2:nd strategy workshop on Intelligent Industrial Processes, IIP

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In this workshop

• Analysis the mainstream roadmaps:
  • what is thought to be the desired level of intelligence
  • particular engineering and scientific challenges which ought to be resolved in order to achieve it.
  • Specifically focusing on the "soft" aspects of the "intelligence": Which algorithms, data structures, programming and communication paradigms should be developed in order to make the 2030-industry more flexible and thus more efficient.
Research agendas -> requirements

• Securing the future of German Manufacturing Industry: Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Final report of the Industrie 4.0 Working group. April 2013.
• Swedish production 2025 Strategic research and innovation agenda to meet the global challenges. September 2011. (Svensk produktion 2025 Strategisk forsknings- och innovationsagenda för att möta de globala utmaningarna. Sept. 2011).
Intelligent industry by 2030: wish list

- Burst manufacturing
- One-of-a-kind production
- Flexible production and manufacturing
- New work forms and social relationships
- Efficient development of new skills
- Environment-aware consumption
- Resource-smart design and production
- Integrated virtual design and operation of the supply chain
- Shorten the time idea-market
- Shorten the time for drastic changes in the entire supply chain

CPS (Cyber-Physical Systems) at the center connecting humans, machines, and the environment.
Two things to remember: (CPS) are integrations of computation with physical processes.

- One shall distinguish the Cyber-Physical approach to the design of computer-controlled Systems, from the vague description of future manufacturing systems as being CPS.

- Any modern manufacturing system is already a cyber-physical system, because it is “integrations of computation with physical processes”.

- To advance future industries we need to enable “true CPS” design approach.
High level interpretation of CPS goals

CPS APPROACH MEANS TO CO-DESIGN

Duality of humans:
- An asset in the optimization process (aka bio-machine)
- A part of the bioenvironment

Globaly integrated, flexible

MAKE THIS A BETTER PLACE
Two things to remember: Where to get inspiration

Industrial automation will remain to be the user (rather than main development driver) of advanced computing platforms initially developed for other application areas

- military, space, consumer electronics, robotics, automotive electronics, business computing, gaming
Towards IIP: Types of Intelligence

**Manual intelligence**
- Expert systems
  - Root-cause analysis
  - Inferring of process models
- Neural networks
- Fast data classifications
- Distributed planning and execution of alternative operation paths
  - Automated fault management
  - Efficient operation
- Manually orchestrated distributed functions
  - Flexible automated processes

**Automated intelligence**
- SoA components
  - Semi-automatic orchestration of distributed functionality
- SoA-based processes
  - Interoperability between components from different vendors
- Agent-based systems
  - Automated distributed planning of alternative operation paths
  - Collective reasoning
  - Efficient usage of human forces

**Evolving Intelligence**
- Flexible SoA
  - Learning by observation
  - Automated orchestration and consistency verification
  - Automated optimization
  - Automated detection of run-time inconsistencies
  - Interactive resolution of inconsistencies for performance optimization
To understand what will be in 16 years, we need to look 16 years back

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<td>• Proprietary SCADA</td>
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Globally integrated industries: selected specific challenges

• Raw data – NOW!
  • Systematization of domain-specific raw data and its conceptualization
  • Provide seamless access to any process related information (measurements) and its integration with process models in real-time, enabling more accurate control and reconfiguration of processes

• Advanced virtualization/co-simulation methods and tools, which will be used daily throughout the engineering life-cycle

• Wireless all the way:
  • Adaptation of LTE-A architecture to machine-to-machine communications in general and the specifics of industrial communications in particular
  • bridge the cross-sectorial gap between, data, telecom and automation industries by homogenizing the design and development principles as well as developing methods for joint analysis and optimization
  • m2m as native service not as “over-the-top”

• Integrated, proactive, intelligent security
Flexible industries: selected specific challenges

- enable co-design of processes and supporting services.
- observation based (learned) models of systems of systems accounting for operators’ actions.
- dynamically evolving SOA based on run-time learned models.
- flexible programming languages allowing for (semi-) automatic re-tasking of functional components.
Towards FLEXIBLE industries: selected Software Development challenges

- Architecture
- Building blocks
- Tools
- Overruns in costs and times
- Surprises after commissioning
- Maintenance
- Degradation

"If builders constructed buildings same way as programmers write programs, the first passing woodpecker would destroy the civilisation"

Weinberg's Law
An intuitive all-visual programming paradigm mapping directly to executable and being able to handle the exponential complexity growth of software in automation is needed.
pTides (Berkley) is a semantic framework for distributed CPS that uses a uniform time concept for both physical and computational parts.

**Main pillars:**
- time-stamped events,
- clock synchronisation

**High level research challenge:** Cross-domain development
A general trend: Modularity and Autonomy

- **Monolythic code**
- **Modules with common Interfaces**
- **Services: Standard Interfaces**
- **Agents: Discovery, Autonomous collaborative behaviour**
- **Intelligent Agents: Reasoning, Cognitive, Learning, exchanging knowledge**
Human-centric IIP

- A new-old trend - the “people analytics” approach:
  - “Accurate people management decisions are the most important and impactful decisions that a firm can make.”
- Enable the “worker-as-a-service” vision:
  - Intelligent Agents
  - Mobile, wearable devices, body-area networks, Biometrics
  - Social networks
- Develop tools and education programs for CPS-enabled specialists for future IIP industries:
  - “Bit-stream” engineers
  - Cross-disciplinary/cross domain programs
  - Virtual environments for fast retraining
Sources of inspiration: ICT Mega Trends and Future Automation

- Globally integrated industries: Totally virtualized factories and enterprises
- Flexible industries: Intelligent machines trained in virtual worlds, collaborating in machine “social” networks
- Integrated, intelligent proactive security
- New work-forms

Smart cities/CityOS
Ubiquitous wireless
Wearable devices, biometrics
Apps, app stores
Virtual worlds
Cognitive robots
Cloud
Knowledge engineering
SOA
3D printers
Social networks
Stuxnet
IBM security strategy
Micro&Nano

CISCO, IBM, Urbiotica, PlanIT
Ericsson, Huawei, m2m operators
Google, Samsung
Google, Apple
Gaming
Boston Dynamics
Amazon, Parallels, VMWARE
Towards IIP: Discussion

Cyber-Physical Systems

- Globally depending industries
- Automated processes
- Autonomated processes
- “Manual intelligence”

- Service-Oriented-Industries
- Flexible distributed automation
- “Automated intelligence”

- Globally integrated flexible and efficient industries
- SOA ++
- “Evolving intelligence”

Progress

Present 2020 2030 Time

Industrial SoA Industrial SoA-Clouds Intelligent SoA