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Context-Aware Knowledge Management for Socio-Cyber-Physical Systems:
New Trends towards Human-Machine Collective Intelligence

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SPIIRAS' Location

SPC RAS

Speaker

SPC RAS

Alexander V. Smirnov, Professor, Dr. habil., PhD

- **Head of Computer-Aided Integrated Systems Laboratory, *SPIIRAS*** (1996); from July 2020 is a part of SPC RAS
- **Head of International Laboratory on Intelligent Technologies for Socio-Cyber-Physical Systems, *ITMO University*** (2014), and Founder of Joint Master Program on Business Informatics between ITMO University and Rostock University (Germany).
- Member:
  - IEEE SMC TC on Cyber-Physical Cloud Systems,
  - IEEE SMC TC on Cognitive Situation Management,
  - IFAC TC 5.1 on Manufacturing Plant Control,
  - IFIP TC WG5.1 on Global Product Development for the Whole Life-Cycle.
- Fellow of the European Academy on Industrial Management.

Prof. Smirnov' Team Current Research Projects in the Area of Digital Business: Main Directions

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- **Information & Knowledge Management** (projects of **Festo, Germany**; Ford Motor Company, USA; Russian Ministry of Science & Higher Education; Russian Science Foundation; Russian Foundation for Basic Research):
  - **Context-Aware Knowledge Management;**
  - **Ontological Modelling of Socio-Cyber-Physical Systems;**
  - Infomobility;
  - **Context-Oriented Collective Interaction of R&D Expert Networks.**
- **Decision Support** (projects of **Russian Science Foundation**; Russian Foundation for Basic Research; Russian Academy of Sciences):
  - **Decision Support Models & Methods Based on Human-Machine Collective Intelligence and Human-Computer Cloud;**
  - Proactive & Context-Aware Recommendation Systems.
- **Human-AI-Robot Teaming** (projects of Russian Foundation for Basic Research; Russian Academy of Sciences; Festo):
  - Context-Driven Robot Coalition Formation and Control:
  - Customer-Oriented Robot Configuration.

Presentation Outline

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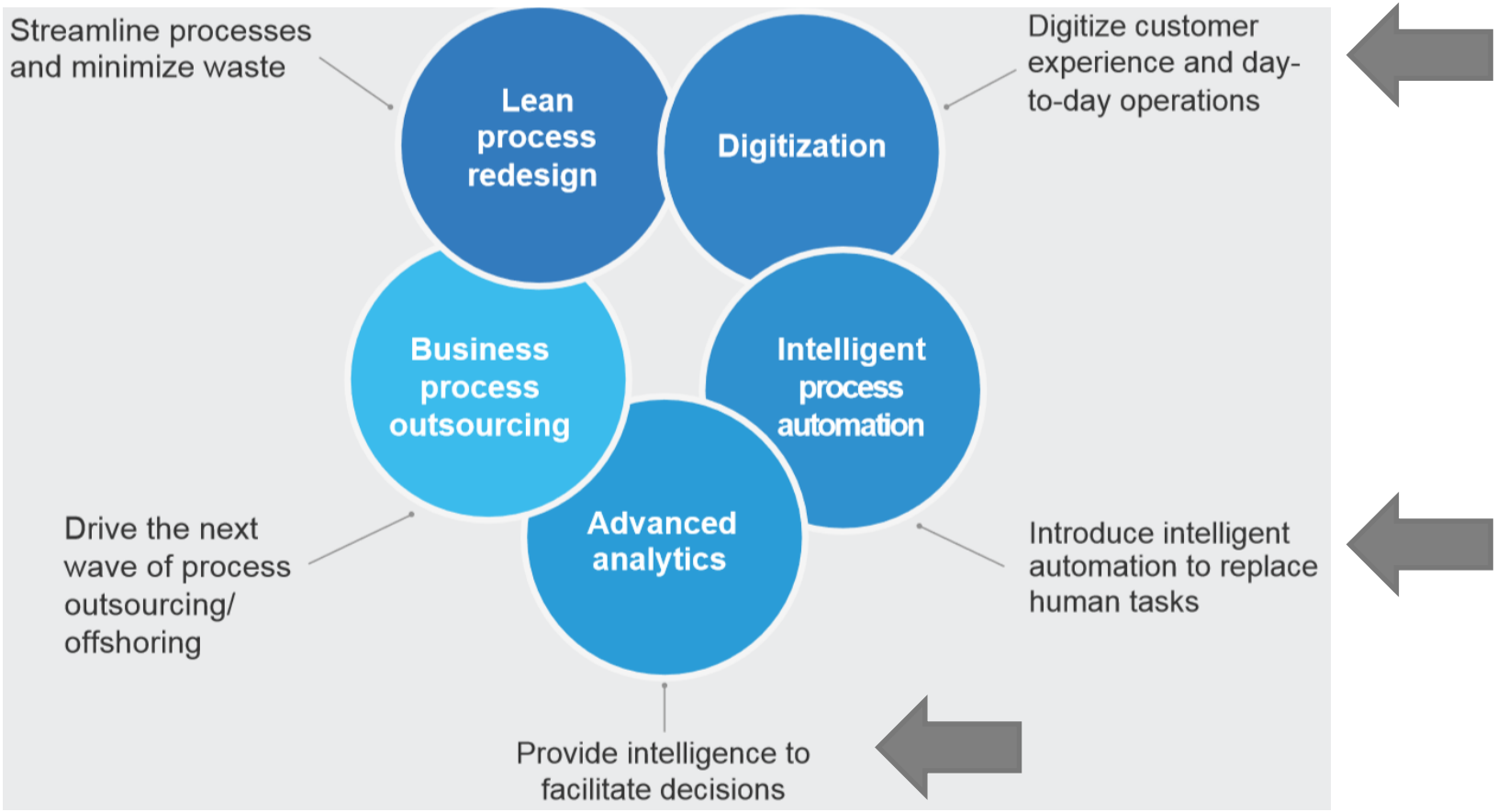
- **Introduction**
- Knowledge Management (in Industrial Automation):
  - Trend 1 “Role-Based Organization”
  - Trend 2 “Dynamic Motivation”
  - Trend 3 “Multi-Aspect Ontology”
- Human-Machine Collective Intelligence
- Conclusion and Future Work

Modern Operating Model for Digitalization



Source: The next-generation operating model for the digital world. A. Bollard, E. Larrea, A. Singla, and R. Sood. Digital McKinsey, 2018

Digital Business

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- *Digital business* is the creation of new business designs by blurring the digital and physical worlds. Digital business promises to usher in an unprecedented *convergence of people, business, and things that disrupts existing business models.*

  Source: http://www.gartner.com/digital-business

- *Digital business is built on* new computing infrastructure – the pillars of *mobile, cloud, Big Data, and analytics* – accelerated *by the Internet of Things (IoT),* advances in *machine learning & AI*, and innovations like *blockchain*.

  Source: https://www.sap.com/trends/digital-business.html

Cyber-Physical and Socio-Cyber-Physical Systems

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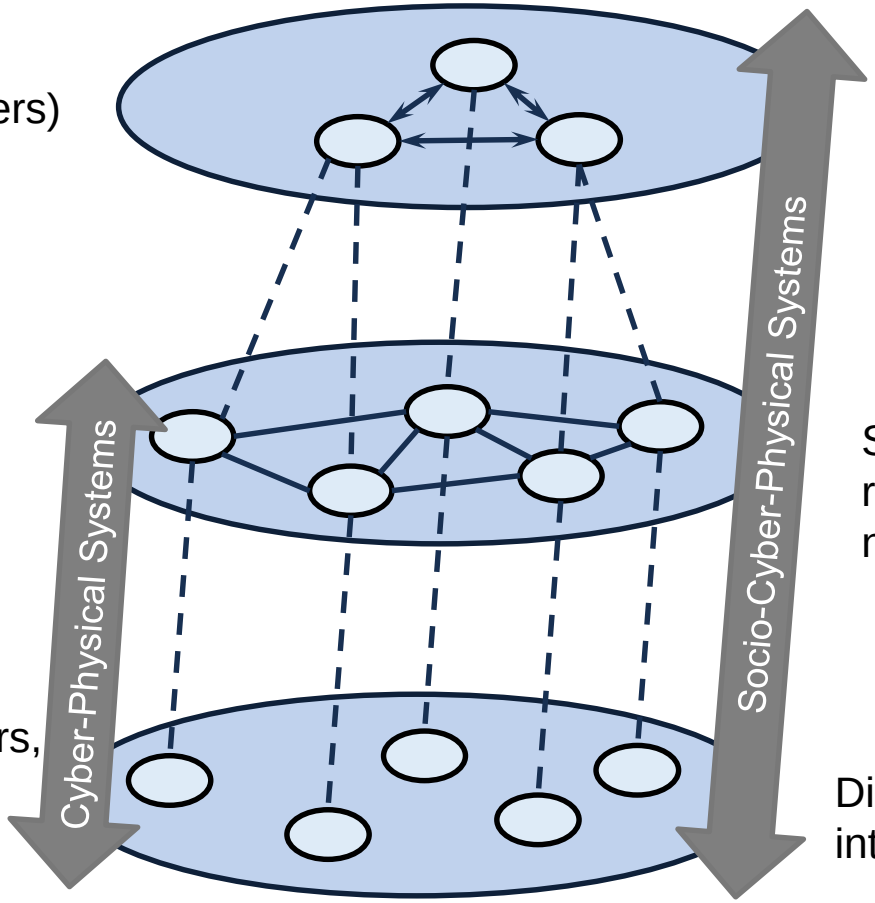
People
(decision makers)

Networks
(interrelated
objects and
services)

Real-world objects (cars,
electronic devices,
etc.)



Human
behavior aspects

Self-configuration of
resources and service
networks

Digitalization and
intellectualization

Network-Wise Modern Socio-Cyber-Physical Systems: Networks & Supported ITs

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- Social networks: who knows whom => Virtual Communities;
- Knowledge networks: who knows what => Human & Knowledge Management;
- Information networks: who informs what => Internet/Intranet/Extranet/Cloud;
- Work networks: who works where => Decision Support based on Crowdsourcing and Recommendation Systems;
- Competency networks: what is where => Knowledge Map;
- Inter-organizational network: organizational linkages => Semantic-Driven Interoperability.

Cognitive Manufacturing / Industry 4.0

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Cognitive manufacturing—also known as smart manufacturing or ***Industry 4.0*** - uses cognitive computing, the Industrial IoT, and advanced analytics to optimize manufacturing processes in ways that were not previously possible.

Cognitive manufacturing is powerful because it combines sensor-based information with machine learning and other artificial intelligence capabilities to find patterns in structured and unstructured data from plant, enterprise and industry systems.

Key Issues Cognitive Technologies Address for Manufacturers:

- Solving business challenges;
- Creating new value from manufacturing data;
- Improving product quality;
- **Enhancing knowledge management**.

Source: Cognitive Manufacturing: An Overview and Four Applications that are Transforming Manufacturing Today (https://www.ibm.com/downloads/cas/VDNKMWM6)

Industrial Intelligence

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- **Industry 4.0 = Industry 4.0 Technologies** (IoT, blockchain, etc.) **+ Industrial Intelligence**.
- **Industrial intelligence is the alliance of artificial intelligence with automation** and energy technology, IT platforms and intralogistics.
  - **Industrial intelligence** can only play its part in **driving the digital transformation** if people have the requisite qualifications to combine all these aspects in a useful way and develop them further. It is crucial that experts from a huge range of fields collaborate much more closely than in the past.
- **Industrial intelligence stands on** two pillars:
  - technology,
  - **knowledge management (based on qualifications and process expertise of people).**

Source: "INDUSTRIAL INTELLIGENCE" - THE NEXT BIG STEP (https://vdmaimpulse.org/article/-/article/render/210089)

Facts about Knowledge Management (1/3)

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- "**A traditional knowledge management (KM) project** was usually a centralized effort to organize resources and content via taxonomies, cumber some e-forms and repositories, and complex review processes. It **missed the point** that knowledge resides with ***people*** and, especially in complex situations, is difficult to access and use without ***collaboration and context***."

  Source: Rozwell, C. (2012). Socialization of Knowledge Management Drives Greater Reuse. Retrieved from Gartner website: http://www.gartner.com/id=2046916

- Many KM leaders agree that **a successful KM implementation is 20% technology and 80% people**, and ***includes management, incentives, culture, and communication***.

  Source: Rozwell, C. & Mann, J. & Drakos, N. (2012). Knowledge Management Projects With Focused Objectives Deliver Most Value. Retrieved from Gartner website: http://www.gartner.com/DisplayDocument?doc_cd=235797&ref=ddisp

Facts about Knowledge Management (2/3)

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- **Knowledge sharing** can be defined as the "***exchange of knowledge*** *between and among* ***individuals***, and *within and among* ***teams***, organizational ***units***, and ***organizations***".

  Source: Schwartz D., Encyclopedia of Knowledge Management, 2006.

- Consider that **70-90% of corporate *knowledge is informal*** ("any unwritten information **that is known within an organization unit but often unknown outside of it**"), with the vast majority occurring within local workgroups and never shared across multiple inter-related functions.
- **Knowledge workers spend 15 - 30% of their time seeking specific information and these searches are successful less than 50% of the time.**

  Source: Harnessing Your Tribal Knowledge: Creating a more productive organization through systematic knowledge capture and dissemination. http://www.informationweek.com/ whitepaper/Business-Intelligence/Knowledge-Management/ harnessing-your-tribal-knowledg-wp1260312372749

Facts about Knowledge Management (3/3)

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- **Less than 10% of the knowledge you need to do your job is in your head. The other 90% is in other peoples' heads.** A KM framework that features ***social technologies*** *gives us a tool by which to access the information that only resides in someone else's brain or memory.*

  Source: Cross, J. Working smarter in the enterprise [Web log post]. Retrieved from Jay Cross website http://www.jaycross.com/wp/2011/05/working-smarter-in-theenterprise-2/

- According to the McKinsey Global Institute, by **using social technologies**, companies **can raise the productivity of knowledge workers by 20 to 25 percent** *by improving collaboration and communication among and across teams.*

  Source: McKinsey Global Institute report, The social economy: Unlocking value and productivity through social technologies, https://www.mckinsey.com/industries/high-tech/our-insights/the-social-economy

Knowledge Management Strategies

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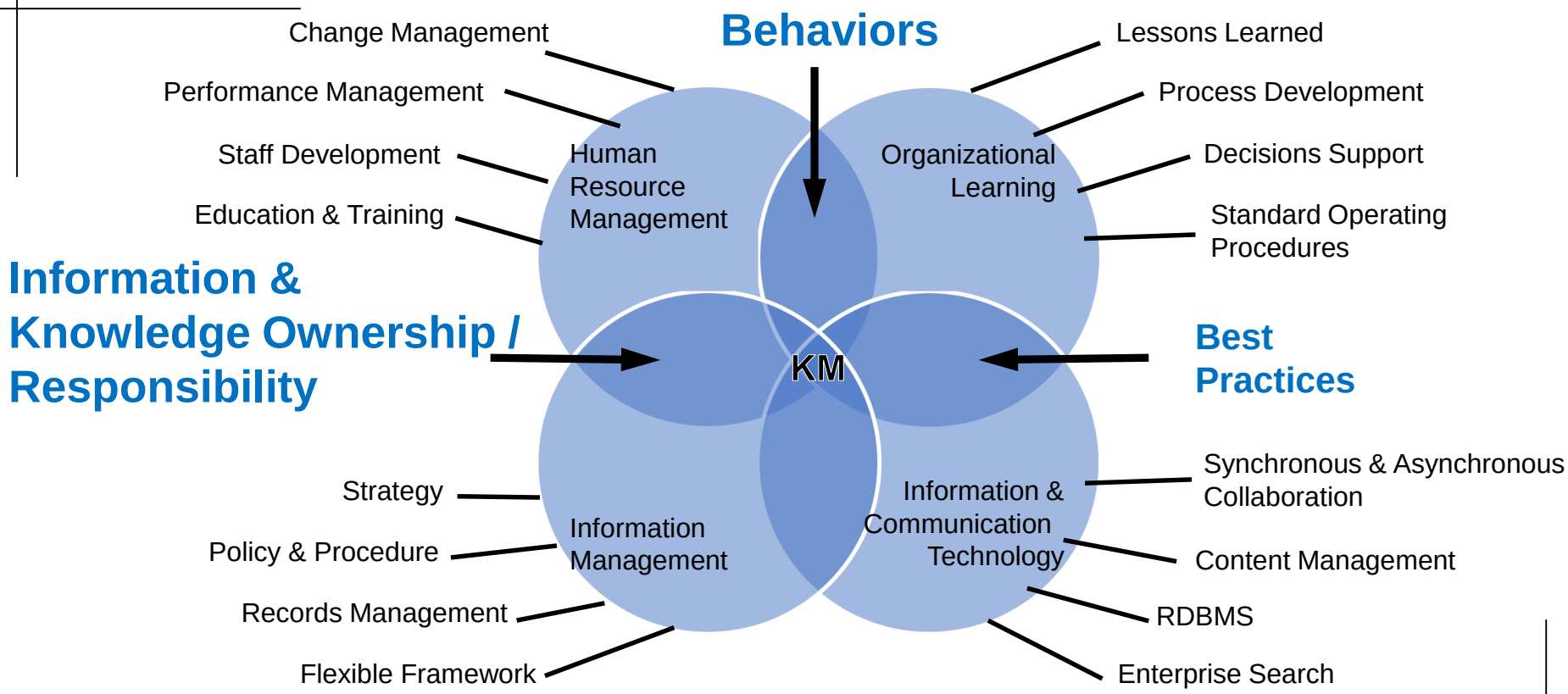
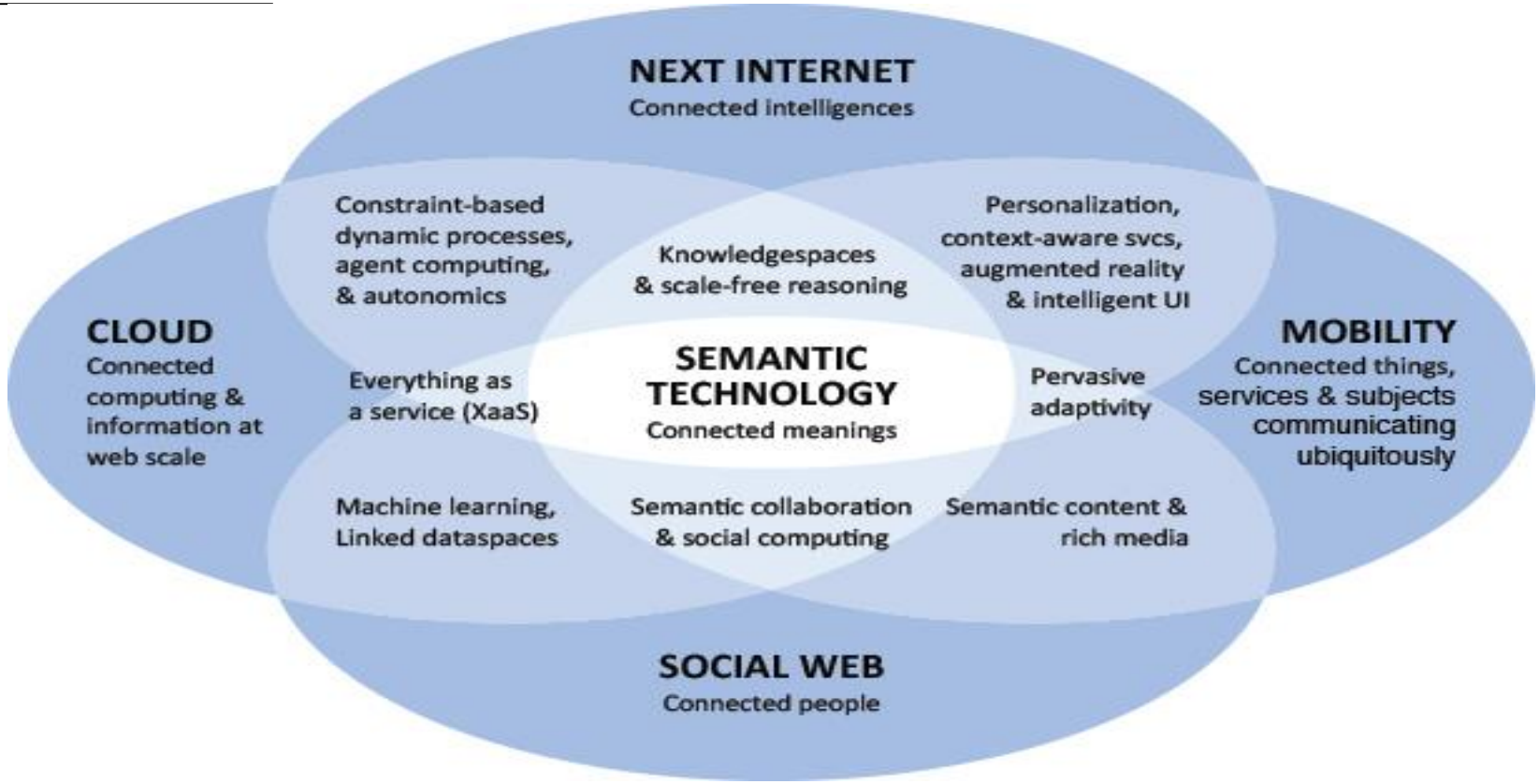


Information ownership and responsibility: The KM can provide devolved ownership and administration of information & knowledge assets to the divisions or units responsible for creating or managing those assets.
Behaviors: The use of the KM can promote the change of individual behaviors required to improve organization management.
Best Practices: The use of the KM can promote the use of best practices in everyday business.

Adapted from [Content Management in a Knowledge Management Context; http://www.prescientdigital.com/articles/content-management/content-management-in-a-knowledge-management-context]

Semantic Technology & Neighbors



- Semantic Technology allows the meaning of and associations between information to be known and processed at execution time
- For a Semantic Technology to be truly at work within a system, there must be a knowledge model of some part of the world (**an active ontology**) that **is used by** one or more **applications** at execution time.

Source: TopQuadrant

Context in Knowledge Management

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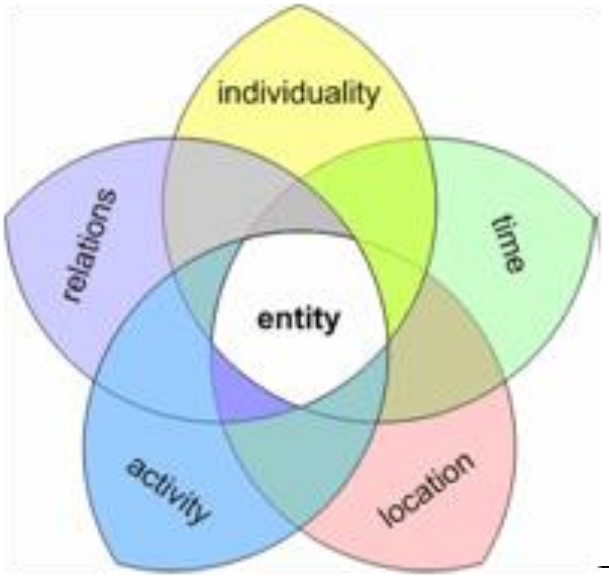
- 50% of the problems in the world result from ***people using the same words with different meanings.***

- the other 50% of the problems results from ***people using different words with the same meaning.***

Source: Kaplan S. The Words of Risk Analysis, *Risk Analysis*, Vol.17, N 4, August 1997

Fundamental categories for context information & knowledge



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Festo AG&Co KG as Use Case

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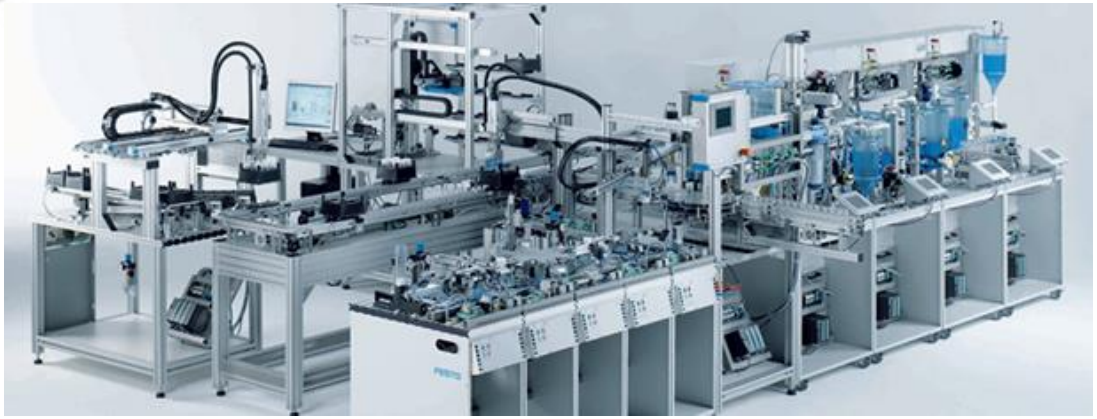
- **Festo AG&Co KG (2003-…) – “The best Digital Transformer of the Year 2019” in the “Industry and Technology” category in the core sectors of the German economy (Munich, March 2020).**
- more than 300 000 customers in 176 countries supported by more than 61 companies worldwide with more than 250 branch offices and authorized agencies in further 36 countries.
- pneumatic, electronic automation equipment and products for the process industry (> 30 000 catalog products)
- benefits for component manufacturers that tend to become system vendors in general.



Festo' Digitalization Framework and SPIIRAS Projects

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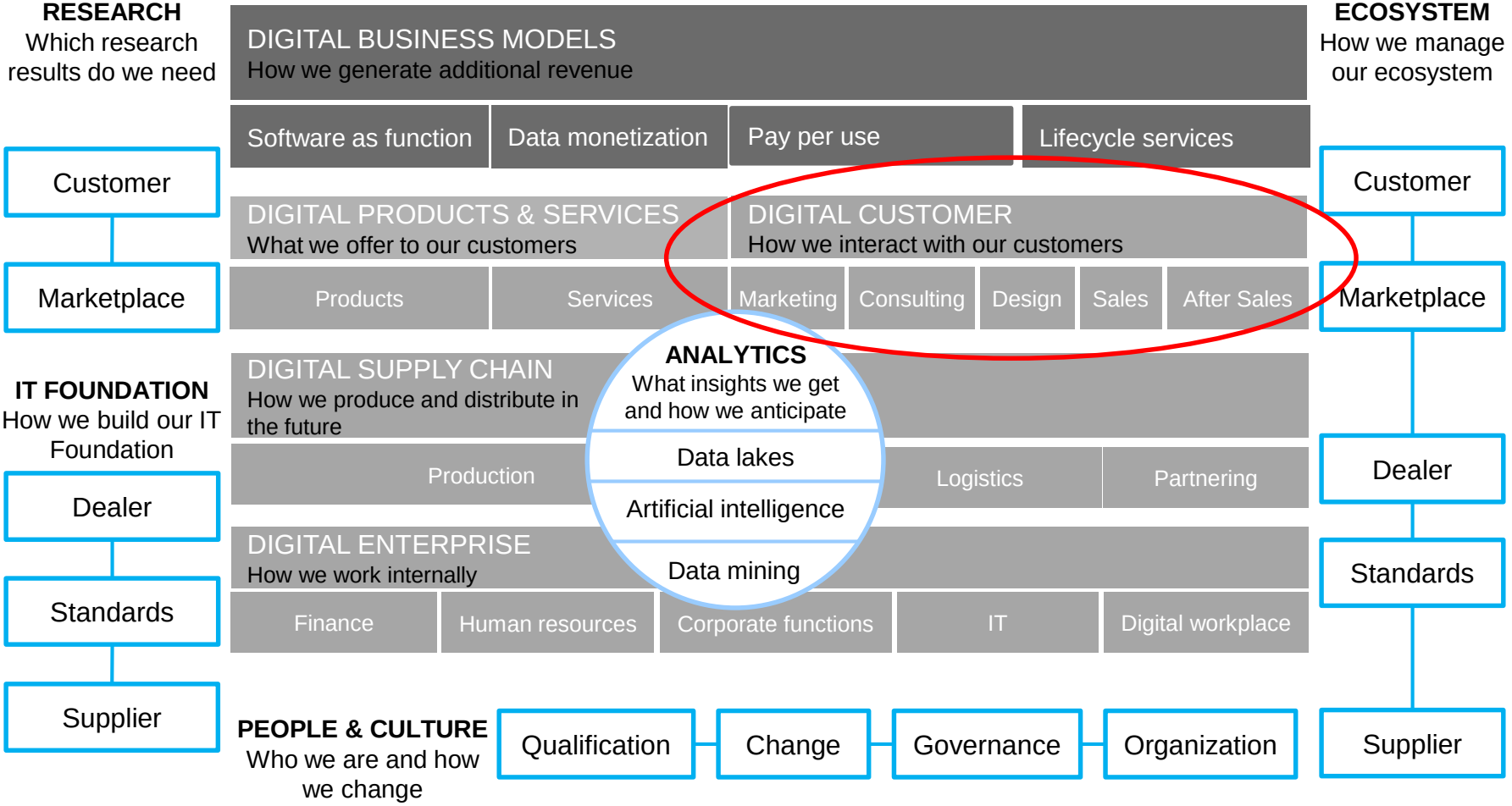

„Speed is the currency of Digitization" Andreas Oroszi, VP Digital Business

Sources: https://ru.pinterest.com/pin/342344009160980345/
https://twitter.com/WSWMUC/status/956670302272020480

Festo’ Viewpoint: Digital Customer Journey

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- Giving *customers comprehensive consultation in the virtual world* in future
- Customers' benefits
  - sales and consultation processes will be more continuous
  - the supply chain more transparent, more stable and safer
- Customers will be able to
  - configure their machinery more rapidly via a consistently structured digital interface
  - test their interaction and functioning in advance by means of simulation tools together with manufacturers and operators
- Embedded sensors in the products will warn against malfunctions or production stoppages before they can occur

- *The objective is to provide a **virtual solutions consultant** that bundles knowledge of our products and their interaction into a system and is at the disposal of customers and partners.*

(Gerhard Borho, member of the Festo’ Management Board)

Source: http://www.aerospacemanufacturinganddesign.com/article/festo-hannover-messe-digitalization-integrated-industries-33117/

Knowledge Logistics Approach (*proposed by Prof. A. Smirnov)*

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- Knowledge is critical core competency for future. ***Only 20% of a firm's knowledge is effectively used by today's organizations***.
- ***Different users (decision makers)*** of knowledge & information look at it from ***different aspects (contexts)***
- Distribution Channel (*Business Network*):
  - A Channel describes how a company gets in touch with its customers. Its purpose is to make the ***right quantities*** of the ***right products or services*** available at the ***right place***, at the ***right time*** to the ***right people*** (Pitt *et.al*., 1999)
- **Knowledge Logistics** Aim:
  - Acquisition, integration, and transfer of the ***right knowledge*** from ***right sources*** in the ***right context*** to the ***right person*** in the ***right time*** for the ***right purpose*** *(**Smirnov et al., 2003**)*

Sources:

- Pitt. L., Berthon P., and J.-P. Berthon (1999). Changing Channels: The Impact of the Internet on Distribution Strategy. Business Horizons, March-April.

- Smirnov A., Pashkin M., Chilov N., Levashova T. Haritatos F. (2003) Knowledge Source Network Configuration Approach to Knowledge Logistics. International Journal of General Systems, 2003, 32 (3), pp. 251—269.

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Festo' Product & Services Configuration: Multilevel Knowledge Management

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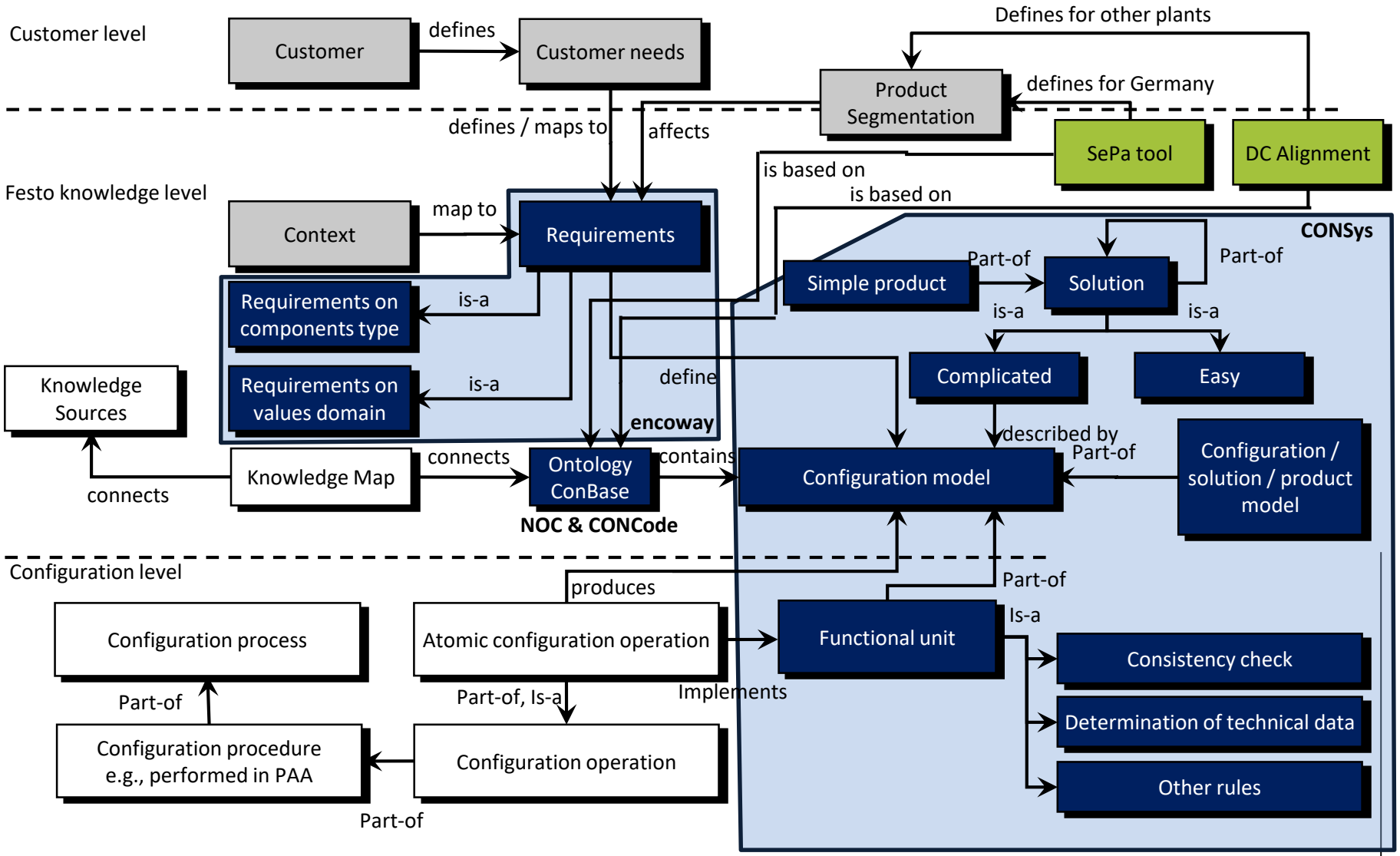

CONBase Ontology for Product Classification and Code Scheme

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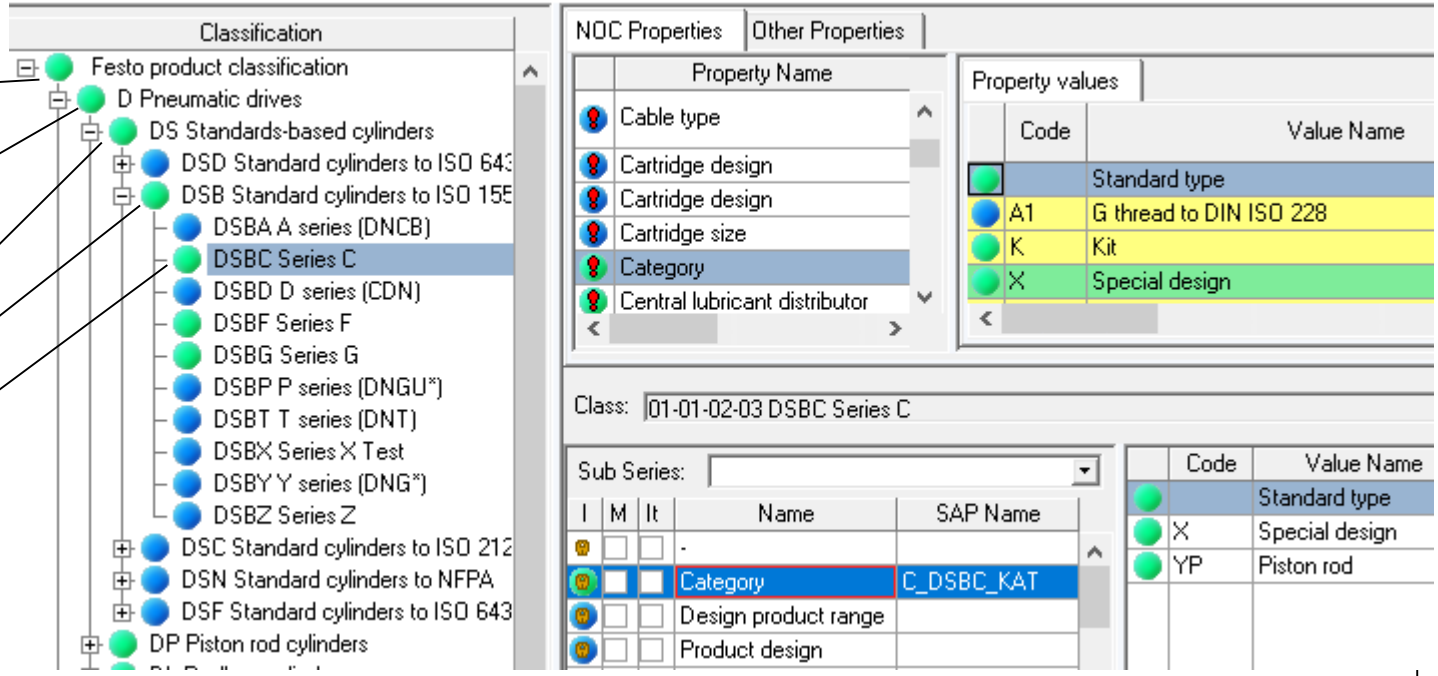
Classification (all products)

Product group

Product subgroup

Product segment

Product series



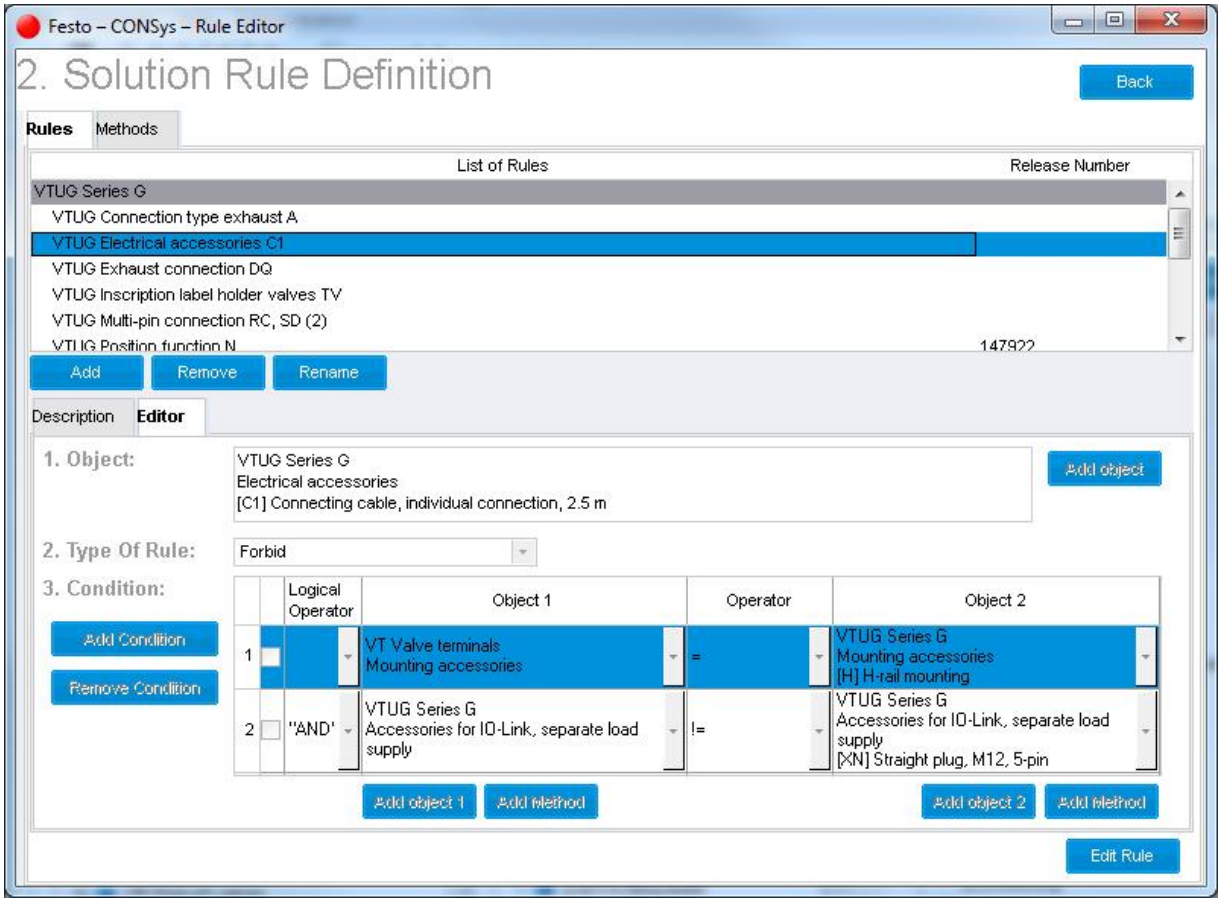
Specifications:

- initially is based on the VDMA classification (German Engineering Federation)
- 4 level taxonomy
- more than 2000 classes
- more than 2000 characteristics
- taxonomical relationships support inheritance

Ontology organization

- Configuration model
- Application data
- Product / system constraints
- Product data
- Product classification & characteristics

Complex Products Rule Example



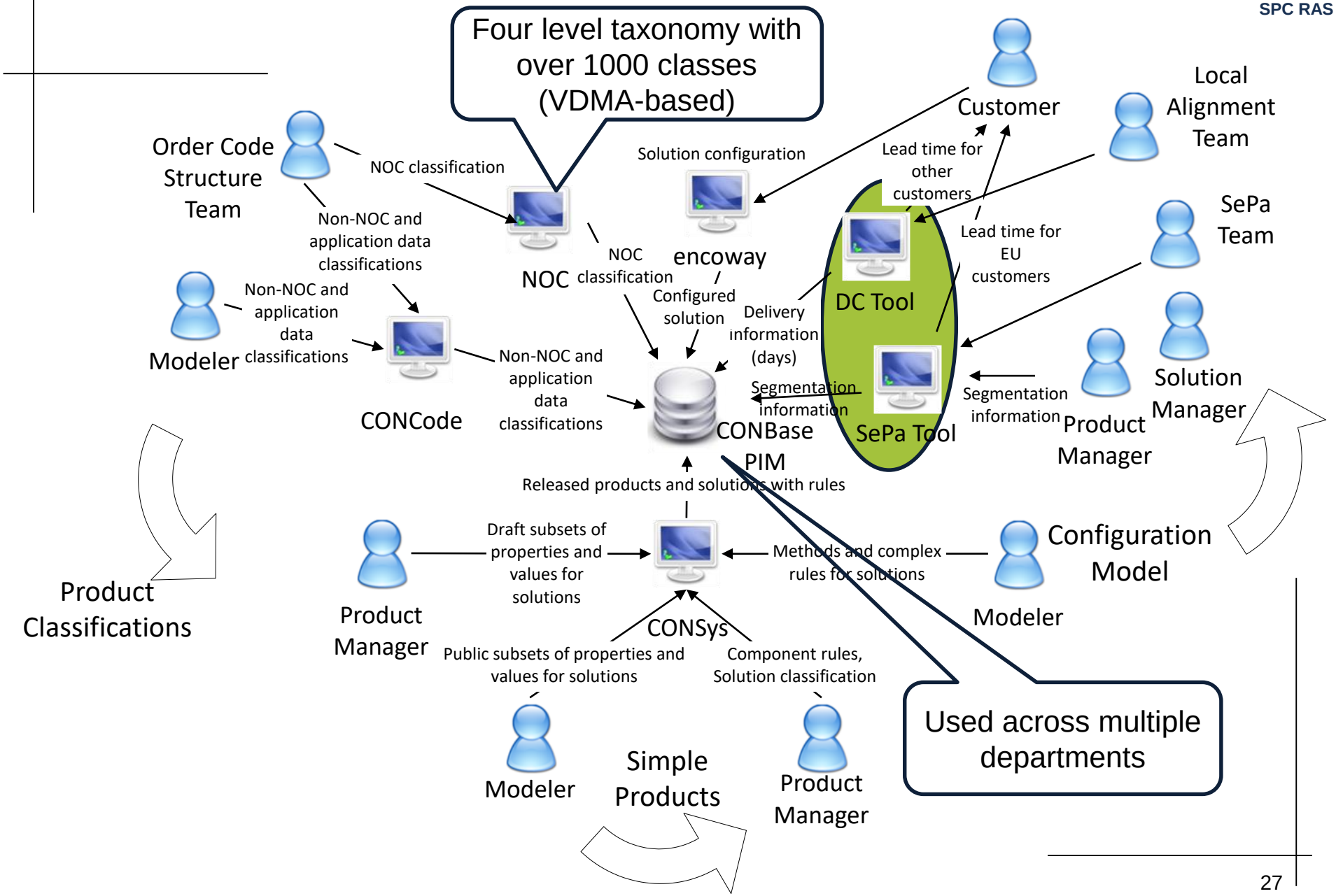
Valve terminal (VTUG) is not compatible with electrical accessories option C1 (individual connecting cable) if

- mounting accessories is H-rail mounting

and

- accessories for input-output link is not 5 pin straight plug M12.

Festo' Knowledge Management Organization



Role-based Perspectives of the Common Ontology

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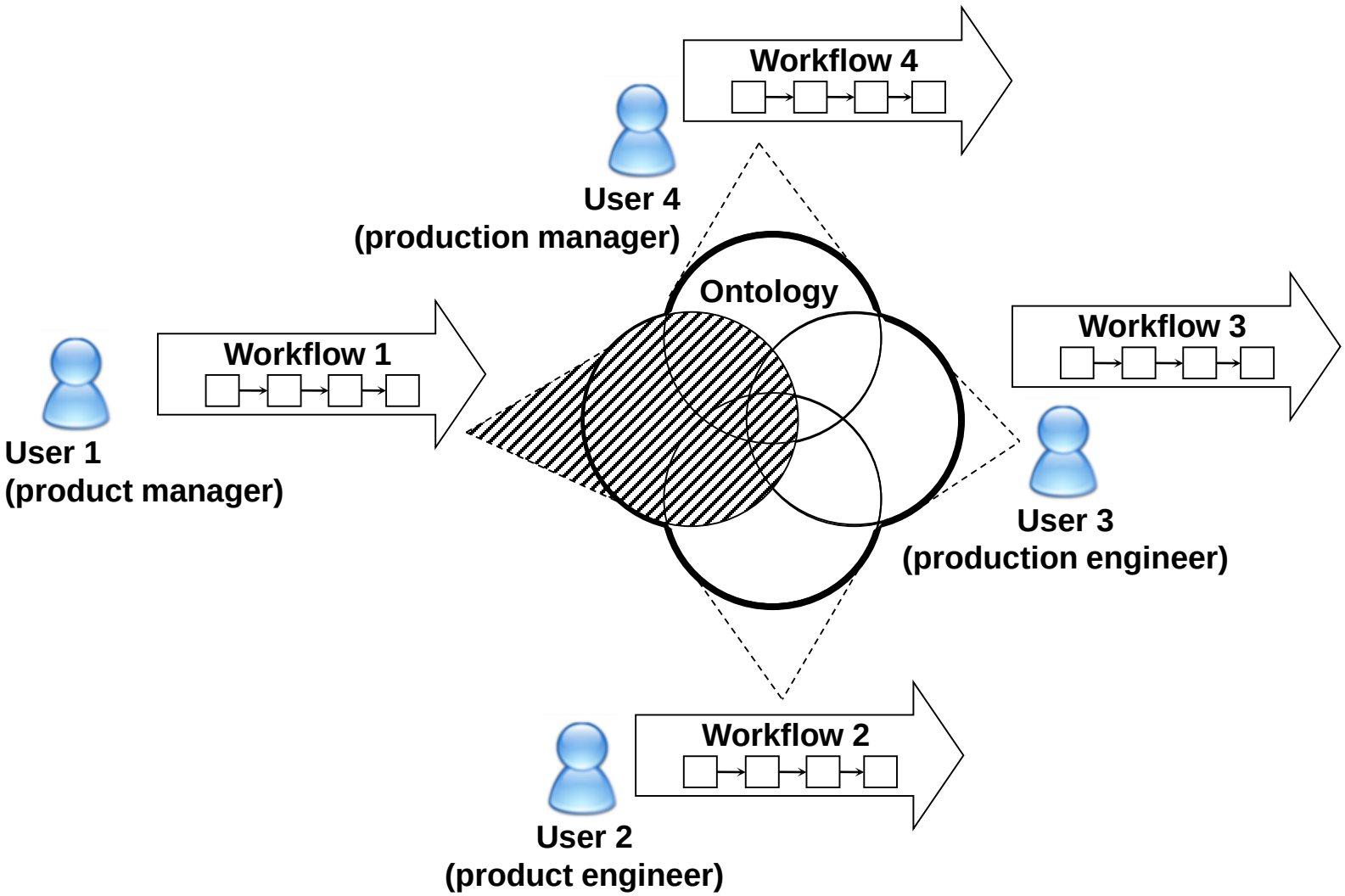

Role-based Knowledge Management (*Trend 1*): Major Ideas

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- **The different stages** of the PLM process in the company are **associated with different roles** like product managers, sales personnel or even customers.
- **Structural information** about workflows and the problem domain is collected and described **in the common ontology**.
- **User roles** are identified and their **relevant parts of the common ontology** are defined.
- **Tasks assigned to the identified roles** are defined.
- **Knowledge required for performing identified tasks** is defined.
- Based on the identified roles, tasks and knowledge, new **knowledge-based workflows** are defined.
- Corresponding **role-based knowledge support of the workflows** is provided based on the usage of the common ontology and knowledge / information storages.

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Knowledge Sharing in Expert Teams & Networks

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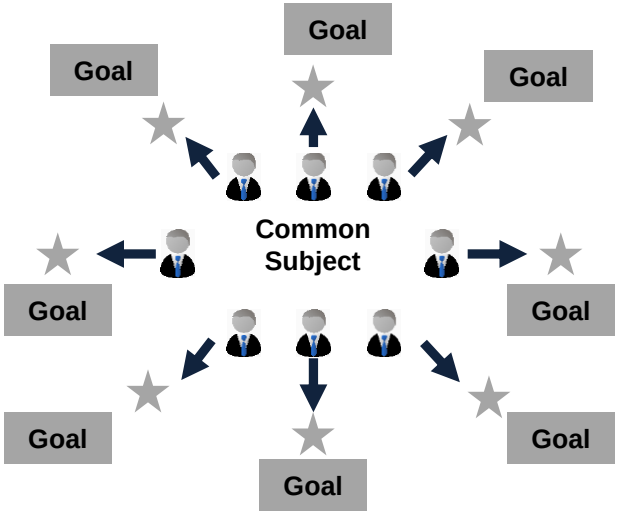
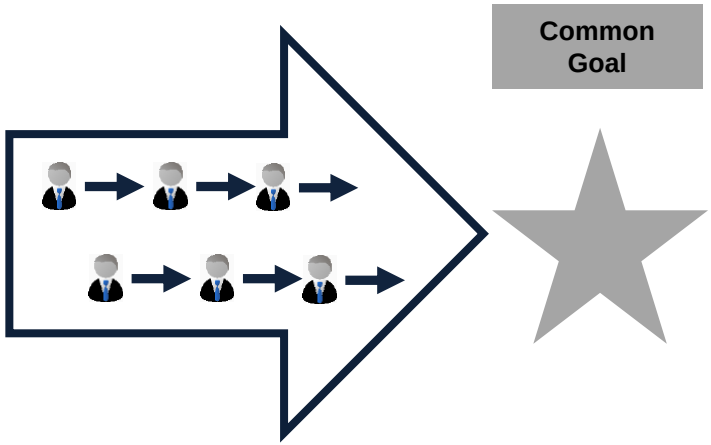
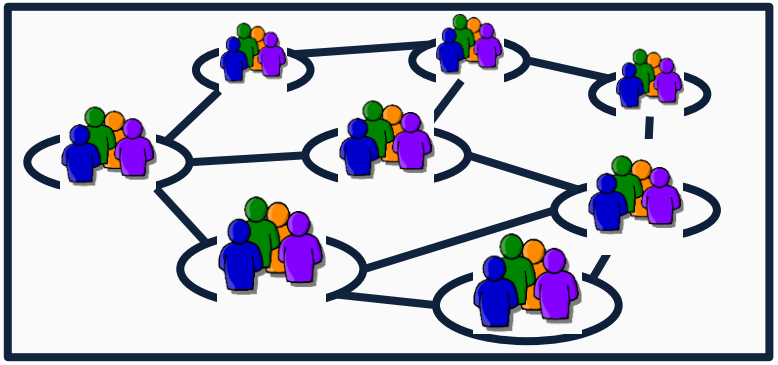


Common Subject => Functional Team



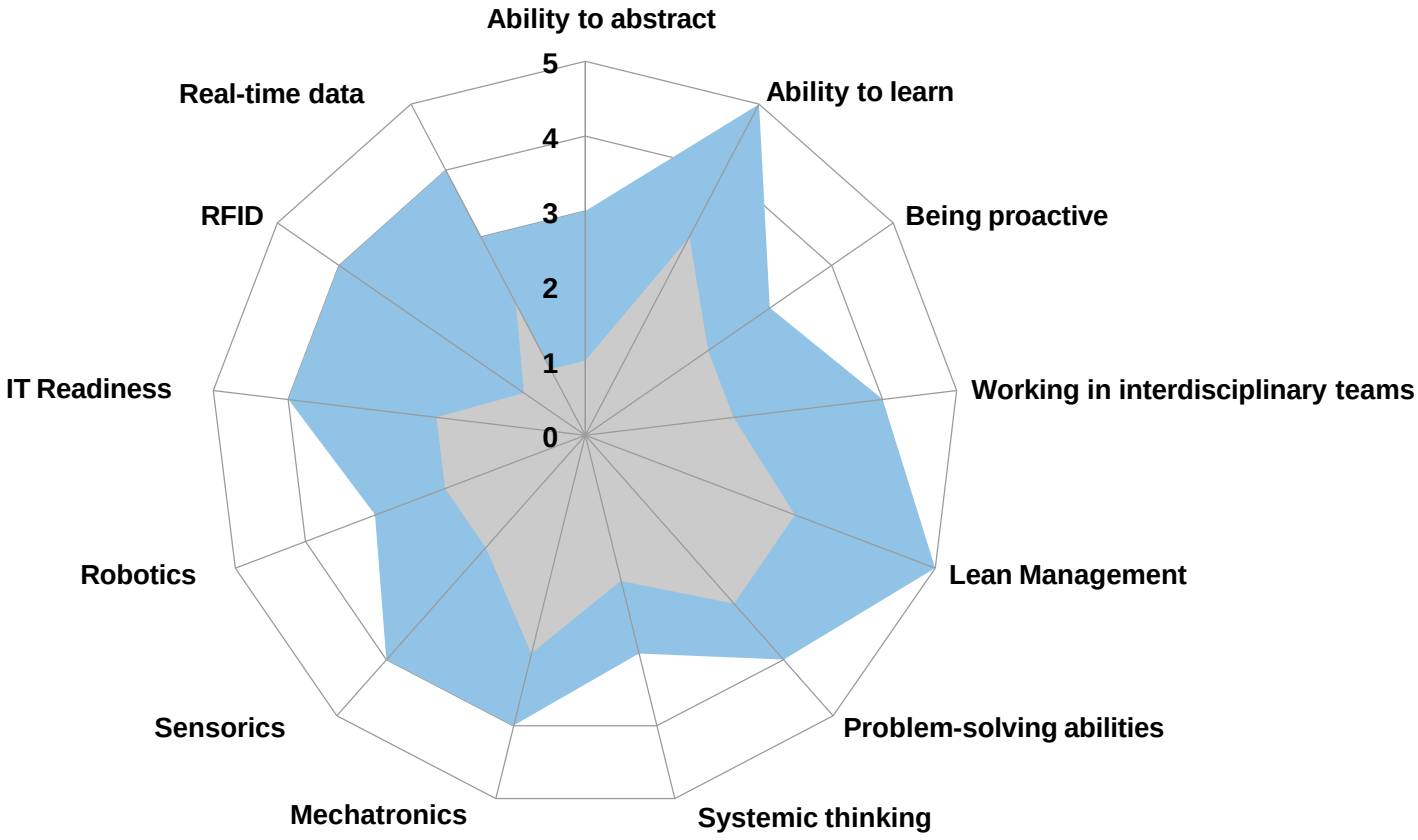
Common Goal => Goal-oriented (project) team

- Knowledge
- Competences



- Capabilities
- Ratings, etc.

Skills, Knowledge & Attitude



Gray = current competency
Blue = required competency for Industrie 4.0

Source: VDMA Competence fields

Some Personalization Aspects

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Motivation draws from research in *persuasive technologies* to further encourage adoption of behaviors. Major factors for persuasive technology *personalization*:

- *Age:* Older users are considered to rely more on social influence in their technology adoption than young ones. Younger employees tend to be more autonomous in their usage and adoption of IT.
- *Gender:* Women are motivated by immersion and social factors, while men are more achievement-oriented and display more competitiveness and need for winning than women.
- *Culture or nationality*: Europe and North America are highly individualistic cultures - foster competition and rivalry (such as leaderboards and points) have a great impact on one's engagement. In Asia (specially China) and other countries are low in individualism - the competitive aspect are not such a strong motivator.

Expert Collaboration–Based Business Process

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- Skill tree determination
- Expert profile description (competencies)
- Motivation list determination
- Task definition
- Expert group search for defined task
- Group working support
  - Chat
  - E-mail exchange
- Rewards assignment to experts

Skill Tree Determination

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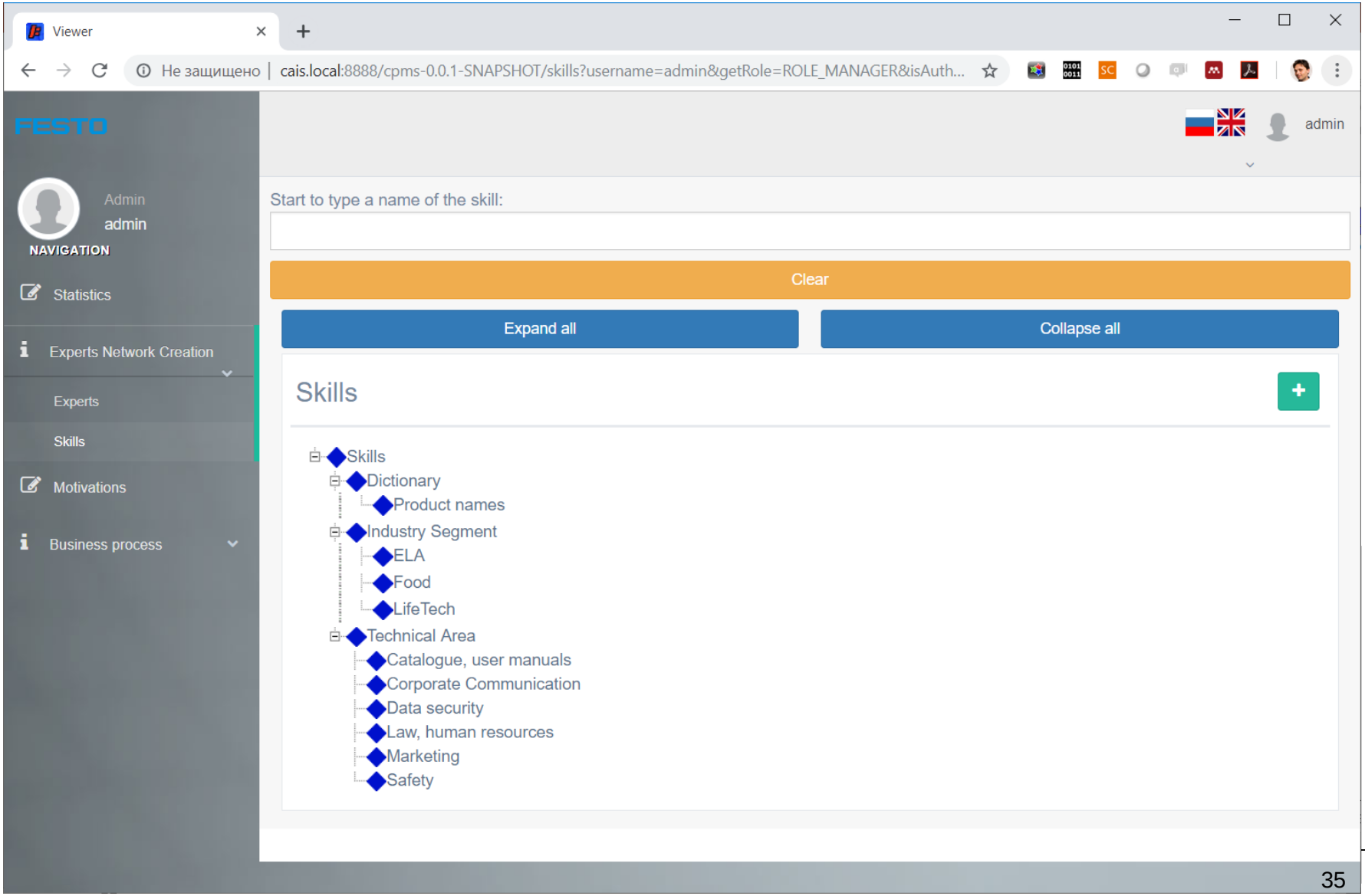

Expert Profile Description

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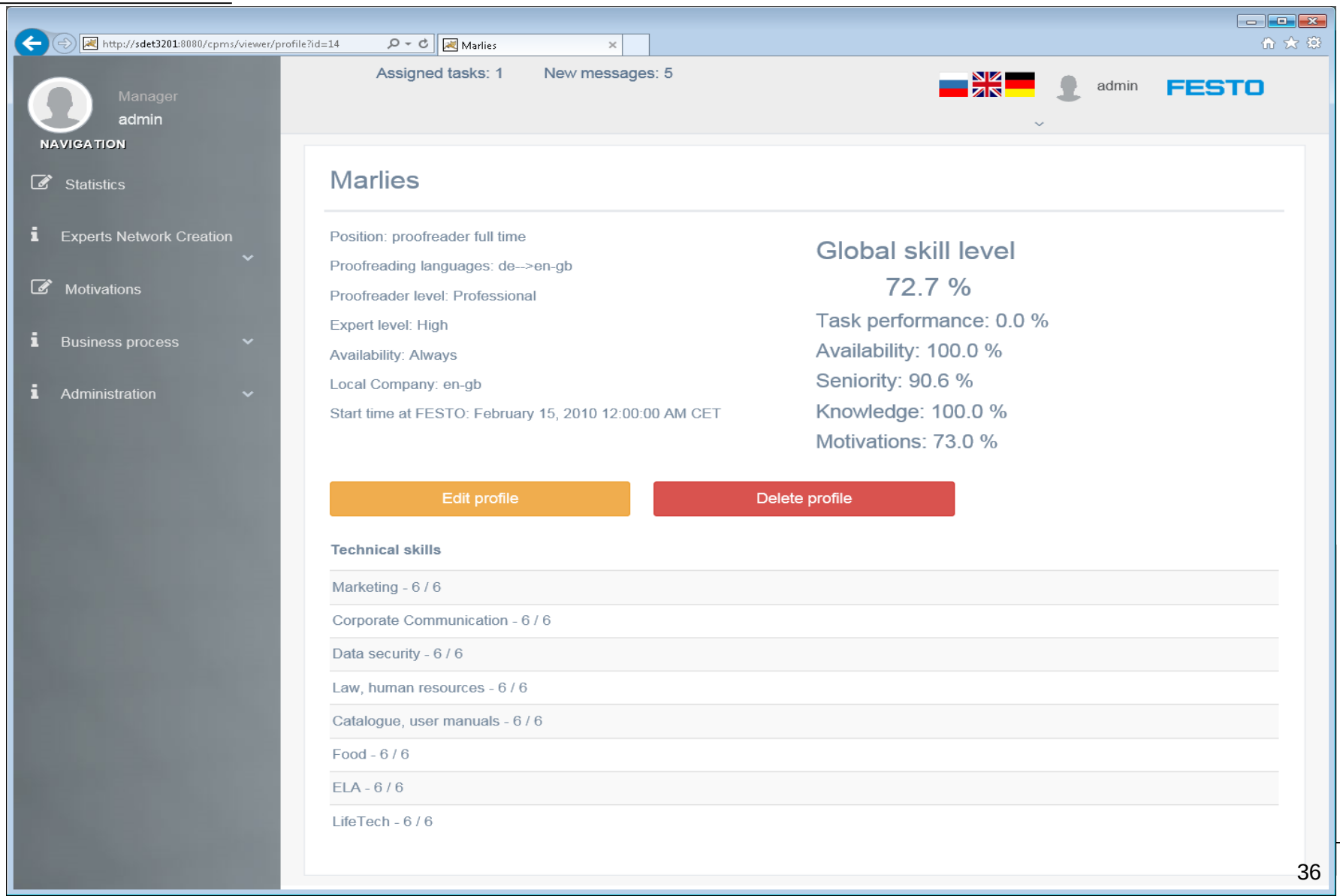

Motivation List Determination

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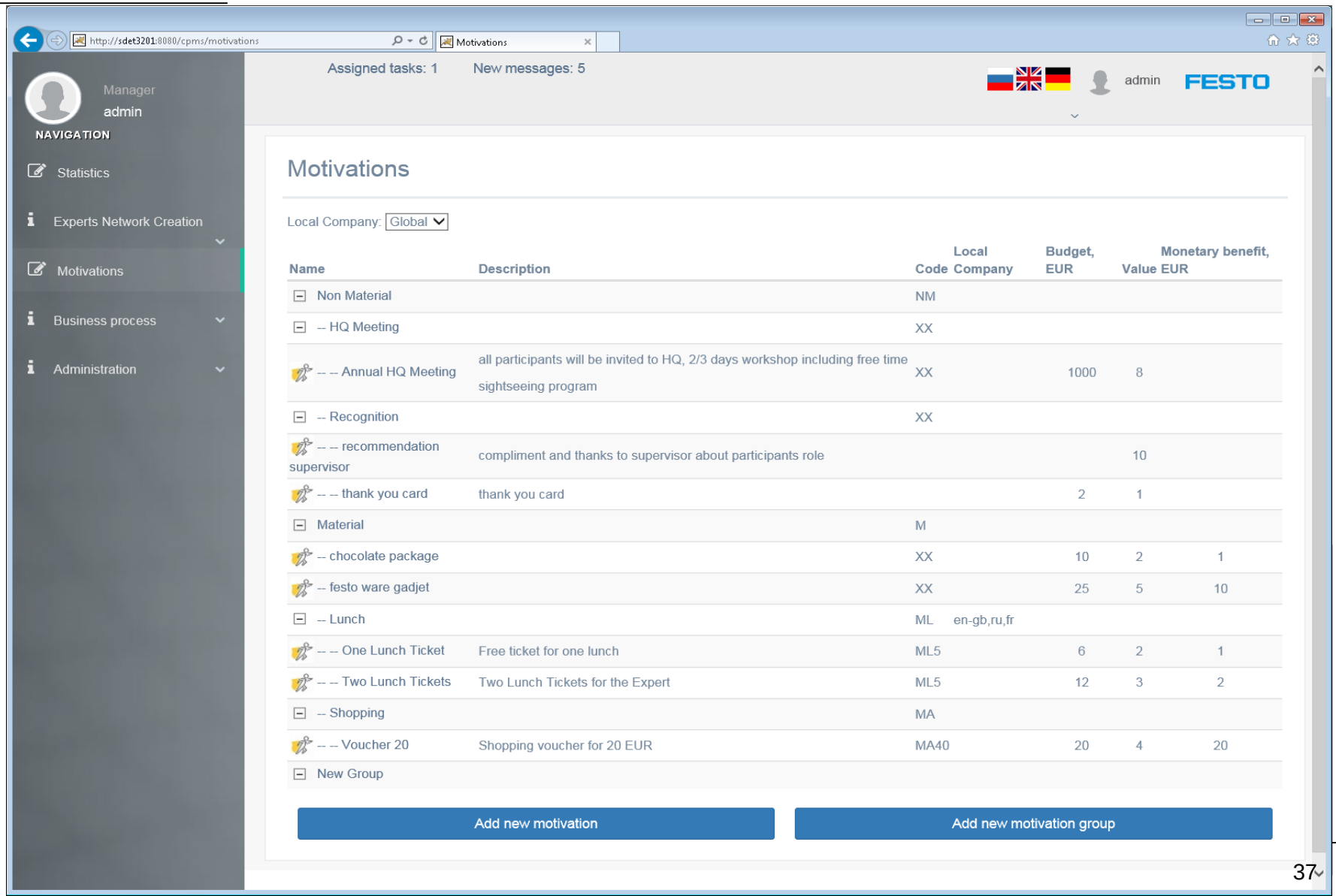

Project Definition. Expert Skill Matching

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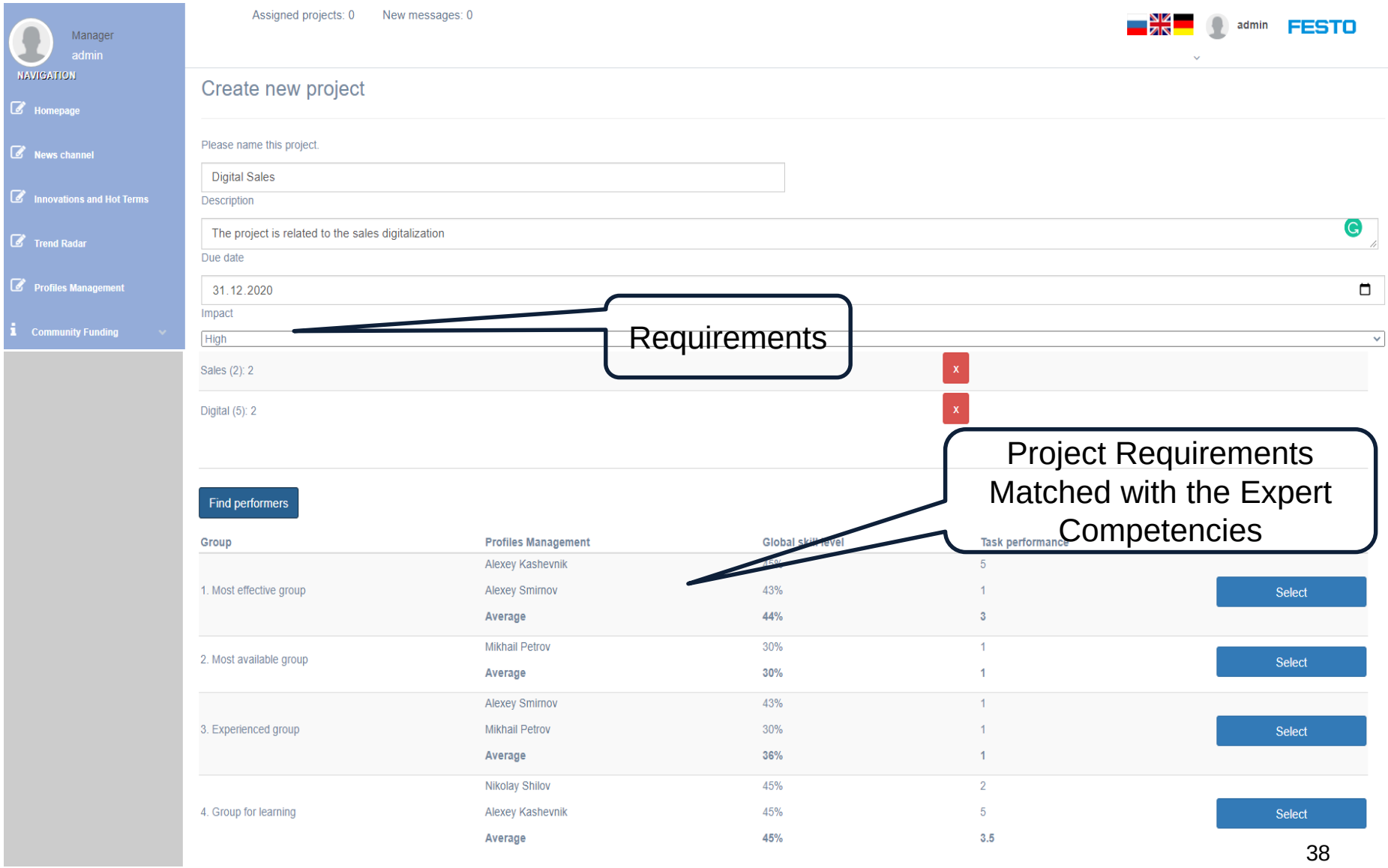

Knowledge Sharing based on Dynamic Motivation (*Trend 2*): Major Ideas

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- ***Knowledge worker (expert) activities*** are based on ***motivational factors*** related to cooperation & competition (as ***social influence strategies***).
- ***Decision makers (managers)*** within company could use or create ***different motivation strategies*** for their employees (knowledge worker) to join and compete for a victory.
- ***Company*** **has to use** ***different motivation strategies for different knowledge workers (roles) in different situations (context).***
- ***Company*** **has to use** ***for different expert teams*** (functional team and project team) ***different motivation strategies.***
- ***Company*** **has to use** ***different sets of KPI*** for evaluation of employees efficiency & quality ***(role-based motivation strategies).***

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Information Priority for Digital Customer Journey Stages

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Market evaluation	Engineering	Production	Sales	Maintenance	Phase out
Industrial Segment	Product Structure	Characteristics	Industrial Segment	Applications	Product Structure
Constraints	Characteristics	Constraints	Constraints	Product Structure	Characteristics
Characteristics	Constraints	Product Structure	Applications	Characteristics	
Product Structure		Applications	Characteristics	Constraints	
Applications			Product Structure		

- One stage (task) corresponds to one aspect.
- Different tasks of different workflows required application of different formalisms.
- These different views (aspects) have to be synchronized and matched by a formalized instrument supporting various processes of the company.

Multi-Aspect Ontology: MVP-OWL

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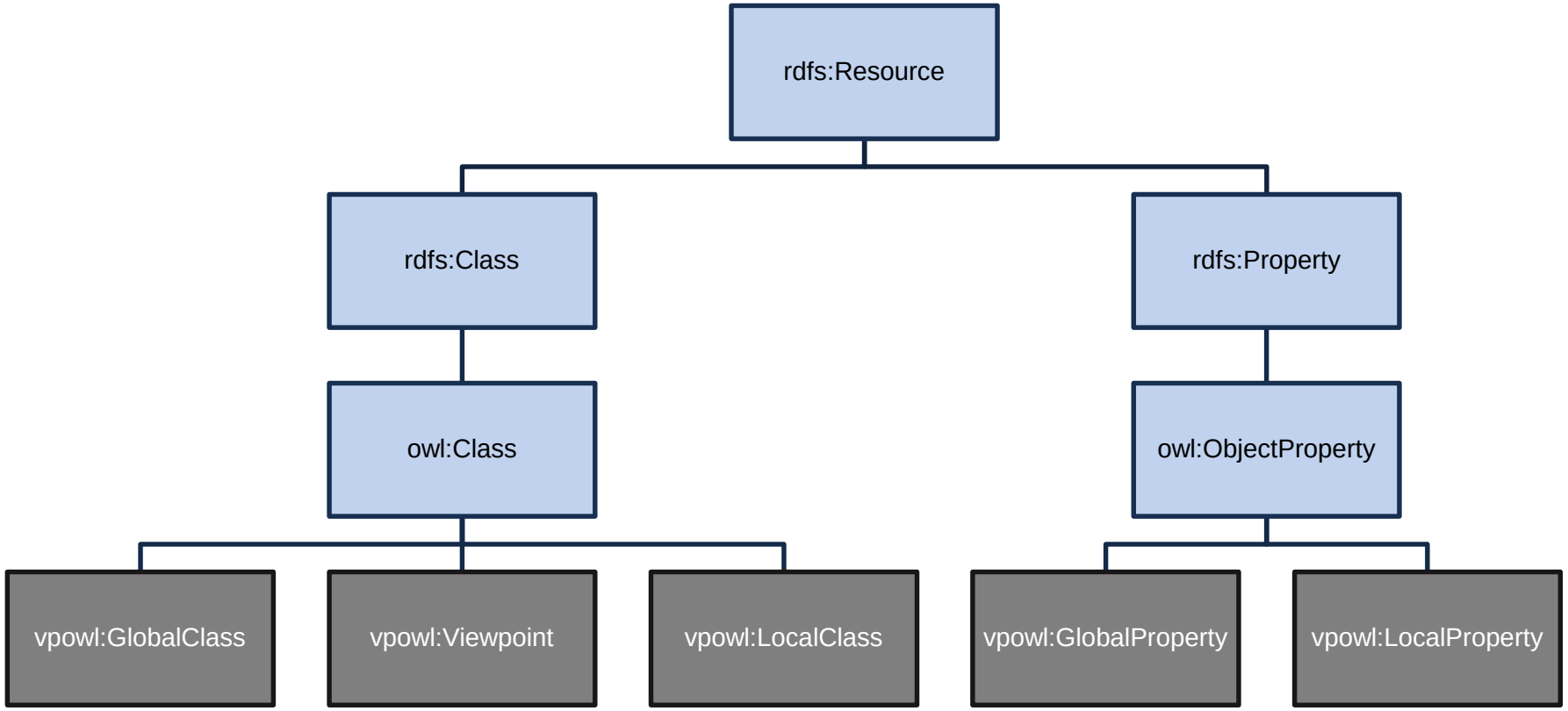


Source: Hemam M, Boufaïda Z (2011) MVP-OWL: a multi-viewpoints ontology language for the Semantic Web. Int J Reason Intell Syst 3:147.

Multi-Aspect Ontology: "Product Engineering" Aspect

SPC RAS

- Task: definition of a new product and its possible features
  - The product engineer needs a possibility to define new classes of products and new products with their possible features and feature attributes (e.g., *Cylinder XXX* is a subclass of *Pneumatic Cylinder* and has such features as "*diameter*", "*stroke*", "*lock in end position*", and others, that, in turn, have certain attributes).
- Formalism: *OWL*
- Example classes
  - "*Product Family*"
  - "*Product Group*" (subclass of *Product Family*)
  - "*Product*" (subclass of *Product Group*)
  - "*Feature*" (associated with the class *Product*)
- To ensure the consistency of product classes that is achieved via OWL and reasoning (the Pellet reasoner is currently used).

Source: Oroszi A, Jung T, Smirnov A, et al (2009) Ontology-driven codification for discrete and modular products. Int J Prod Dev 8:162–177.

Multi-Aspect Ontology: "Sales" Aspect

SPC RAS

- Task: definition of functional dependencies between parameters of products and their processing when a product or an assembly of products are being configured by/for a customer
- Formalism: *object-oriented constraint networks*
  - makes it possible to define functional dependencies (represented by constraints) between product parameters and then process these via a constraint solver when a particular product or a system is being configured
- Example classes
  - "*Product*"
  - "*Parameter*" (product parameter such as "*mass*", "*power*", etc.)
    - not the same as *Feature* in the "*Product Engineering*" aspect
  - "*Constraint*"

Source: Smirnov A, Kashevnik A, Teslya N, et al (2013) Knowledge management for complex product development framework and implementation. IFIP Adv Inf Commun Technol 409:110–119

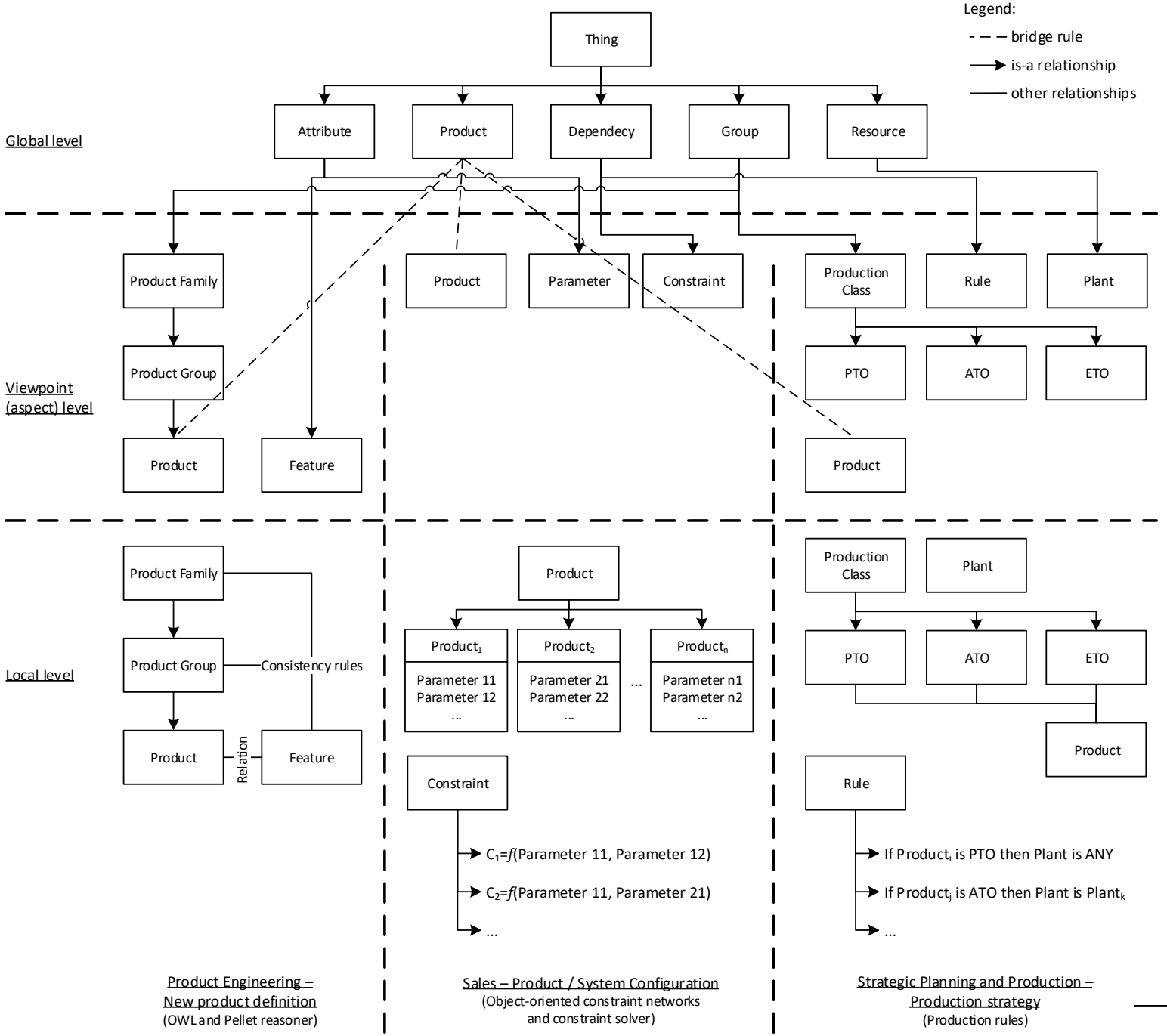
Multi-Aspect Ontology: “Strategic Planning and Production” Aspect

SPC RAS

- Task: definition of lead time for each product together with the plant, where it is to be produced
- Formalism: *production rules (if … then …)*
- Example classes
  - “*Production Class*”
  - “*Product*”
  - “*Plant*”
  - “*PTO*” (pick to order)
  - “*ATO*” (assemble to order)
  - “*ETO*” (engineered to order)
  - “*Rule*”

Source: Smirnov AV, Shilov N, Oroszi A, et al (2018) Changing information management for product-service system engineering: Customer-oriented strategies and lessons learned. Int J Prod Lifecycle Manag 11:1–18.

Multi-Aspect Ontology (a part)



Multi-Aspect Ontology: Major Ontology Elements

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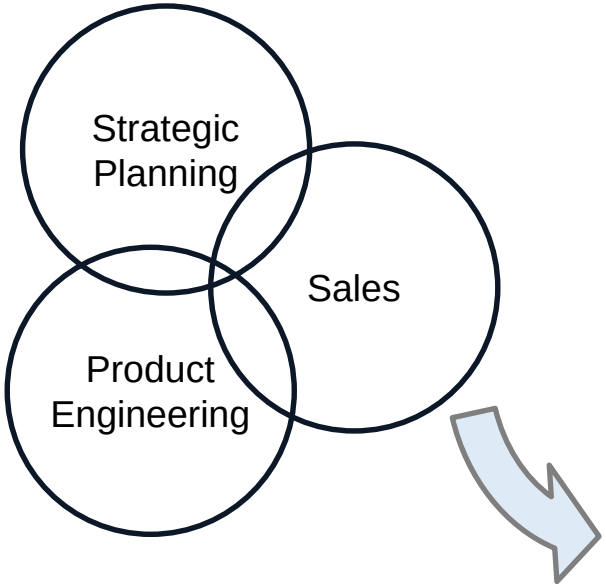
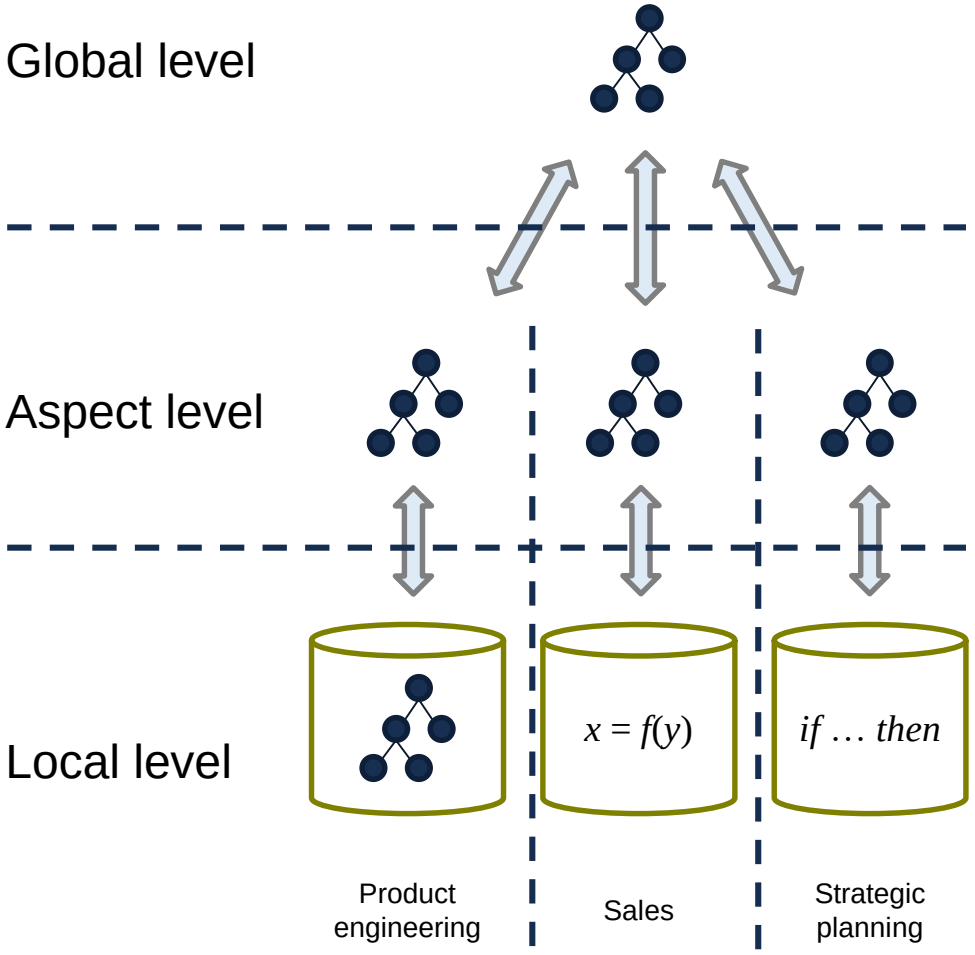
- Viewpoints (aspects)
  - *Product Engineering*, *Sales*, *Strategic Planning*
- Global classes
  - *Thing*, *Product, Attribute, Dependency, Group, Resource.*
- Local Classes:
  - *Product Engineering: Product Family*, *Product Group, Product, Feature*
  - *Sales: Product, Parameter, Constraint*
  - *Strategic Planning: Product, Production Class, Plant, Rule, ATO, ETO, PTO*
- Bridge Rules (bidirectional inclusion bridge rule: two concepts under different viewpoints are equal):
  - $Product \overset{\equiv}{\leftrightarrow} Product_{Sales}$
  - $Product \overset{\equiv}{\leftrightarrow} Product_{ProductEngineering}$
  - $Product \overset{\equiv}{\leftrightarrow} Product_{StrategicPlanningAndProduction}$

Multi-Aspect Ontology (*Trend 3*): Reference Model





Multi-Aspect PLM Ontology is represented by MVP-OWL *

Source: (*) Hemam M, Boufaïda Z (2011) MVP-OWL: a multi-viewpoints ontology language for the Semantic Web. Int J Reason Intell Syst 3:147.

Presentation Outline

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- Introduction
- Knowledge Management (in Industrial Automation):
  - Trend 1 “Role-Based Organization”
  - Trend 2 “Dynamic Motivation”
  - Trend 3 “Multi-Aspect Ontology”
- **Human-Machine Collective Intelligence**
- Conclusion and Future Work

More Human-AI Interaction Modes Lead to Better Results (Significant Financial Benefits)

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- Leaders haven't found just one way to structure and refine human-AI interactions.
- Leaders deploy multiple modes of human-AI interaction (***AI decides and implements; AI decides, human implements; AI recommends, human decides; AI generates insights, human uses them in a decision process; Human generates, AI evaluates***)**.**
- Organizations that successfully use all five modes are six times more likely to attain significant financial benefits than those able to use **just one (5%)** or two (6%).
- Companies gain the most when they increase their expertise from three-four (15%) to **five modes (32%).**
- Broader competencies allow organizations to fit a wider variety of interaction modes to a wider variety of situations (context).

Source: S. Ransbotham, S. Khodabandeh, D. Kiron, F. Candelon, M. Chu, and B. LaFountain, "Expanding AI's Impact With Organizational Learning," MIT Sloan Management Review and Boston Consulting Group, October 2020. https://sloanreview.mit.edu/ai2020

Modes of Human-AI Interaction

- **AI decides and implements:** In this mode, AI has nearly all the context and can quickly make decisions. Human involvement would only slow down an otherwise fast process.
- **AI decides, human implements:** AI can capture the context well and make decisions, but humans — rather than software or robotics, for instance — implement the solutions.
- **AI recommends, human decides:** This mode is appropriate when organizations must make a large number of decisions repeatedly and the AI can incorporate most but not all of the business context.
- **AI generates insights, human uses them in a decision process:** In this mode, inherently creative work requires human thought, but AI insights can inform the process.
- **Human generates, AI evaluates:** Humans generate many hypothetical situations but rely on AI to tediously assess many complex dependencies.

Source: S. Ransbotham, S. Khodabandeh, D. Kiron, F. Candelon, M. Chu, and B. LaFountain, “Expanding AI's Impact With Organizational Learning,” MIT Sloan Management Review and Boston Consulting Group, October 2020. https://sloanreview.mit.edu/ai2020

Human-Machine Collective Intelligence (HMCI): AI and CI

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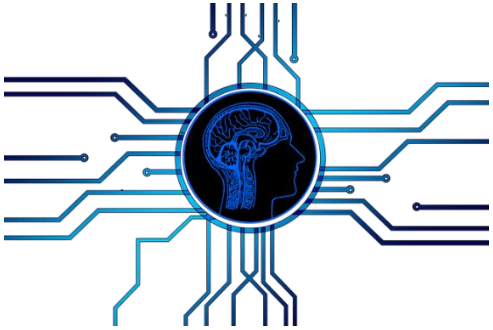
- Efficient organization of groups
- Complement actions of people
- Process human-specific data (e.g., emotions)



Collective Intelligence (CI)

Artificial Intelligence (AI)

- Interpretation of ambiguities and common sense
- Learning (active learning, by example)
- Verification for compliance with ethical principles

HMCI-Environment: Motivation and Goal

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- Decision support:
  - Interactive and iterative exploration of the problem
  - Uncertainty and the lack of data
  - Exact steps are not clear
- Decision support **requires *ad hoc* planning** of the low-level activities and should leverage self-organizing capabilities of the participants of the decision support process

<u>Goal:</u> to create *HMCI-Environment* supporting (and promoting) collective intelligence in the form of self-organisation of communities of the participants to solve common problem

HMCI-Environment: Major Challenges

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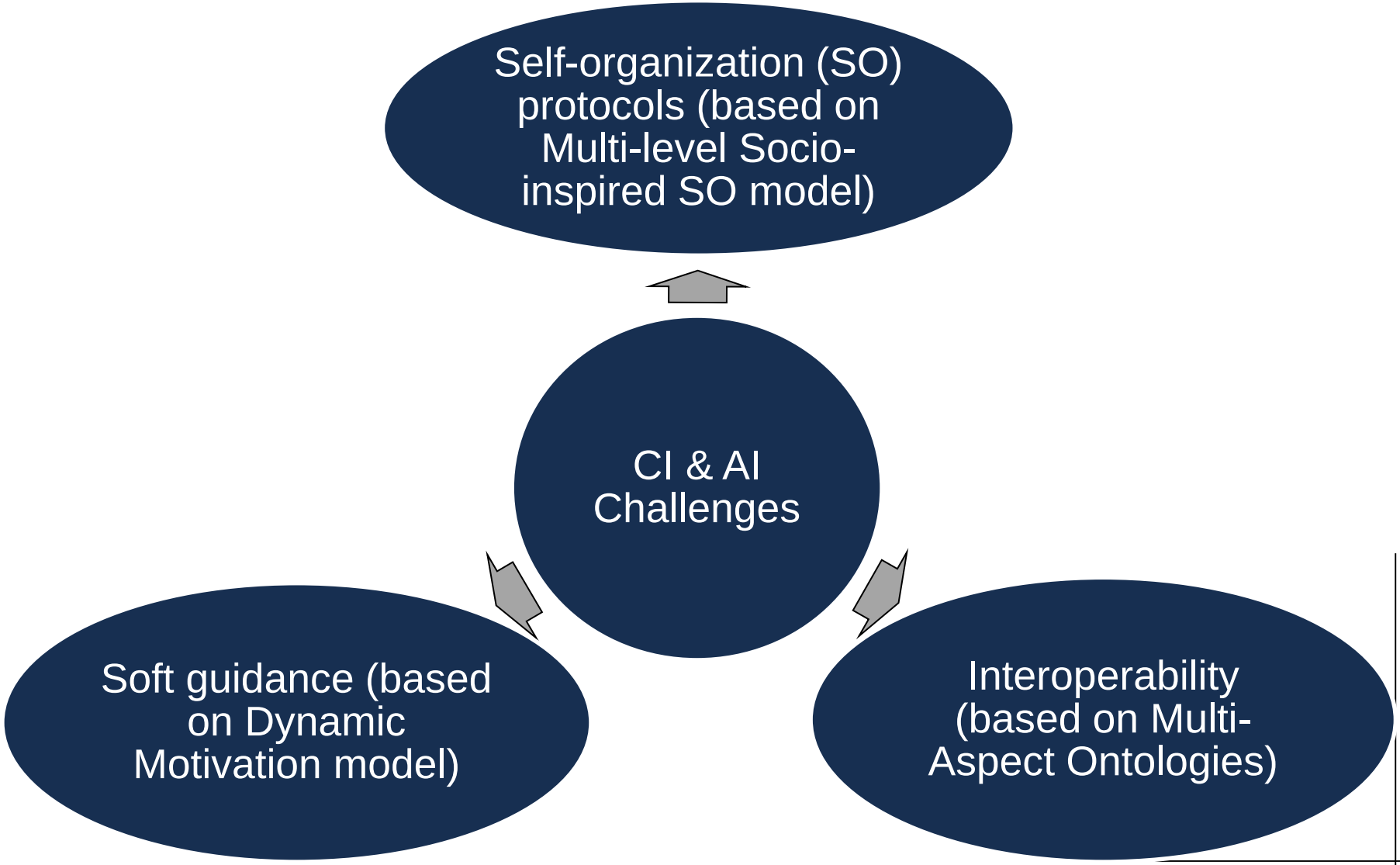

Theoretical Background: Requirements

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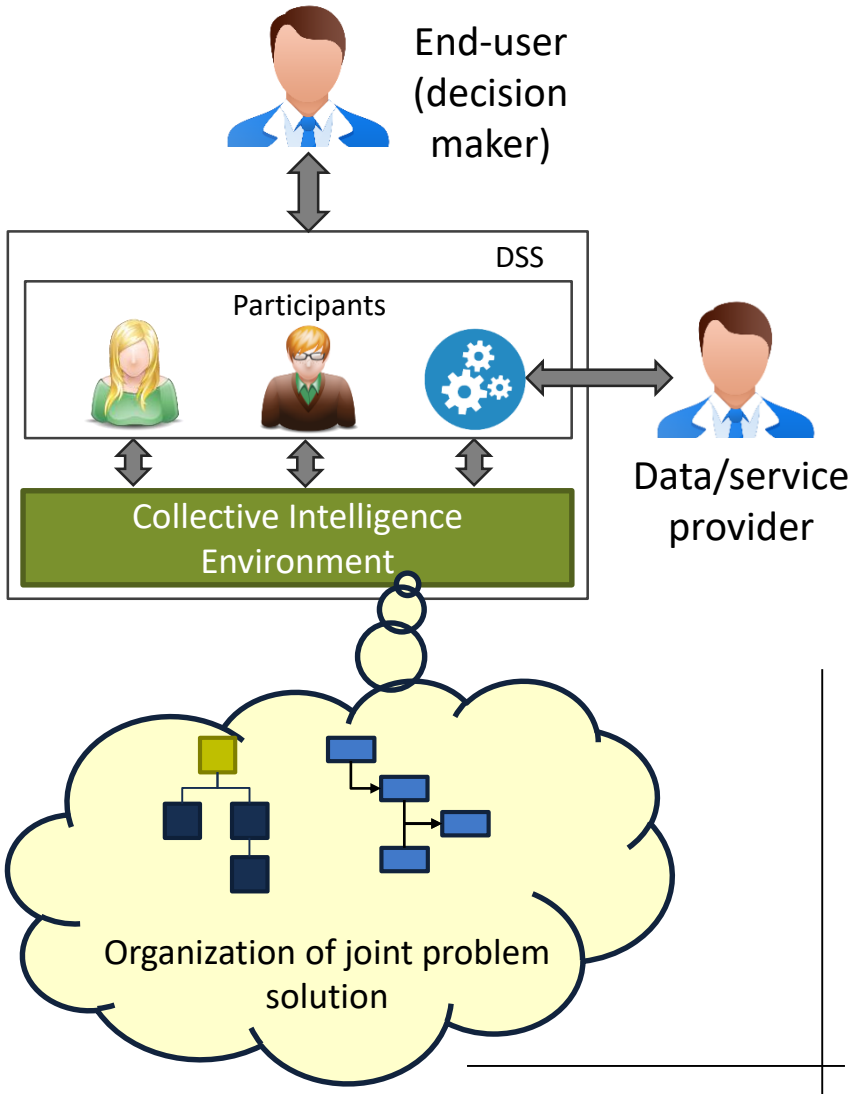
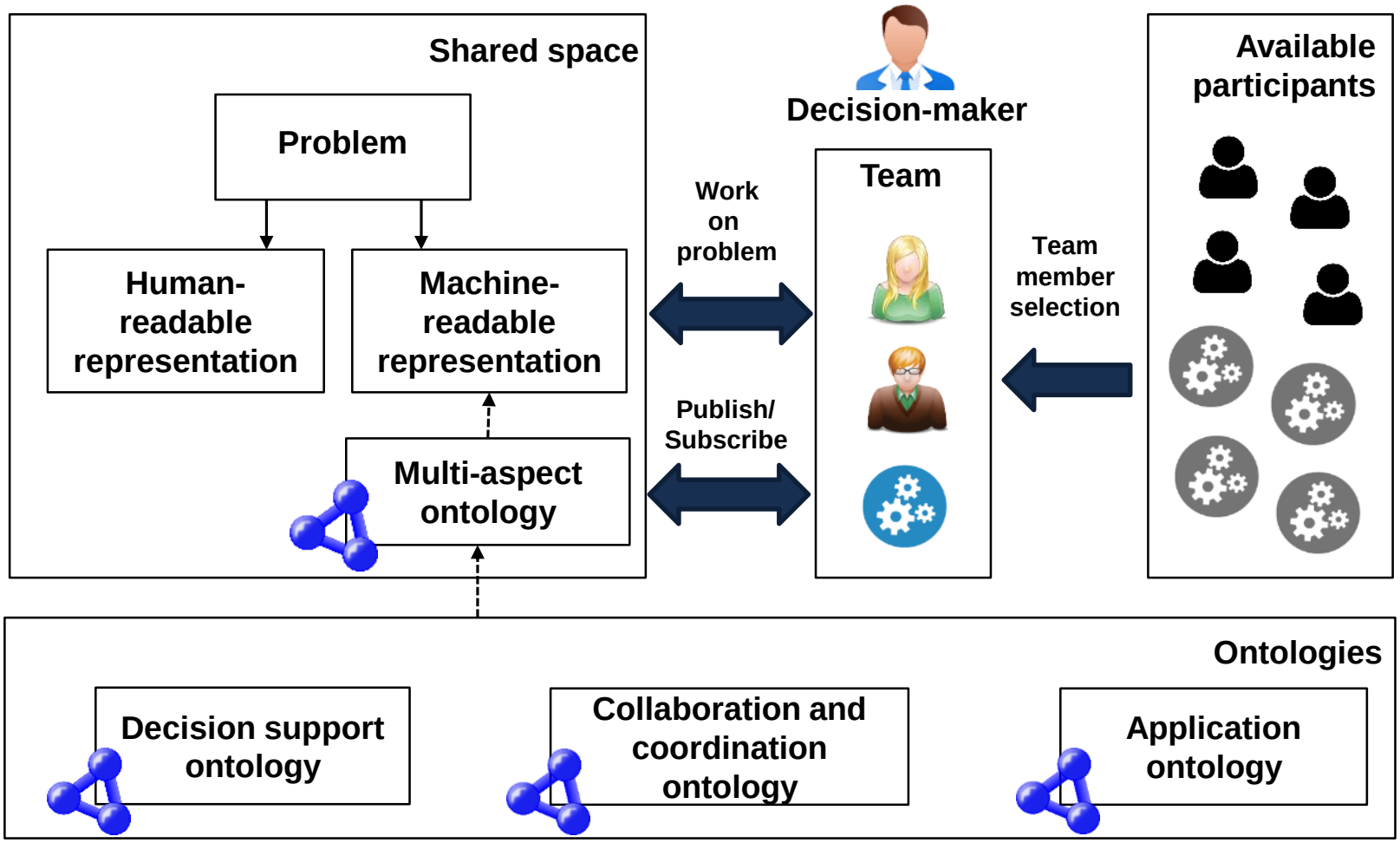
1. Elements of **self-organization** are critical, especially when solving complex problems.
2. **Social norms** and the adaptation of the behavior policies of team members.
3. **Role-based** coordination.
4. **Patterns**, structures and coordination schemes.
5. **Formal representation** of problem-related information supporting provenance.
6. **Dynamic motivation** mechanisms.

HMCI-Environment: Principal Actors

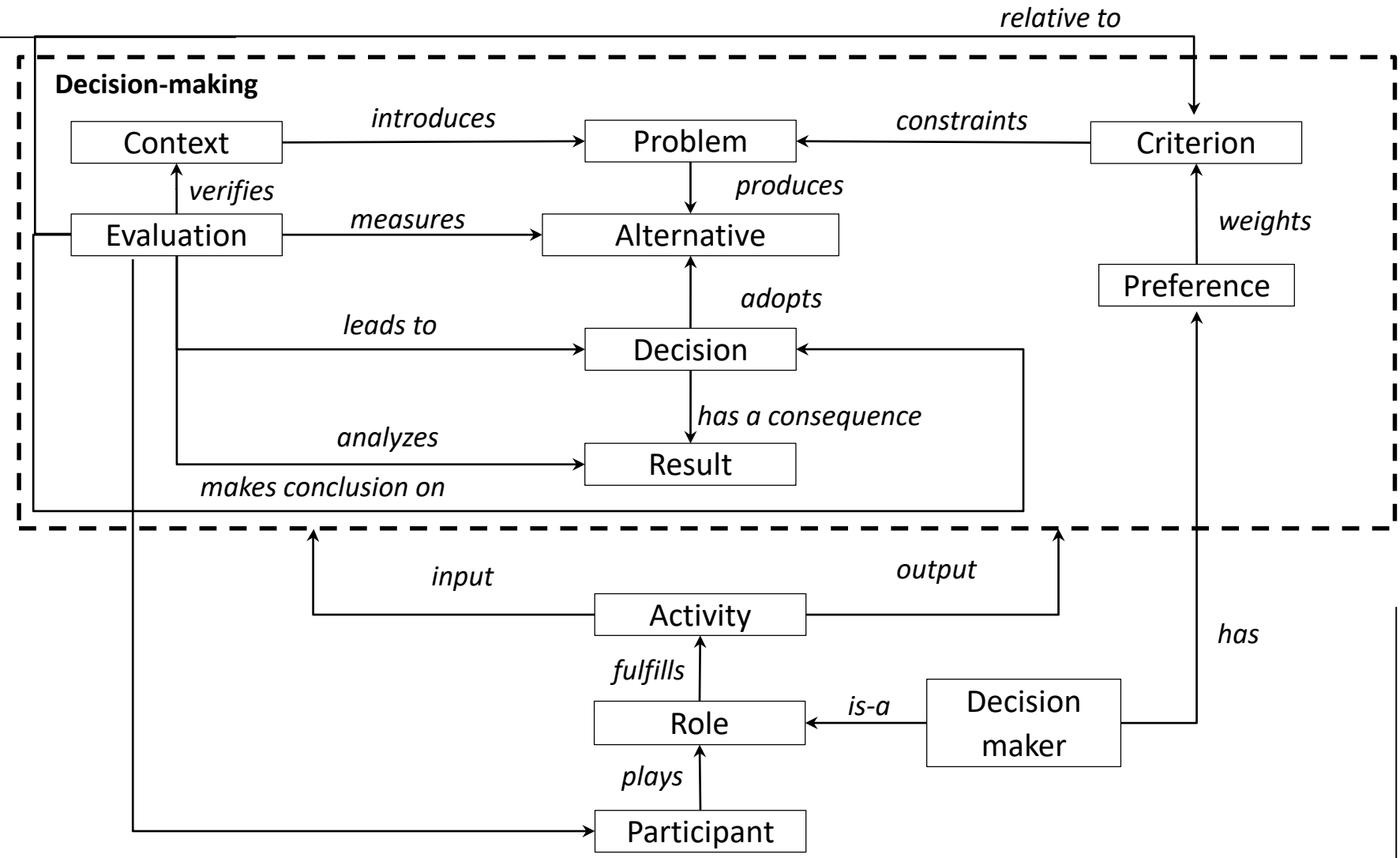
- **End-user (decision-maker)**
  - needs an access to problem-relevant expertise
  - middle-to-top level manager
- **Participant**
  - provides the expertise:
    - construct (and collaborate) on the reasonable workflow
    - judgments and conclusions
- **Data/service provider**
  - Integrates and supports software services. Responsible for the deployed services



HMCI-Environment: Conceptual Model



HMCI-Environment: Decision Making Ontology



Presentation Outline

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Conclusion

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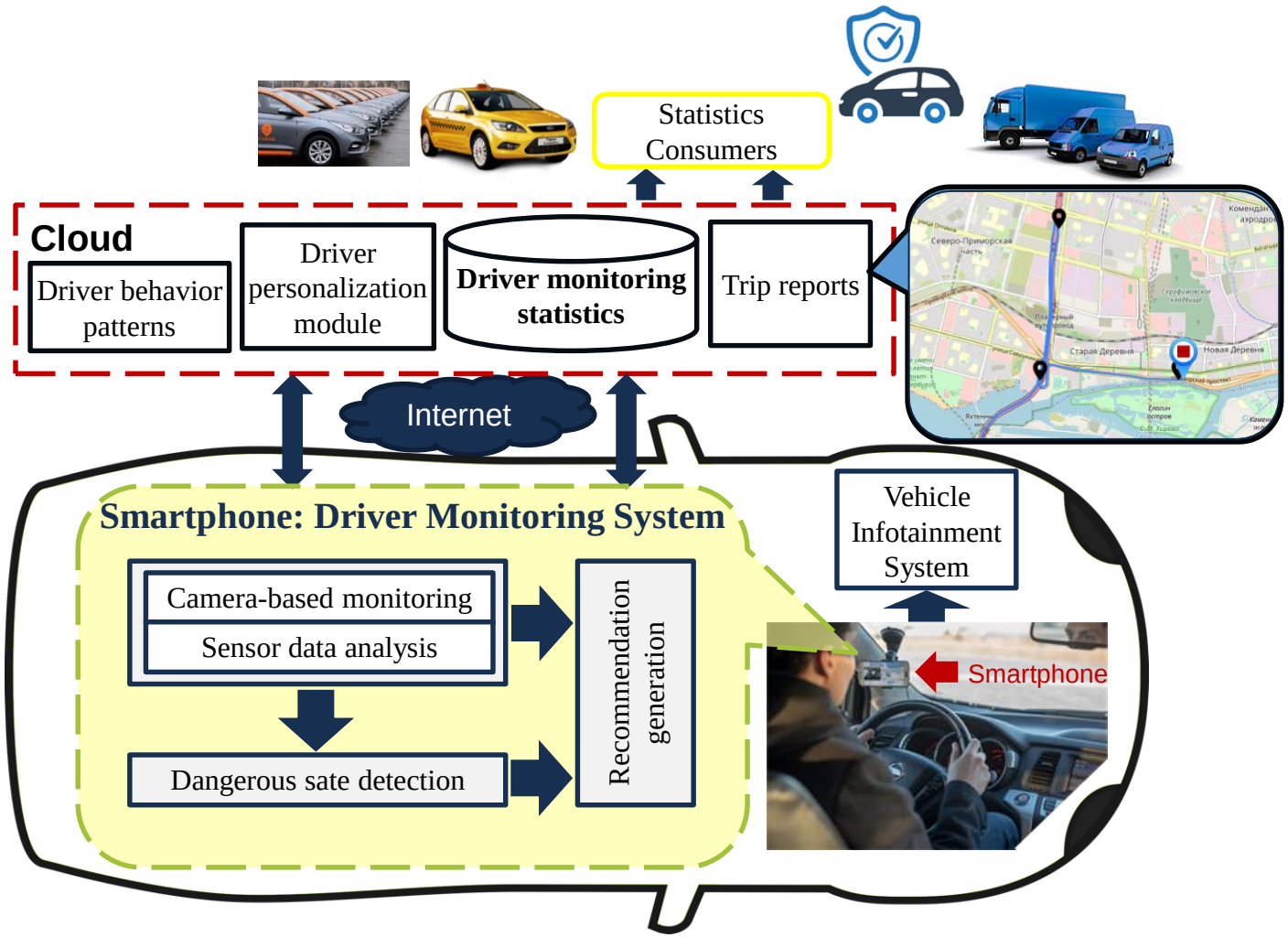
The design of the Human-Machine Collective Intelligent Environment is heavily affected by the discussed Context-Aware Knowledge Management trends:

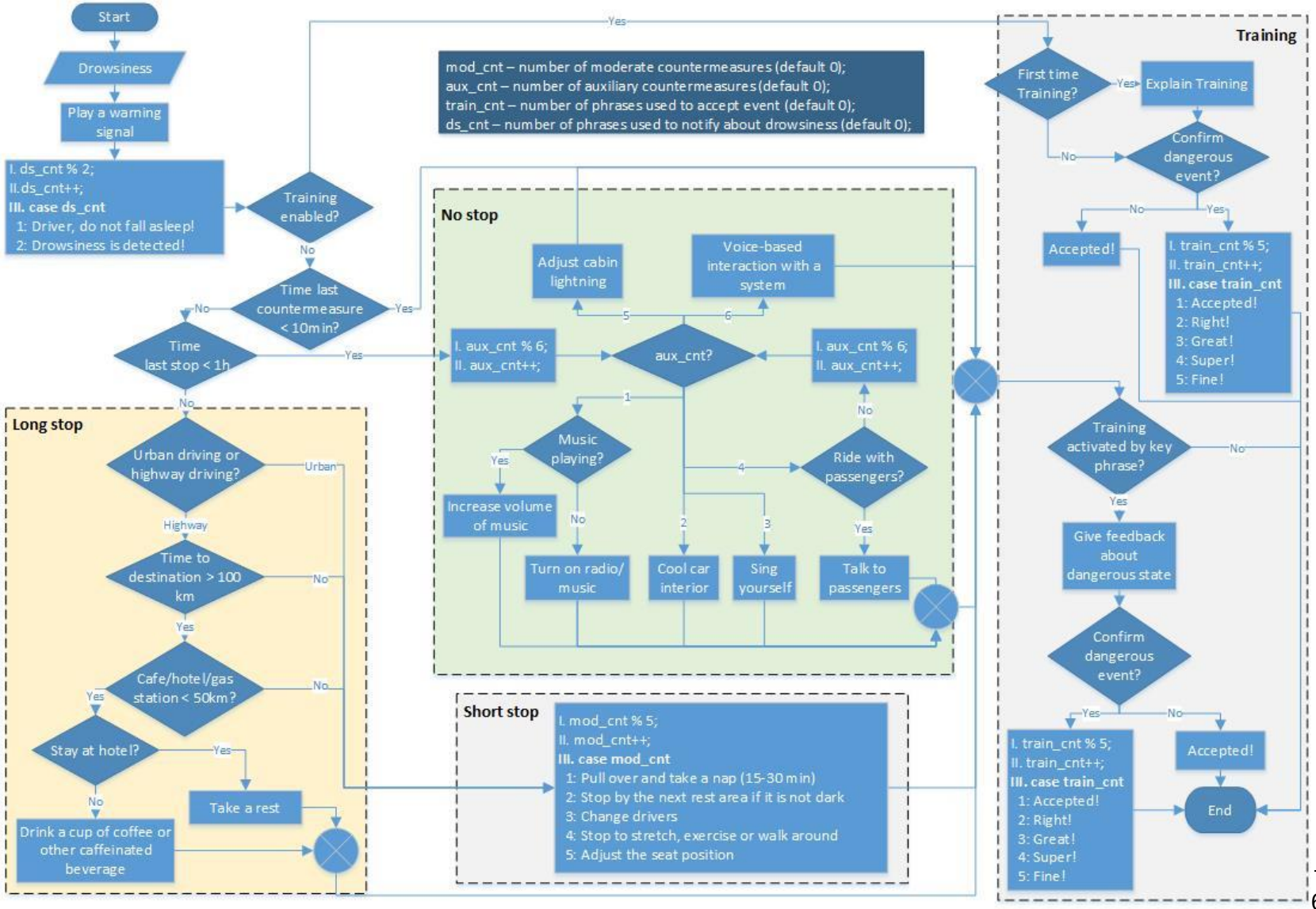
- **Ontology-based context modeling** and specialization are at the core of the problem representation (to achieve interoperability between human and software participants).
- **Role-based organization and multi-aspect ontologies** are used to help to reconcile different aspects of the decision support (e.g., domain structure vs. process structure), because every decision-making process can be viewed as an interaction of different roles (project leader, data analyst, domain expert, etc.).
- **Dynamic motivation** mechanisms play a role in process planning and team recruiting, because reward sharing is an important aspect of process definition.

SPIIRAS' Background: Fleet Driver Monitoring System

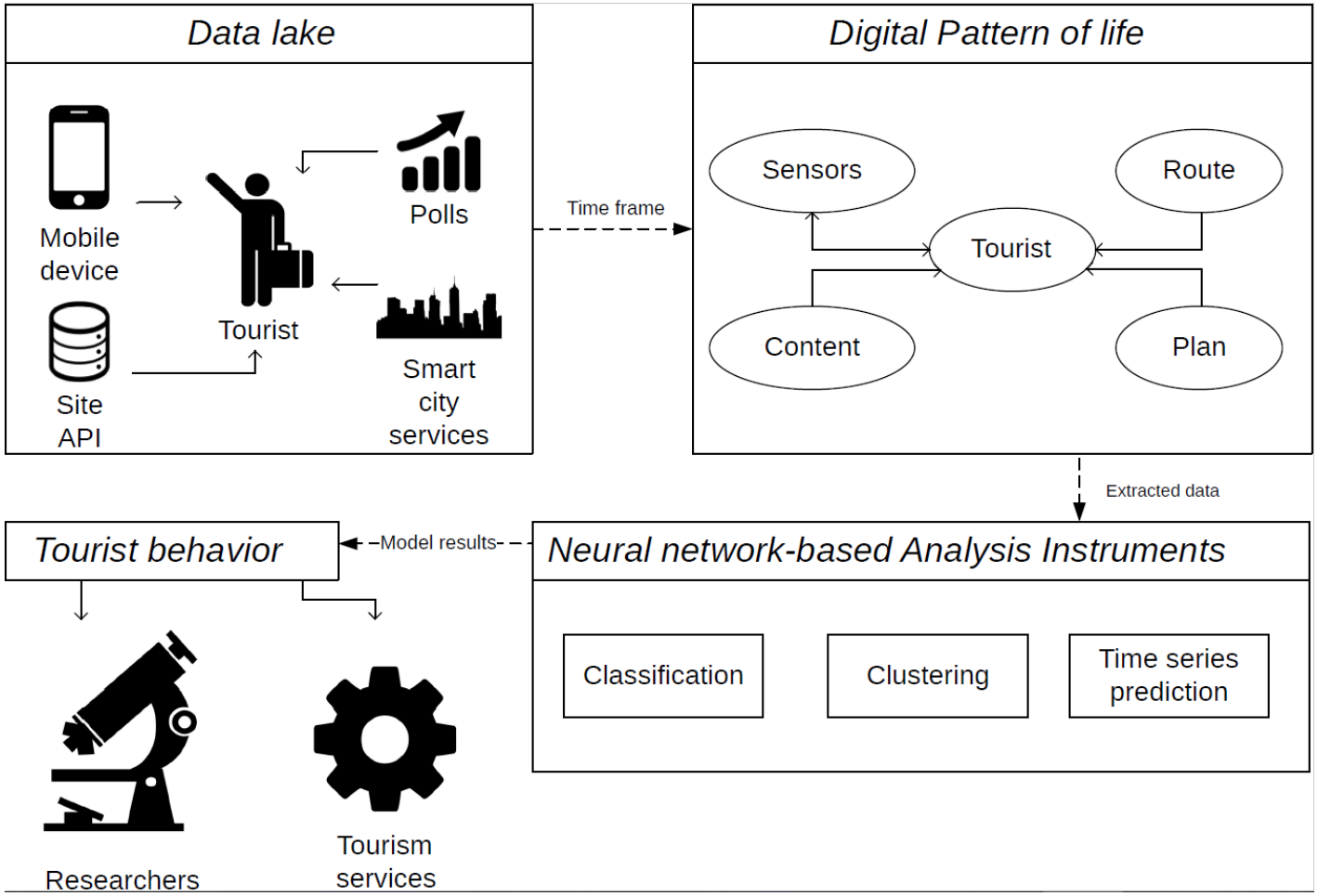


SPIIRAS' Background: Driver Behavior Analysis Based on Machine Learning & Recommender

SPC RAS

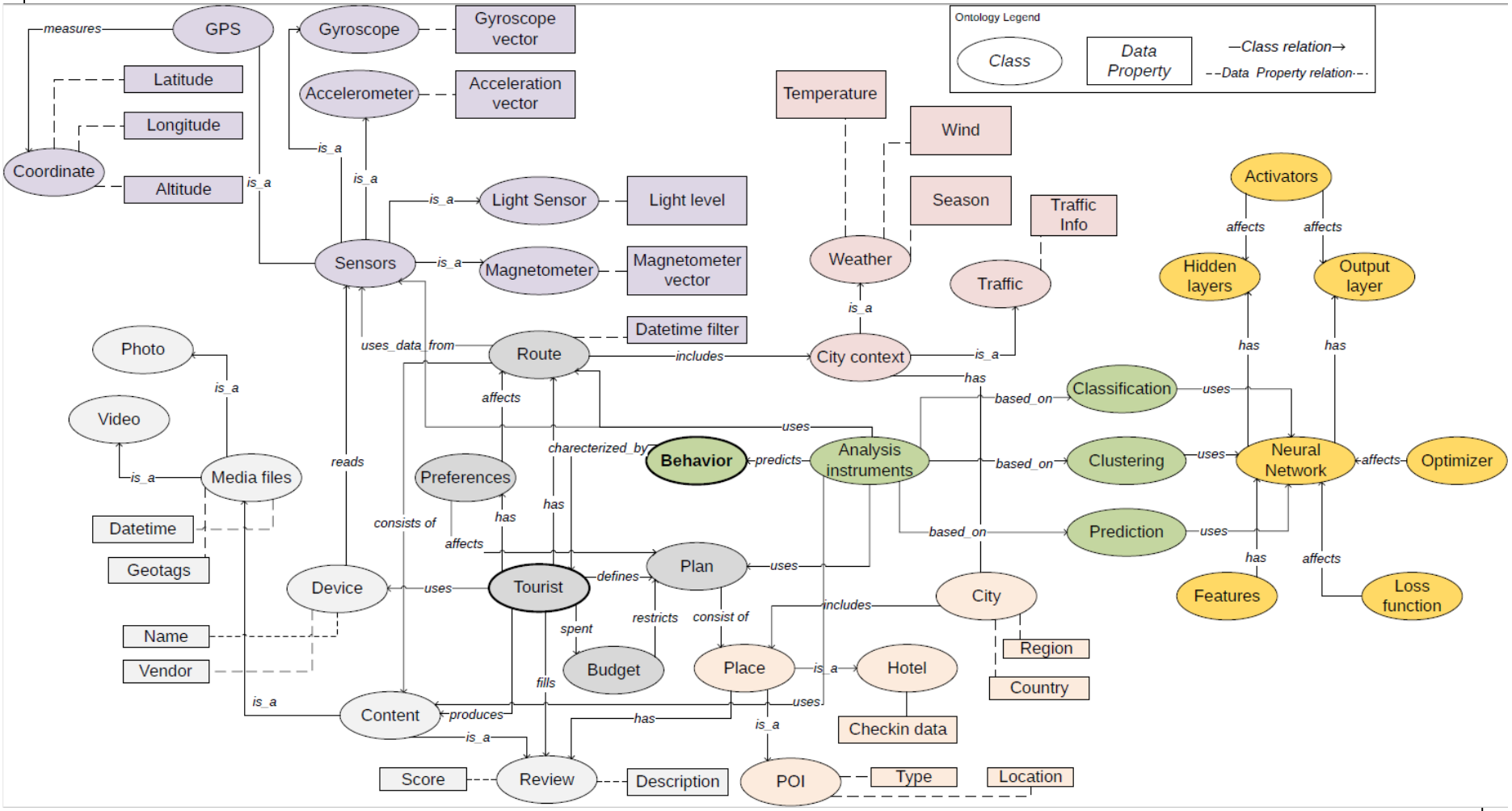


SPIIRAS' Background: Reference Model for Tourist Behavior Analysis



SPIIRAS' Background: Tourist Behavior Analysis based on Digital Life Model & Neural Networks

SPC RAS



Future Work: Principles of Decision Support Based on User Digital Life Models

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- **Users with similar Preferences & Behaviors are grouped.**
- A **Group Pattern describes collected information about Preferences & Behaviors** of Users belonging **to this Group.**
- The recommended **Decision is predicted based on Group Patterns.**
- The sources of **User Preferences are User Profiles existing in various Domains (life areas-segments).** A User can have several Profiles.
- **The sources of information about the User Behavior are the User Digital Life Traces.**
- **User Digital Life is represented by a model** that specifies the Problems that the User has ever dealt with and the decisions made with references to the Domains these Problems came from.
- **User Digital Life Models & Profiles are compliant with the Domain Ontologies.**
- **Ontology Reasoner performs the classification of Users in** a User **Context** (situation) **into a User Group**. Belonging of the User to a Group depends on the User Context. **In different Contexts, the same User can be classified in different User Groups.**

Future Work: Reference Model of Decision Support based on User Digital Life Model

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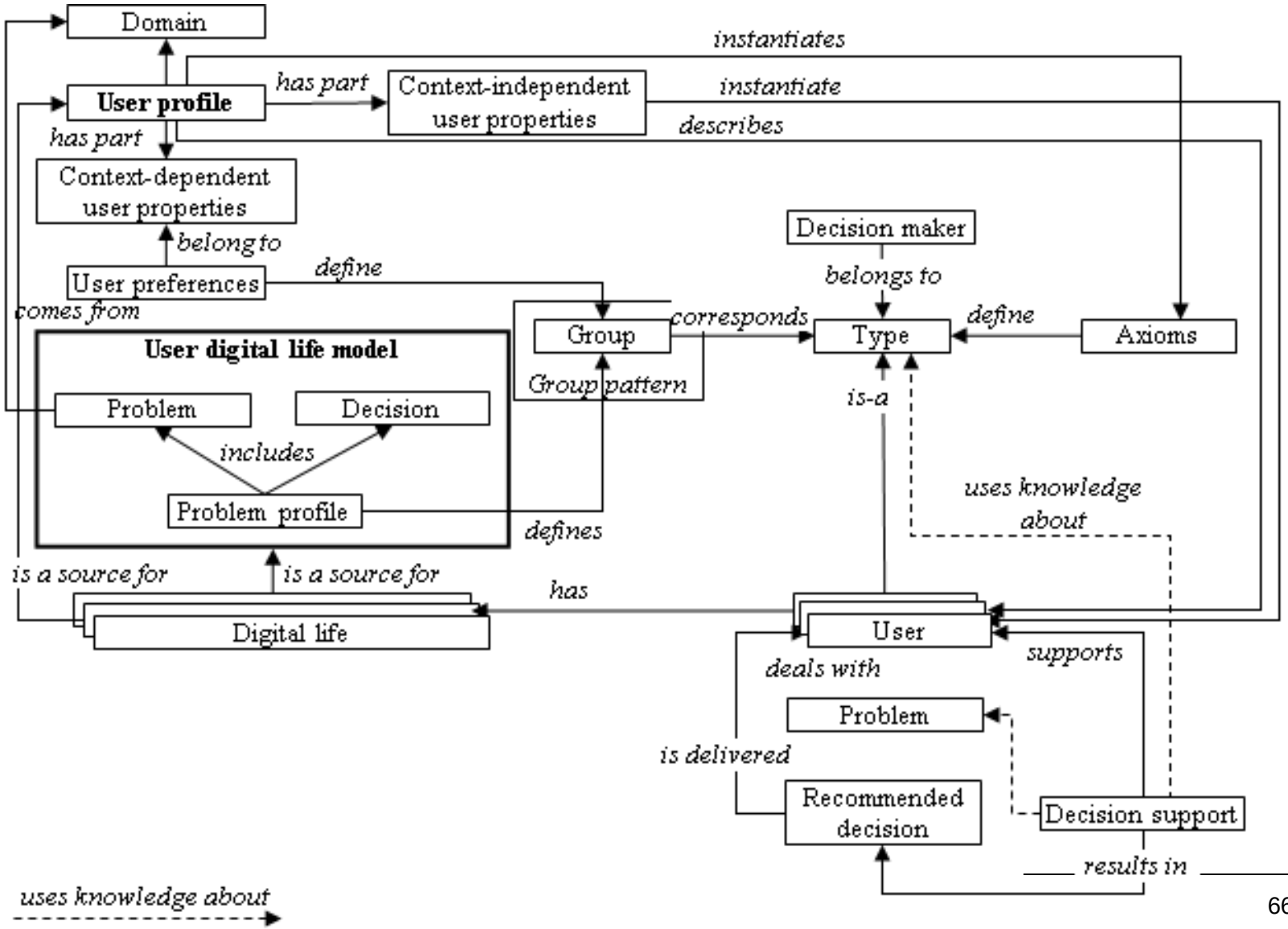

Prof. Smirnov' References related to Trends

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IN4PL2020: Keynote Speakers
http://www.in4pl.org/KeynoteSpeakers.aspx

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IN4PL2020: International Conference on Innovative Intelligent Industrial Production and Logistics (Budapest, Nov. 2-3, 2020)

- **Digitalization at Festo: Our Way in Digital Transformation**
  Mr. Andreas Oroszi, Senior Vice President of Digital Business at Festo AG & Co. KG (Germany), and a Member of the Management Board for MindSphere World Association.

  November 2: 15=00 - 16=00 (GMT)

- **Industry 4.0 and Beyond: Challenges and Opportunities**
  Prof. László Monostori, Director of the Research Institute on Computer Science and Control (SZTAKI, Hungary), full professor at Budapest University of Technology and Economics, and President of the Industry 4.0 National Technology Platform, Hungary.

  November 3: 17=00 - 18=00 (GMT)

Thank you!!!

SPC RAS

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