Language: English
- Registration is compulsory **(Will start on 21.03.2023)**
- **Evaluation:** Assignments + Participation
- **Pre-requisite:** 330.267 Knowledge Management 4.0
- **Participation in team work activities is mandatory**

Overview of the Course

Lecture (VO) and Exercise (UE)

Date	Place	Topic
07.03	Bombardier Hörsaal + HS 2	• Introduction to the course • What is a CPPS?
14.03	Bombardier Hörsaal + HS 2	• CPPS & Digital Twin in Industry 4.0 • Smart Factory concept including CRISP DM
21.03	Bombardier Hörsaal + HS 2	• Introduction to Exercise • Exercise 1: Introduction to IDS
28.03	Bombardier Hörsaal + HS 2	• Exercise 2: Advanced IDS
18.04	Bombardier Hörsaal + HS 2	• Introduction to Industrial AI and Technical Language Processing
25.04	Bombardier Hörsaal + HS 2	• Knowledge Management 4.0: Theories and Foundation
02.05	Bombardier Hörsaal + HS 2	• Knowledge-Based Maintenance
09.05	Bombardier Hörsaal + HS 2	• Knowledge Representation (Ontologies/Knowledge Graph + Industry Project
16.05	Bombardier Hörsaal + HS 2	• Expert Talk • Exercise Session III: Industrial Data Science Project with CRISP methodology
23.05	Bombardier Hörsaal + HS 2	• Exercise Session IV: Applied Artificial Intelligence in Industrial Data Science & Ontology Modelling with Protégé



Lecture Materials (Slides, further readings, etc.) will be uploaded at

TUWEL

Timetables and organizational issues on

TISS

EXPERT TALK – Dr. Jens Neuhüttler

Topic: Digital Service Transformation of manufacturing companies

Position

- Head of Digital Service Transformation, Fraunhofer-Institut für Arbeitswirtschaft und Organisation (IAO)
- Lecturer Service Design (Kalaidos UAS)
- Lecturer Smart Service Business (DHBW Stuttgart)

Previous positions:

- in 2020 Invited Visiting Researcher, University of Cambridge (UK)
- 2019-2021 Head of Business Innovation Engineering Center, Fraunhofer IAO
- 2016-2019 Project Lead Team "Service Business Innovaiton, Fraunhofer IAO

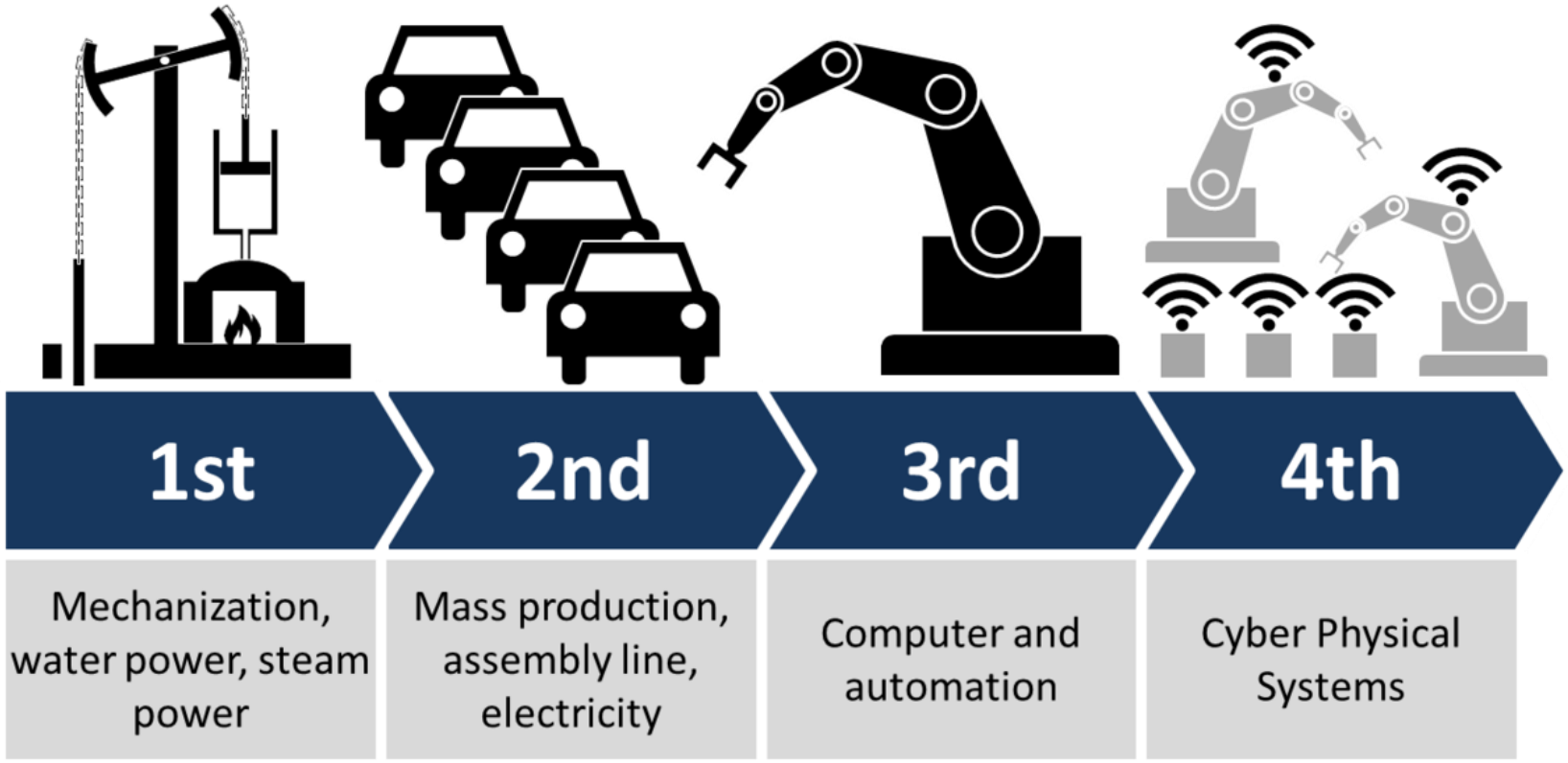
Areas of Expertise:

- Development of Smart Sevices
- Testing Smart-Service-Quality
- Business Model Innovation

Lecture on: 16.05.2023| 14:00 - 15:30 | Where: Bombardier Hörsaal

Who you are?

What do you Know about Knowledge Management and CPPS?



WHAT IS A CPPS?

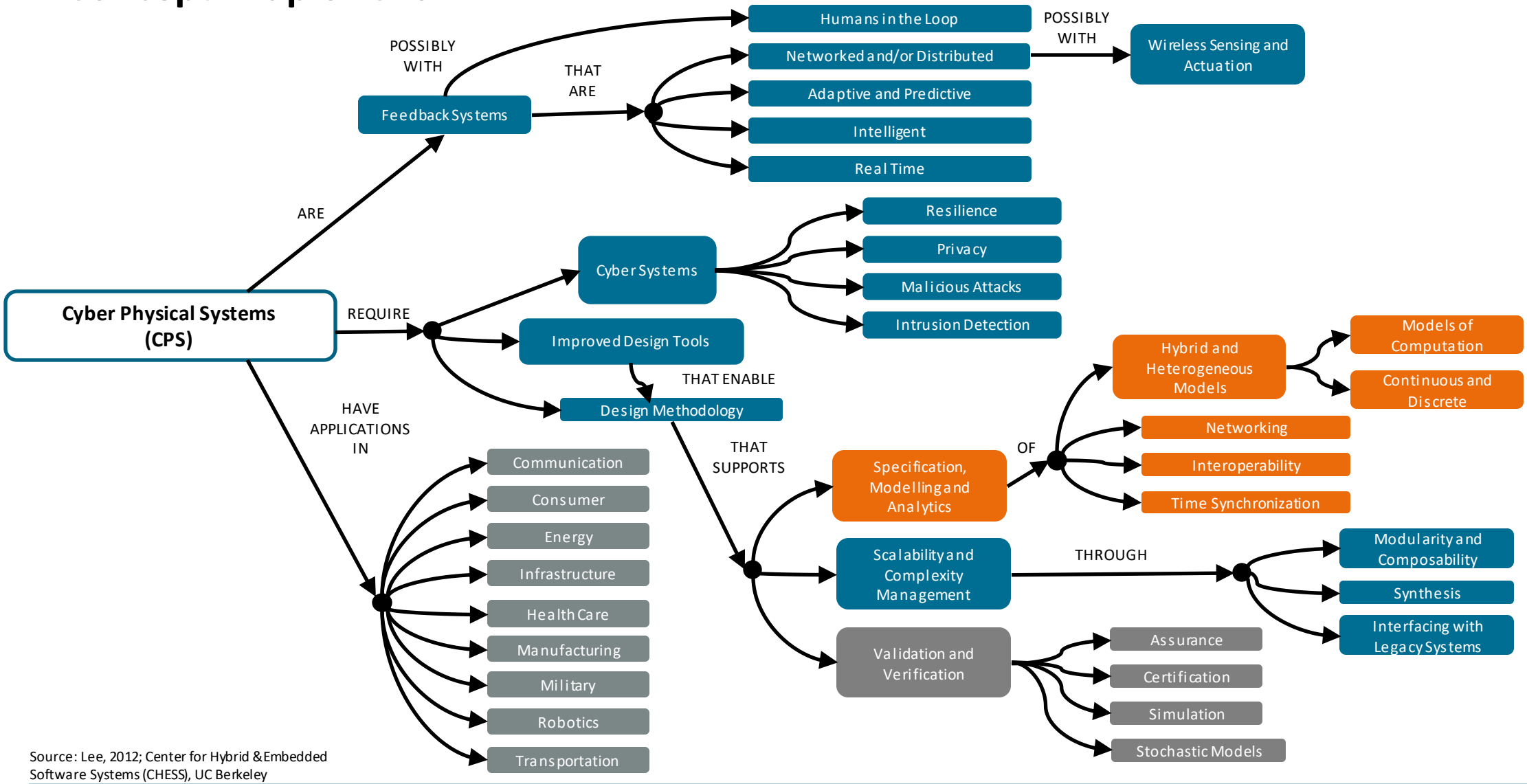
Cyber Physical Systems (CPS)

Basic Definition

- **A CPS is an …**
  - **orchestration of computers and physical systems**
  - **integration of computation with physical processes.**
- Embedded computers and networks monitor and control the physical processes, usually with **feedback loops** where physical processes affect computations and vice versa.
- As an intellectual challenge, CPS is about **the intersection, not the union, of the physical and the cyber (elements/components).**
- It is not sufficient to separately understand the physical components and the computational components. **We must instead understand their interaction.**

(Lee and Seshia,2015)

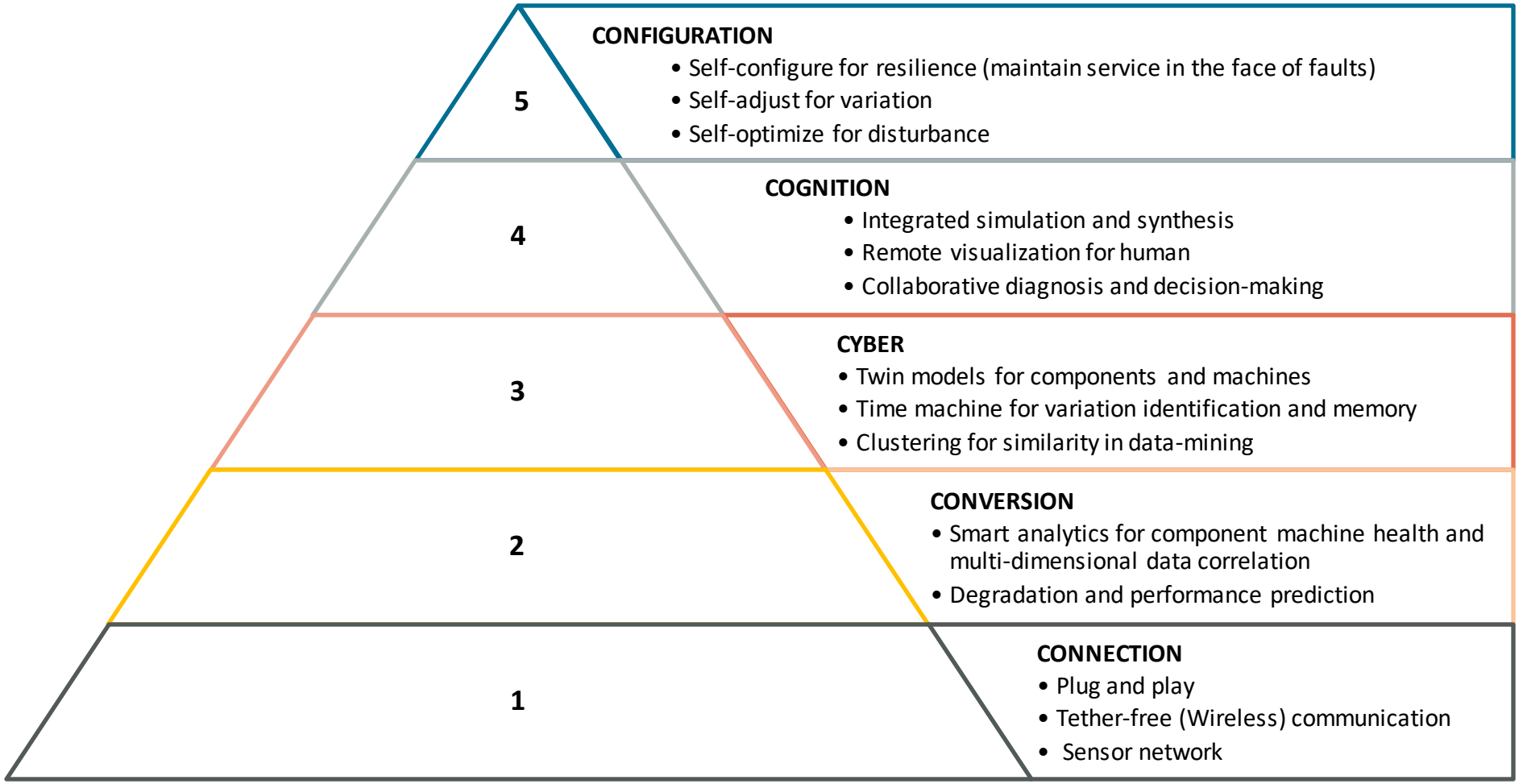
A Concept Map of CPS



Source: Lee, 2012; Center for Hybrid & Embedded Software Systems (CHESS), UC Berkeley

Cyber Physical Systems (CPS)

5C Functions



Source: J. Lee, B. Bagheri, H.-A. Kao, A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems, Manufacturing Letters 3 (2015) 18–23

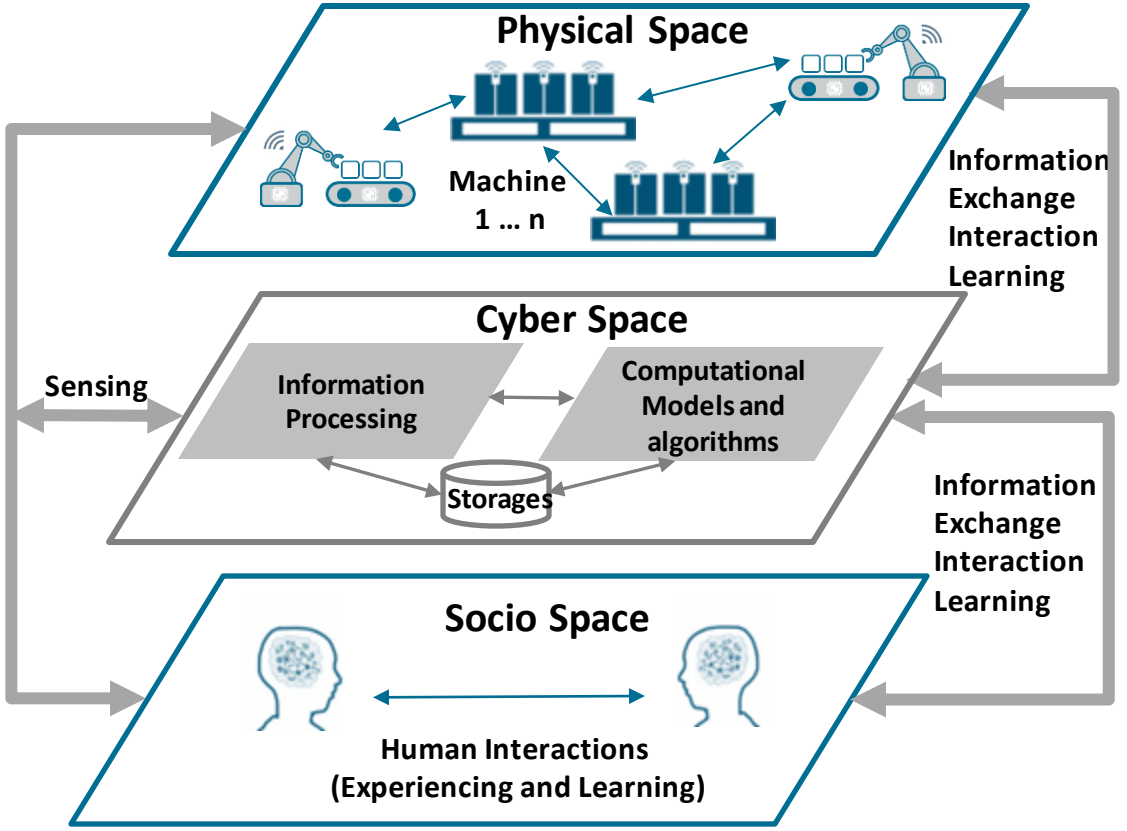
Cyber Physical Production Systems (CPPS)

A Point of View

Industry 4.0's Driver of Change: Cyber Physical Production Systems (CPPS)

Coalition of Cyber-Physical-Socio Spaces

- According to (Monostori et al., 2016): CPPS consist of **autonomous** and **cooperative elements** as well as **sub-systems** that are connected based on the context within and across all levels of production, from processes through machines up to production and logistics networks.
- Three main characteristics of CPPS are:
  - **Intelligence** (smartness), i.e. the elements are able to acquiring information from their surroundings and act autonomously.
  - **Connectedness**, i.e. the ability to set up and use connections to the other elements of the work system –**incl. human beings** – for cooperation and collaboration, and to the knowledge and services available on the Internet.
  - **Responsiveness** (Resilience, Adaptiveness, Flexibility) towards internal and external changes and disturbances.



How do we manage human-machine collective knowledge?

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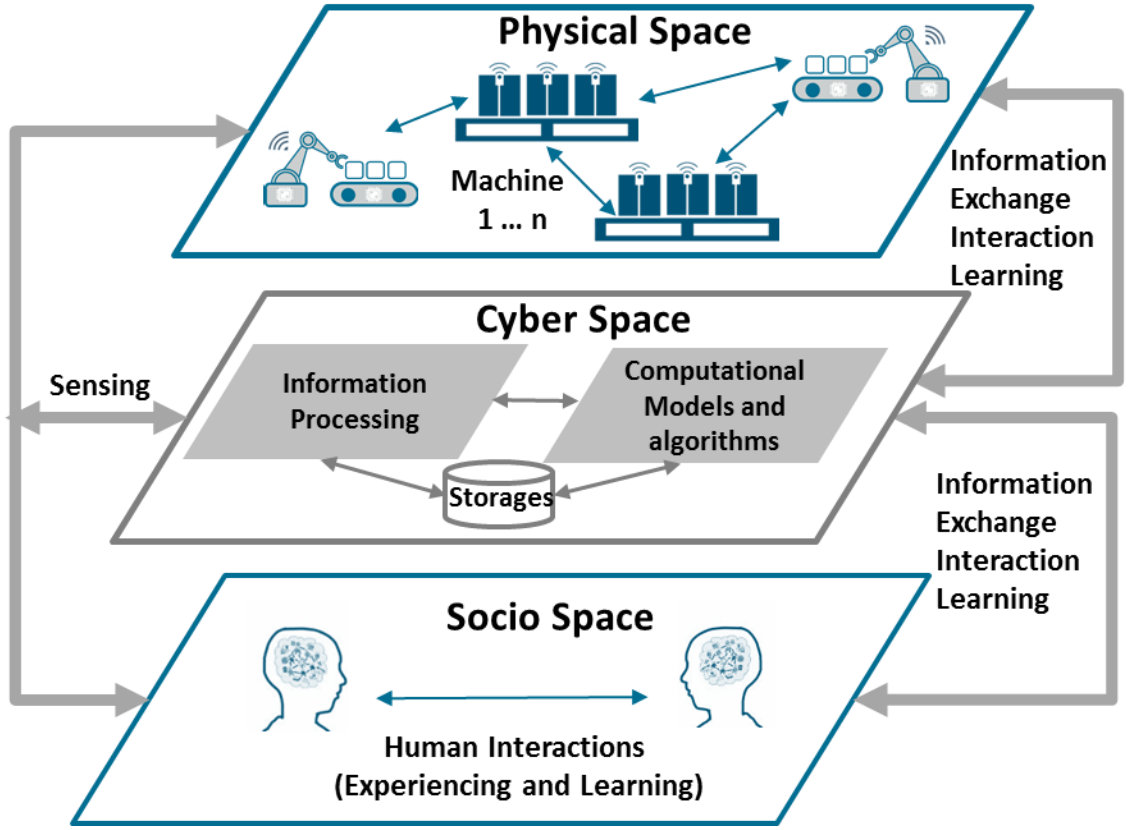
Human-Centered CPPS

Collaboration vs. Assistance



Human-centered CPPS inherited several features from Open-Socio-Technical Systems “tightly conjoined, coordinated, and integrated with human and social characteristics”, and aims to deeply interact and collaborate with human towards achieving a common goal.

Source: F. Ansari, M. Khobreh, U. Seidenberg & W. Sihn, A Problem-Solving Ontology for Human-Centered Cyber Physical Production Systems, CIRP Journal of Manufacturing Science and Technology, Elsevier, Vol. 22C, 2018, pp. 91-106.

11 Fundamental Challenges of CPS/CPPS

Design and Realization Perspectives

1. Compositionality i.e. integration of heterogeneous cyber and physical aspects of CPS
2. Distributed Sensing, Computation and Control
3. Physical Interfaces and Integration
4. Human Interfaces and Integration
5. **Extracting Knowledge from heterogeneous data sources (From Data to Knowledge)**
6. Modeling and Analysis of physical and cyber components
7. Privacy, Trust, Security
8. Robustness, Adaptation, Reconfiguration
9. Software
10. Verification, Testing, and Certification
11. Societal Impact

Adopted from: (CPS Summit, 2008), (Lee and Seshia,2015), (Ansari & Seidenberg, 2016), (Seidenberg & Ansari, 2017)

11 Fundamental Challenges of CPS

Technological & Non-Technological Aspects

Challenges	Description	Type	
		Technological	Non-Tech.
Compositionality	Compositionality problems may cause due to the **integration of heterogeneous cyber and physical aspects of CPS**	✓	
Distributed Sensing, Computation and Control	Key problems include **(semi-)real-time collection of adequate information, processing and asserting control** in a distributed environment.	✓	
Physical Interfaces and Integration	An essential feature of CPS is to be able to contact with the **physical world using various sensor technologies**.	✓	
Human Interfaces and Integration	Another essential feature of CPS is the ability to **effectively communicate with various types of end-users in diverse qualification and competence level** through use of **human-machine interfaces**.	✓	✓
Extracting Knowledge from heterogeneous data sources	Processing **raw-data collected in structured, semi-structured and non-structured format** as well as various quality and veracity level, and extracting knowledge for **supporting decision-making and learning from each decision instances**, require deploying **smart data analytics and artificial intelligence (AI) techniques**, in particular predictive data analytics and deep learning.	✓	
Modeling and analysis of physical and cyber components	A massive complexity is exhibited through **modeling and analysis of heterogeneous physical and cyber components** with different notions of time, across different scales, and integration of the feedback collected from them.	✓	

Adopted from: (CPS Summit, 2008), (Lee and Seshia,2015), (Ansari & Seidenberg, 2016), (Seidenberg & Ansari, 2017)

11 Fundamental Challenges of CPS

Technological & Non-Technological Aspects

Challenges	Description	Type	
		Technological	Non-Tech.
Privacy, Trust, Security	Application of CPS in diverse sectors raises **new issues in privacy, trust and security**, inter alia, revealing information from cyber-physical-socio space may require **new rules on accessibility and transparency of information**, i.e. what information can be hidden. In addition, new kinds of physical and cyber-physical attacks are possible e.g. in the context of smart and connected factories, i.e. there is a **demand to new concepts and tools for cyber-security**.	✓	✓
Robustness, Adaptation, Reconfiguration	CPS operates in dynamic (production) environments and thus needs to **handle uncertain situations and disturbances without affecting the outcome quality**. In addition, CPS should be **reconfigurable and adaptive to deal with (unexpected) faults in both physical and cyber levels**.	✓	
Software Technology	Development and deployment of CPS require **new programming languages**, whereas traditional one, which could deal with complexity of cyber-physical spaces. In addition, CPS requires integrated software solutions to support performance planning, monitoring and controlling of CPS and dealing with high volume of (real-time) data fellow among sub-systems, systems-of-systems and environment.	✓	

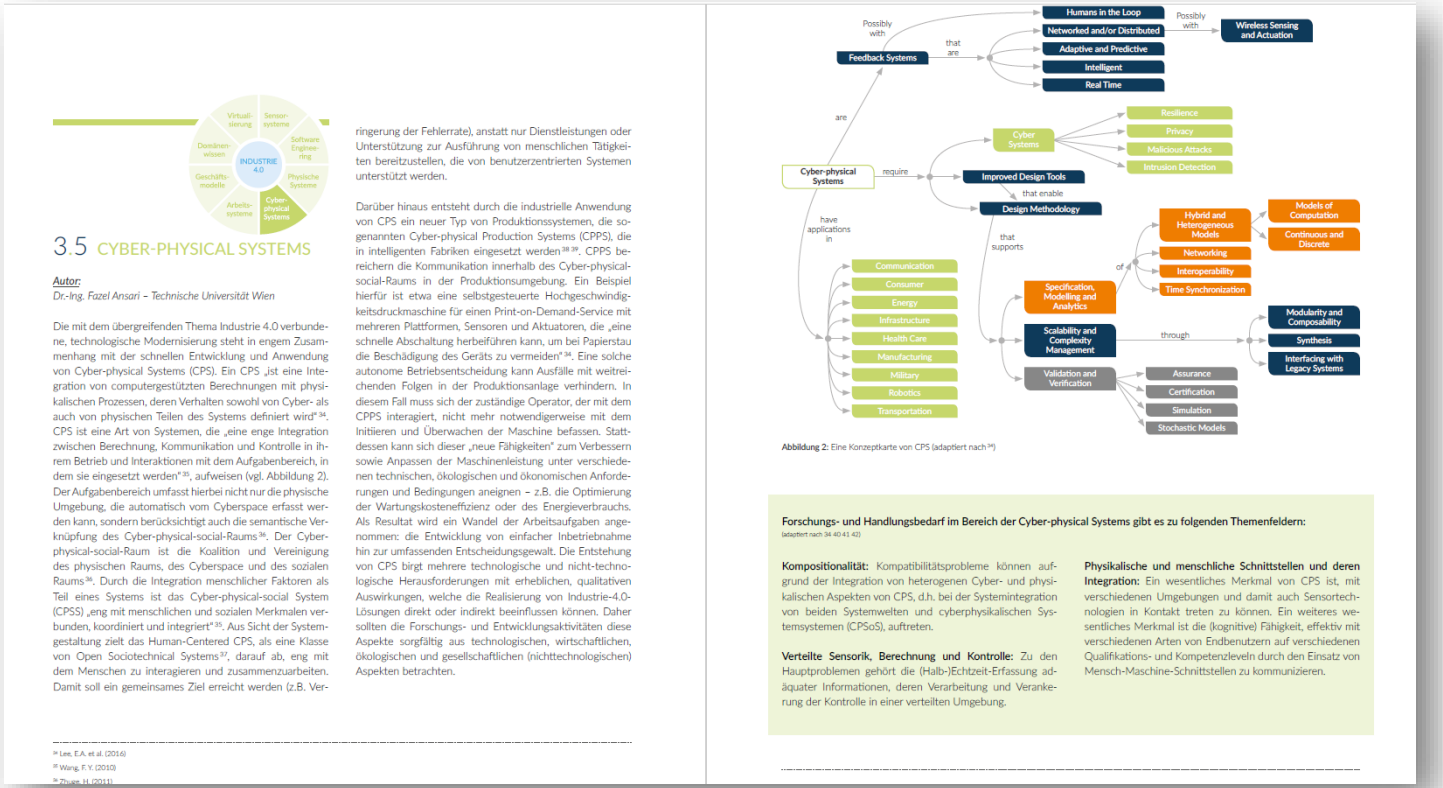
Adopted from: (CPS Summit, 2008), (Lee and Seshia,2015), (Ansari & Seidenberg, 2016), (Seidenberg & Ansari, 2017)

11 Fundamental Challenges of CPS

Technological & Non-Technological Aspects

Challenges	Description	Type	
		Technological	Non-Tech.
Verification, Testing, (Safety)Certification and guidelines	CPS requires **new approaches for verification and testing to check and regulate potential events such as physical or cyber related fault by comparing with certain standards**. For this purpose, a detection, learning and reasoning module should be developed to assure correctness of decisions and promotes learning from former ones. Application of CPS in diverse industrial sectors also requires handling safety certifications, e.g. to identify hazard sources and the way to deal with them in accordance with health and safety legal requirements in the workplace.	✓	✓
Societal Impact	Social aspects of CPS may also **affect the design, verifiability, validation, operation, privacy, trust, and fault tolerance**. Especially, developing human-centered CPS confronts several **societal, cultural and ethical resistance** to technological change e.g. due to the risks that robots or intelligent systems may take over human jobs and authorities in the workplace.		✓

Adopted from: (CPS Summit, 2008), (Lee and Seshia,2015), (Ansari & Seidenberg, 2016), (Seidenberg & Ansari, 2017)



3.5 CYBER-PHYSICAL SYSTEMS

Autor:
Dr.-Ing. Fazel Ansari – Technische Universität Wien

Die mit dem übergreifenden Thema Industrie 4.0 verbundene, technologische Modernisierung steht in engem Zusammenhang mit der schnellen Entwicklung und Anwendung von Cyber-physical Systems (CPS). Ein CPS „ist eine Integration von computergestützten Berechnungen mit physikalischen Prozessen, deren Verhalten sowohl von Cyber- als auch von physischen Teilen des Systems definiert wird“[34]. CPS ist eine Art von Systemen, die „eine enge Integration zwischen Berechnung, Kommunikation und Kontrolle in ihrem Betrieb und Interaktionen mit dem Aufgabenbereich, in dem sie eingesetzt werden“[35], aufweisen (vgl. Abbildung 2). Der Aufgabenbereich umfasst hierbei nicht nur die physische Umgebung, die automatisch vom Cyberspace erfasst werden kann, sondern berücksichtigt auch die semantische Verknüpfung des Cyber-physical-social-Raums[36]. Der Cyber-physical-social-Raum ist die Koalition und Vereinigung des physischen Raums, des Cyberspace und des sozialen Raums[36]. Durch die Integration menschlicher Faktoren als Teil eines Systems ist das Cyber-physical-social System (CPSS) „eng mit menschlichen und sozialen Merkmalen verbunden, koordiniert und integriert“[35]. Aus Sicht der Systemgestaltung zielt das Human-Centered CPS, als eine Klasse von Open Sociotechnical Systems[37], darauf ab, eng mit dem Menschen zu interagieren und zusammenzuarbeiten. Damit soll ein gemeinsames Ziel erreicht werden (z.B. Verringerung der Fehlerrate), anstatt nur Dienstleistungen oder Unterstützung zur Ausführung von menschlichen Tätigkeiten bereitzustellen, die von benutzerzentrierten Systemen unterstützt werden.

Darüber hinaus entsteht durch die industrielle Anwendung von CPS ein neuer Typ von Produktionssystemen, die sogenannten Cyber-physical Production Systems (CPPS), die in intelligenten Fabriken eingesetzt werden[38,39]. CPPS bereichern die Kommunikation innerhalb des Cyber-physical-social-Raums in der Produktionsumgebung. Ein Beispiel hierfür ist etwa eine selbstgesteuerte Hochgeschwindigkeitsdruckmaschine für einen Print-on-Demand-Service mit mehreren Plattformen, Sensoren und Aktuatoren, die „eine schnelle Abschaltung herbeiführen kann, um bei Papierstau die Beschädigung des Geräts zu vermeiden“[34]. Eine solche autonome Betriebsentscheidung kann Ausfälle mit weitreichenden Folgen in der Produktionsanlage verhindern. In diesem Fall muss sich der zuständige Operator, der mit dem CPPS interagiert, nicht mehr notwendigerweise mit dem Initiieren und Überwachen der Maschine befassen. Stattdessen kann sich dieser „neue Fähigkeiten“ zum Verbessern sowie Anpassen der Maschinenleistung unter verschiedenen technischen, ökologischen und ökonomischen Anforderungen und Bedingungen aneignen – z.B. die Optimierung der Wartungskosteneffizienz oder des Energieverbrauchs. Als Resultat wird ein Wandel der Arbeitsaufgaben angenommen: die Entwicklung von einfacher Inbetriebnahme hin zur umfassenden Entscheidungsgewalt. Die Entstehung von CPS birgt mehrere technologische und nicht-technologische Herausforderungen mit erheblichen, qualitativen Auswirkungen, welche die Realisierung von Industrie-4.0-Lösungen direkt oder indirekt beeinflussen können. Daher sollten die Forschungs- und Entwicklungsaktivitäten diese Aspekte sorgfältig aus technologischen, wirtschaftlichen, ökologischen und gesellschaftlichen (nichttechnologischen) Aspekten betrachten.

[34] Lee, E.A. et al. (2016)
[35] Wang, F. Y. (2010)
[36] Zhuge, H. (2011)

Abbildung 2: Eine Konzeptkarte von CPS (adaptiert nach [34])

Forschungs- und Handlungsbedarf im Bereich der Cyber-physical Systems gibt es zu folgenden Themenfeldern:
(adaptiert nach [34 40 41 42])

Kompositionalität: Kompatibilitätsprobleme können aufgrund der Integration von heterogenen Cyber- und physikalischen Aspekten von CPS, d.h. bei der Systemintegration von beiden Systemwelten und cyberphysikalischen Systemsystemen (CPSoS), auftreten.

Verteilte Sensorik, Berechnung und Kontrolle: Zu den Hauptproblemen gehört die (Halb-)Echtzeit-Erfassung adäquater Informationen, deren Verarbeitung und Verankerung der Kontrolle in einer verteilten Umgebung.

Physikalische und menschliche Schnittstellen und deren Integration: Ein wesentliches Merkmal von CPS ist, mit verschiedenen Umgebungen und damit auch Sensortechnologien in Kontakt treten zu können. Ein weiteres wesentliches Merkmal ist die (kognitive) Fähigkeit, effektiv mit verschiedenen Arten von Endbenutzern auf verschiedenen Qualifikations- und Kompetenzleveln durch den Einsatz von Mensch-Maschine-Schnittstellen zu kommunizieren.

F. Ansari, Cyber-Physical Systems, Chapter In: Strategy Paper of the Research, Development & Innovation Expert Group: Priority Research Areas & Measures to Support the Austrian Research Landscape in the Context of Industry 4.0, The Association Industry 4.0 Austria (Verein Industrie 4.0 Österreich), 2018, pp.26-28.

WHY KM IN INDUSTRY 4.0 (KM 4.0)?

– ORIENTATION

Digitalization and Industry 4.0

Drivers of Change

Source: https://www.youtube.com/watch?v=F06gB7mJX98

Interactive Workshop

Question – Active Participation

1) Write your Keywords
2) Explain your points and the keywords
3) Discuss with others in the open round

What is “Knowledge” in Industry 4.0?

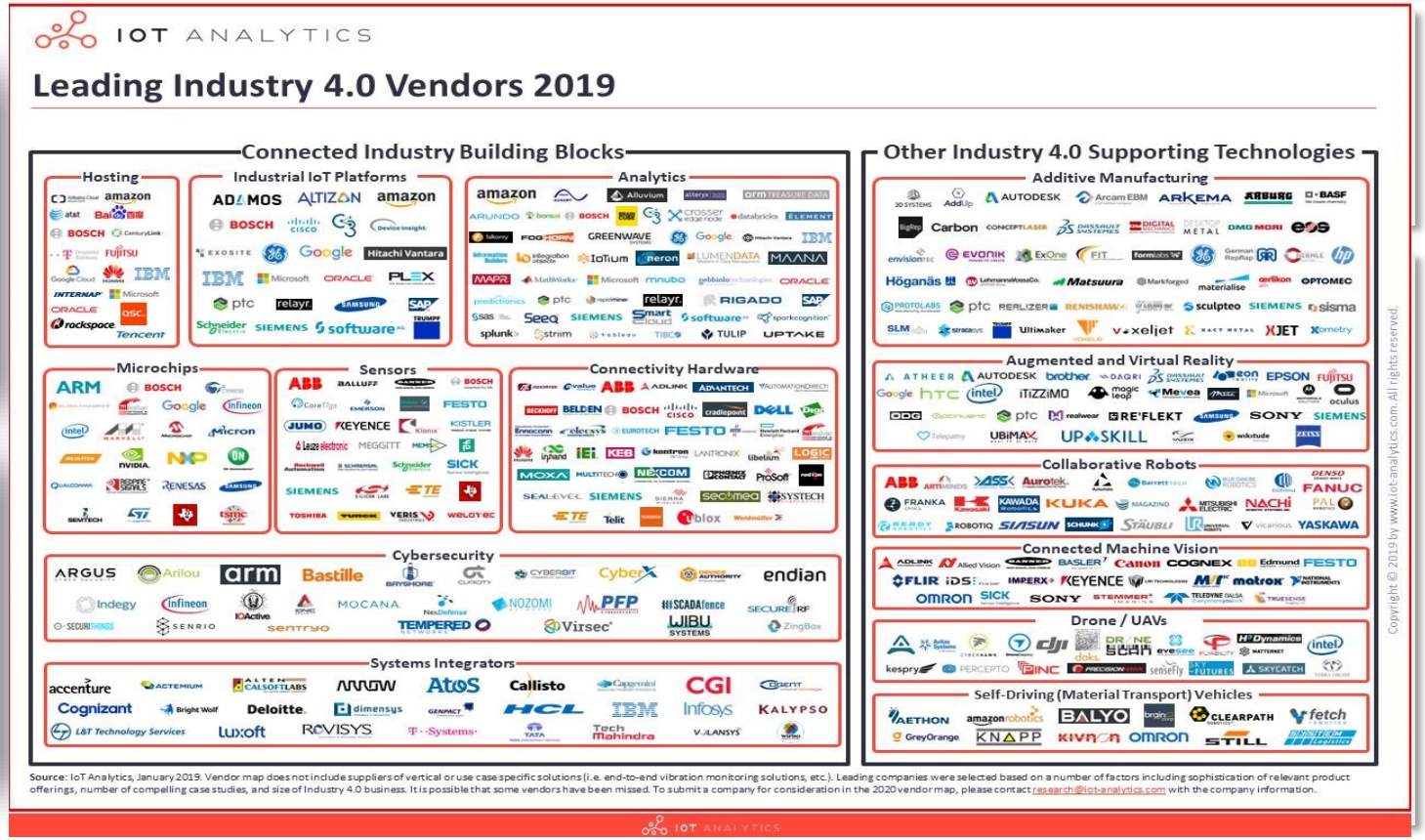
Why do we need to manage knowledge in Industry 4.0?

Industry 4.0 – A Paradigm Shift in Production and Industrial Management

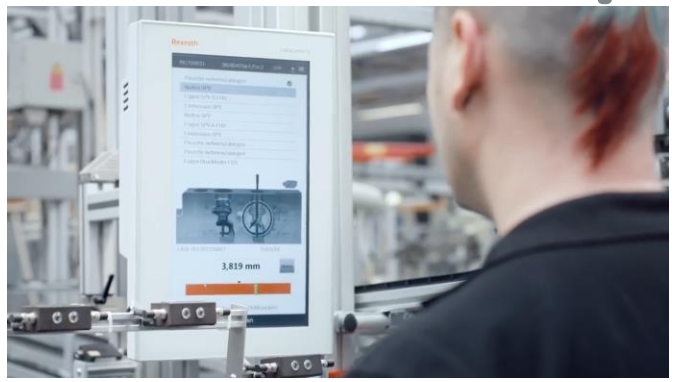
Transformation to Autonomous Production- What are the Key Challenges?

Industry 4.0 (4th Industrial Revolution)

2013



Tomorrow ?



Rexroth
Bosch Group

Intelligentization can be approached from various angles, in particular organizational, individual and technological point of view.

Digitalization **Smart Connectivity** **Automation** **Integration** **Intelligentization**

SWOT Analysis

Technological & Non-Technological Aspects

Strengths

- Control decentralized and in real-time
- Adaptive, flexible system
- Condition monitoring
- Masses of information
  → time, costs, quality

Weaknesses

- Dependency on correct data and interpretation
- Vulnerability due to increased complexity
- Major investment for hardware and software

Opportunities

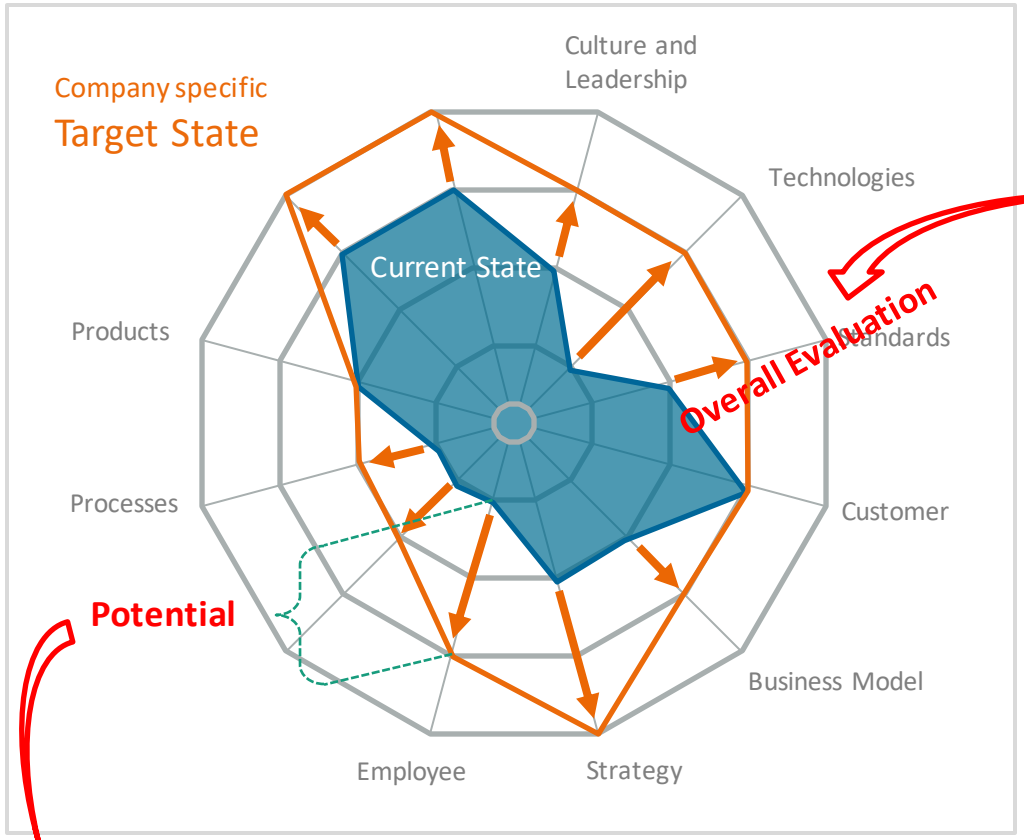
- Match with market conditions
- Innovative business models
- Shift in economical balance of power

Threats

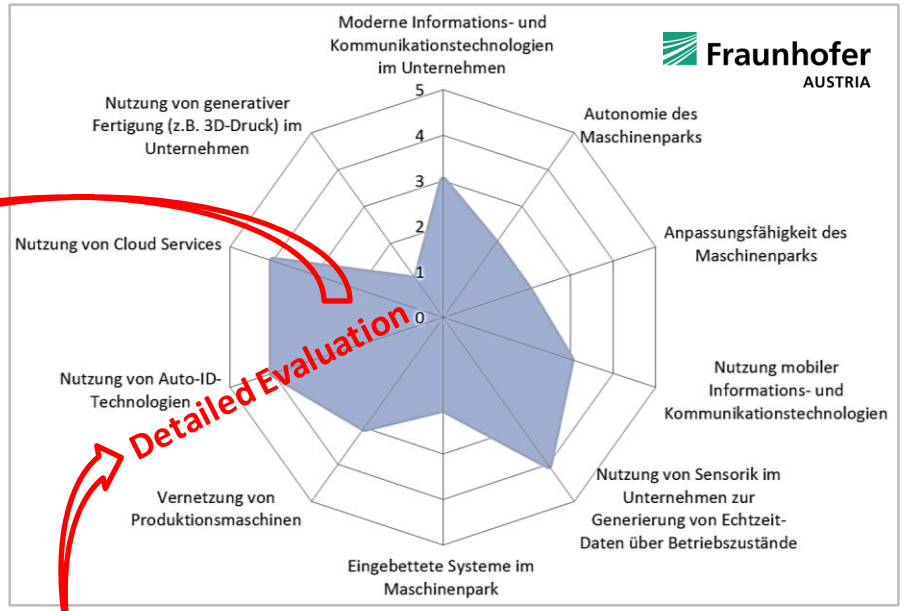
- Security issues
  - Data theft; Manipulation
  - Lack of privacy protection
- Dependencies on
  - Internet connection/cloud
  - Service provider
- Shift of jobs

Maturity Assessment – Technological & Non-Technological Aspects

Industry 4.0 Maturity Model



Overall Evaluation

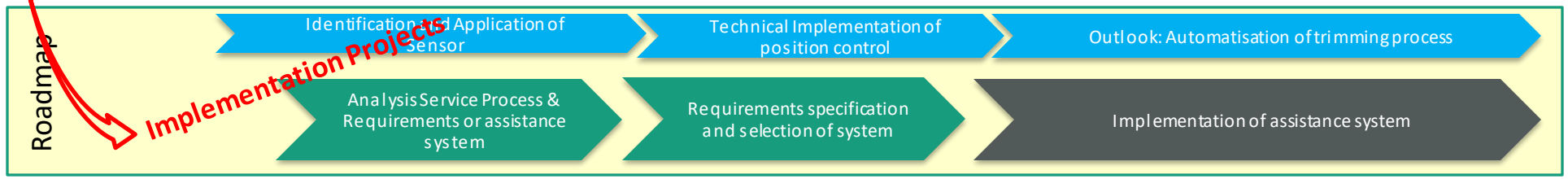


Detailed Evaluation

Evaluation Model

9.5	Sind in Ihrer Produktion Sensorik-Systeme zur Generierung und Nutzung von Echtzeit-Daten im Einsatz?	1 – 5 (Nicht im Einsatz – Sehr umfassend eingesetzt)	☐	☐	☐	☐	☐
9.6	Sind elektronische Rechner und Computer (Embedded Systems) in Ihre Produktionsmaschinen integriert? (Mit dem Ziel der Digitalisierung und Vernetzung der Maschinen)	1 – 5 (Nicht vorhanden – Sehr umfassend vorhanden)	☐	☐	☐	☐	☐
9.7	Sind die Produktionsmaschinen des Unternehmens in der Lage selbstständig miteinander zu kommunizieren bzw. Informationen auszutauschen? (M2M-Kommunikation)	1 – 5 (Nicht in der Lage – Sehr gut in der Lage)	☐	☐	☐	☐	☐
	Werden in Ihrer Produktion Auto-ID-Technologien (z.B.						

Implementation Projects



Q&A?

- Any question so far?
- Next Lecture: 14.03.2023
- Question of the next Day:
- Why we should manage knowledge in I4.0?
- What is a Digital Twin?

chnology for People!

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