Industrial Internet of Things (IIoT) in Nuclear

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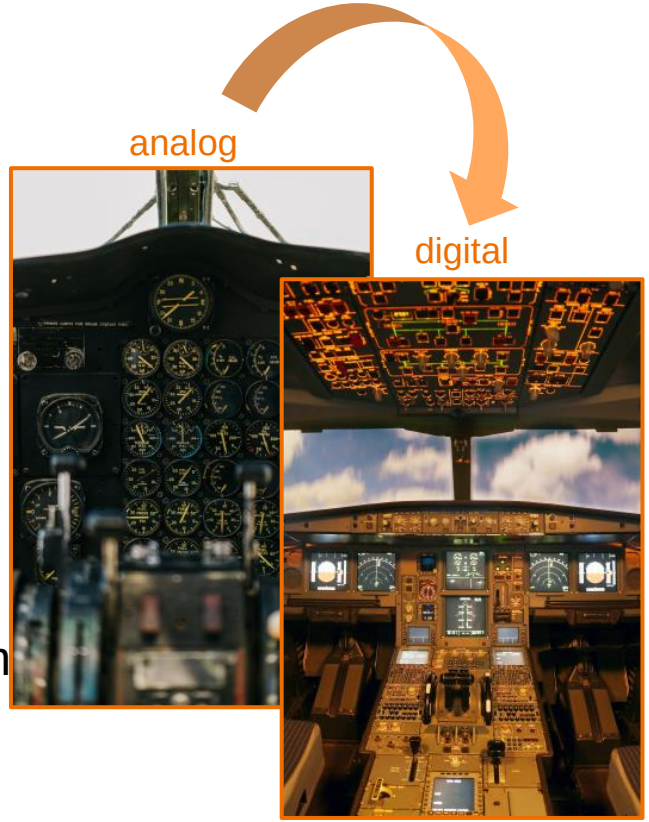
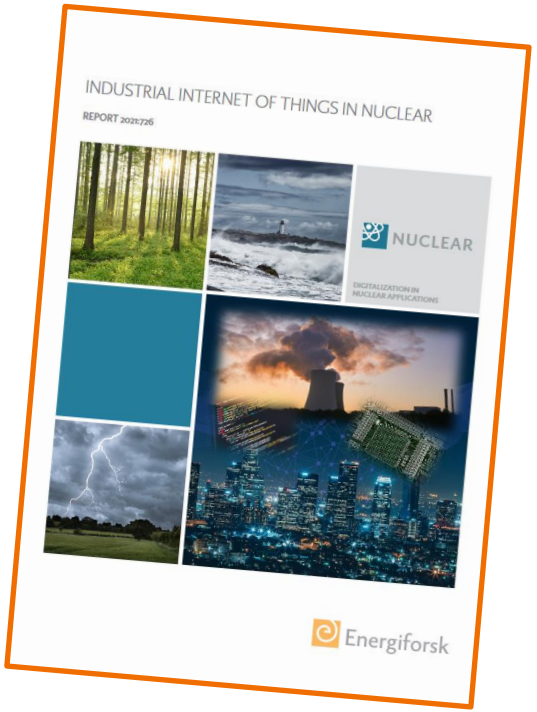
Background and introduction

- Digitalization is one of the mainstream driving themes across industries and society.
- Nordic NPPs have been designed and constructed before the digitalization age has started.
- Interest but also reluctance towards IIoT adoption in NPPs exist.
- Our report is based on literature reviews from various sources, experience gained from other projects and on-line surveys with selected experts from the Nordic NPPs.



Main content of the report

- IIoT technologies
- IIoT applications in nuclear
- IIoT applications in other industries
- Final considerations

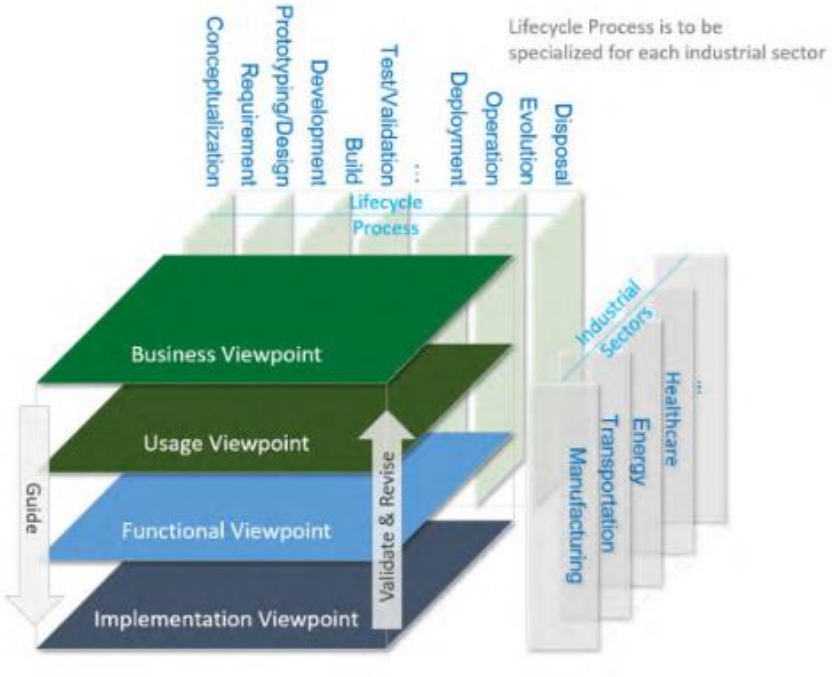


Link to the report: https://energiforsk.se/program/karnkraftens-digitalisering/rapporter/industrial-internet-of-things-in-nuclear-2021-726/

Section 1 / 4
IIoT technologies

IIoT technologies in brief

- Wireless technologies
- Data management
- Cyber security
- IoT platforms
- IoT forecasts



Industrial Internet Consortium's (IIC)
Industrial Internet Reference Architecture (IIRA)

Wireless technologies

- Important part in many IoT environments.
- Presented more detailed in the earlier Energiforsk report "*Wireless in Nuclear Feasibility Study*". *)
- Brief updated summary presented in this report to make it standalone.

5G usage areas.
© ETSI (https://www.etsi.org/technologies/mobile/5g)

*) https://energiforsk.se/en/programme/energiforsk-nuclear-safety-related-ic-ensric/reports/wireless-in-nuclear-feasibility-study/

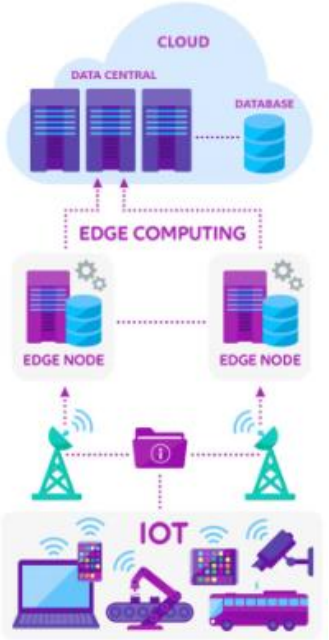
Wireless technologies, in Nordic NPPs

- Although wireless has been considered as “no go” in the Nordic NPPs, there are already some wireless technologies in use…

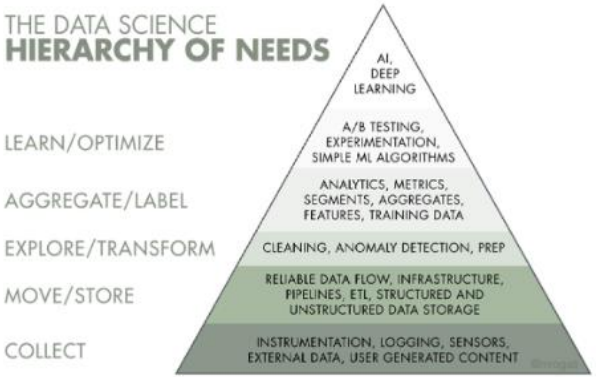
- Wireless communication for humans but also for machines.
- Private wireless networks built or planned in Nordic NPPs at
  - Ringhals, Loviisa, Hanhikivi,…

Data management

- Cloud and edge computing
- Big data analytics, e.g.
  - Amazon Web Services (AWS)
  - Microsoft Azure
  - IBM Watson
  - Cloud IoT Core
  - Telecom and ICT operator IoT environments
- Artificial intelligence (AI)



Edge computing principle. (Figure source Telia)

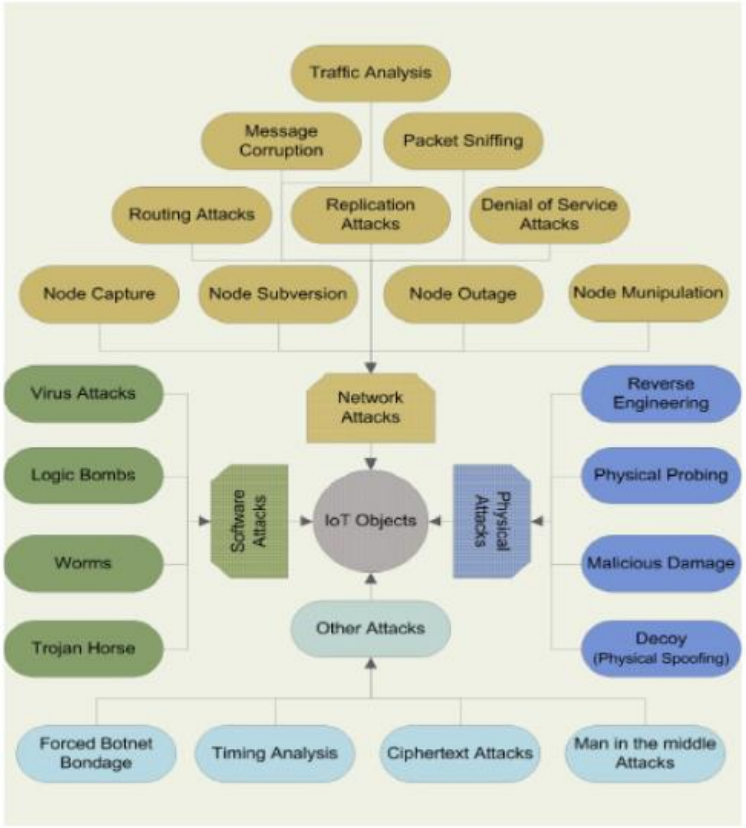


Rogati, M. (2017). The AI Hierarchy of Needs. https://hackernoon.com/the-ai-hierarchy-of-needs-18f111fcc007

Cyber security

- Vast group of malicious actors are active with different agendas for their cyber-attack, cyber sabotage and cyber espionage campaigns in mind.

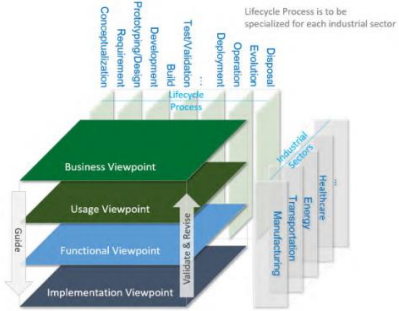
- Some of them are also well resourced and have even veiled governmental support for their actions.
- *We will hear more about security issues in another presentation today*



Brief list of attack types on IoT
Saleem, J. & al. 2018. IoT Standardization - Challenges, Perspectives and Solution. ICFNDS

IoT platforms

- Without an IoT platform, the challenges of building an IoT application are significant: developing the application logic user interface and database and developing data analytics.
- IoT platform providers leverage the underlying technologies and assets they have, while taking into consideration their business models and customers.
- Understanding what each provider offers is required when evaluating IoT platforms.
- Selection of the underlying platform can be a critical decision for an IoT-based service developer.



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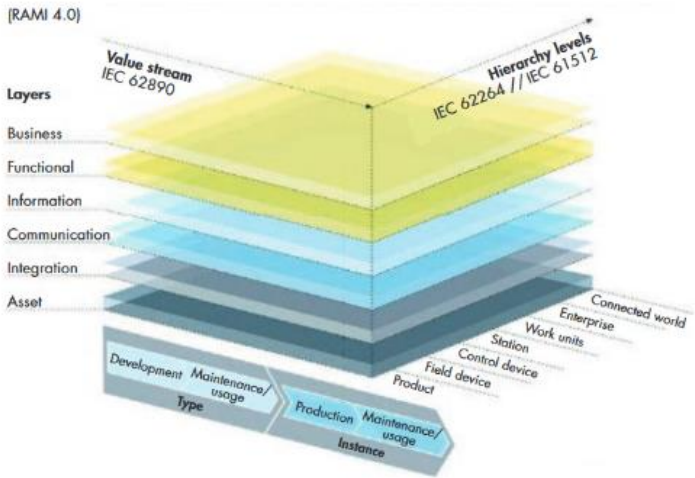
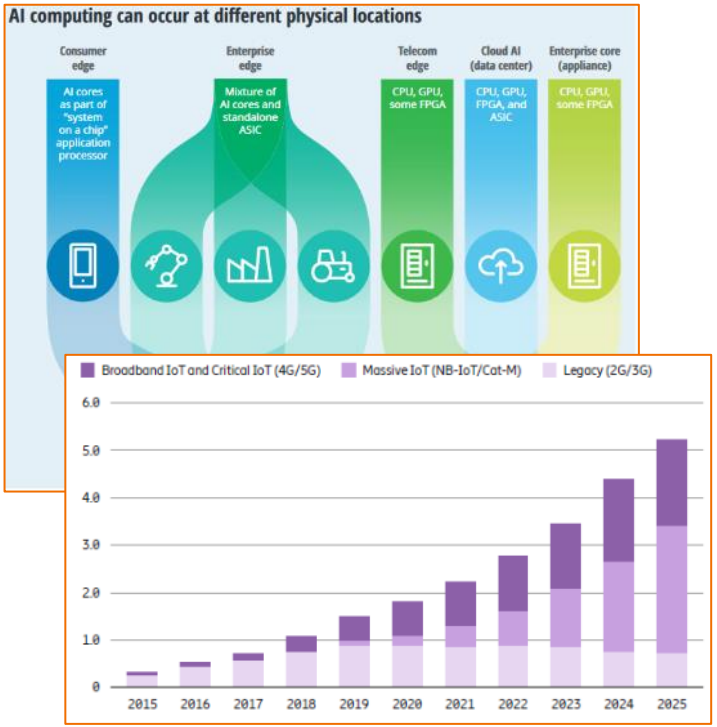


Reference architectural model Industry 4.0 (RAMI 4.0)
by ZVEI (© Platform Industrie 4.0)

IoT forecasts

- IIoT will be a main-stream technology in the industry and the evolution of enabling technologies will help new use cases to be implemented and bring new industries on-board
- Many companies and institutions are making forecasts about IIoT technology evolution and expansion both technology as well as market wise.
- These market and technology research reports are often subject to a charge.

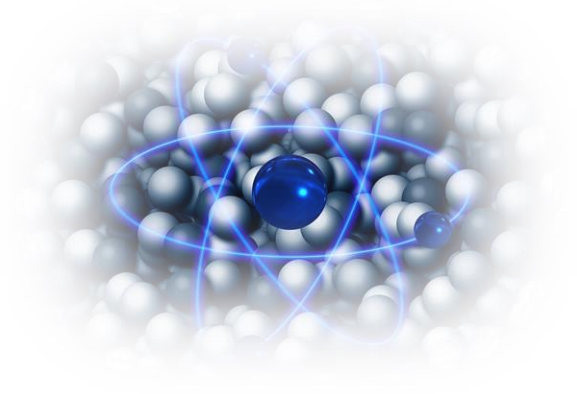


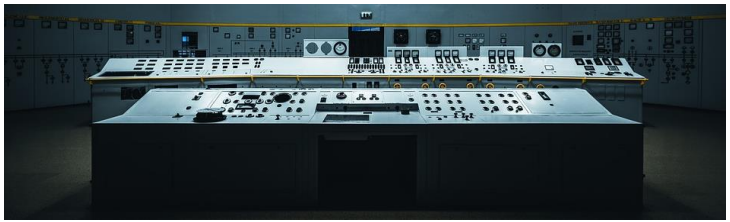
- AI computing at different physical locations (Deloitte 2020)
- Cellular IoT connections by segment and technology (billion) (Ericsson mobility report, June 2020

Section 2 / 4
IIoT applications in nuclear

IIoT applications in nuclear

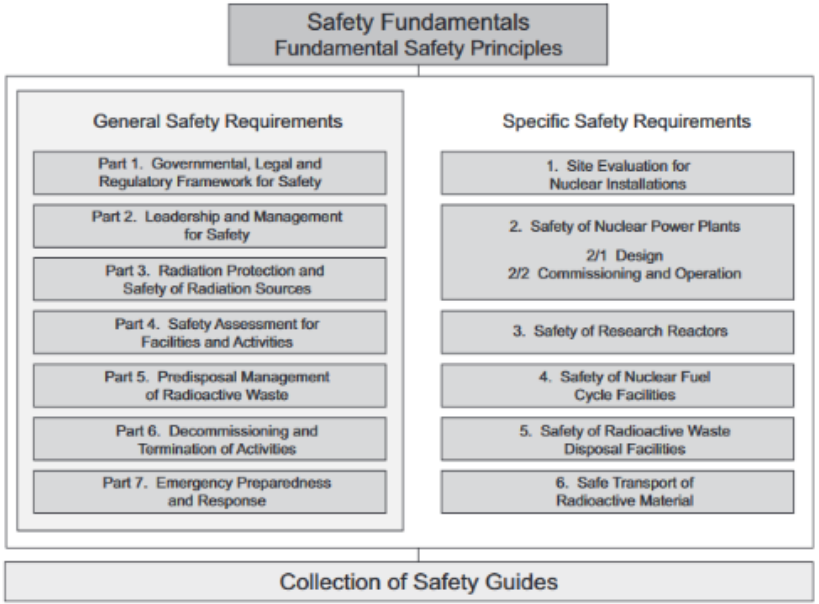
- Regulatory requirements and restrictions
- Standardization
- IIoT applications in Nordic NPPs
- IIoT applications in international NPPs





Regulatory requirements and restrictions

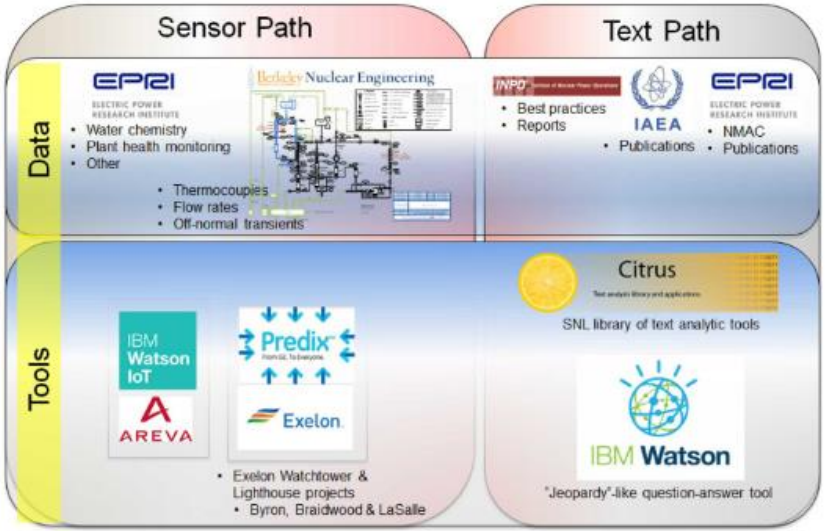
- Several countries (in Europe) use the IAEA Safety Standards as a basis for formulating national regulations.
- OECD Nuclear Energy Agency (NEA)
- Western European Nuclear Regulators Association (WENRA).
- In the Nordics:
  - STUK (FI) and SSM (SWE).



The long-term structure of the IAEA Safety Standards Series

Standardization

- Many technologies involved, both from Nuclear field & ICT field.
- IAEA, EPRI, IEEE, ISO, ETSI, …
- Several standards and documents mentioned in the report.



Data analytics applied to nuclear power
Industrial Internet-of-Things & Data Analytics for Nuclear Power & Safeguards. Sandia National Laboratories.

IIoT applications in Nordic NPPs (1/2)

- Modernization of old NPPs is taking place in the Long-Term Operation (LTO) programs, which can provide an opportunity to bring IIoT into the Nordic NPPs.
- IoT and wireless usage is still quite modest in the Nordic NPPs.
- Some wishes already expressed, but business case justification still needed.
- Posiva and SKB are using modern technologies for their nuclear repository site testing projects.

15 Reactors in the Nordic countries.
Source, IAEA Power Reactor Information System (PRIS)

IIoT applications in Nordic NPPs (2/2)

- Most of the NPP information is classified and not publicly available.
- Some examples of applications in use include:
  - Local (temporary) measurements have been implemented e.g. wireless vibration monitoring
  - Safeguards surveillance technologies (Seals and Cameras) are in use
  - Fire alarm using TETRA SDS messages
  - Short rage RFID identification
  - Perimeter radiation control

- *We will hear more insights from Ringhals and Loviisa plants today.*

IIoT applications in International NPPs (1/2)

- Contains a non-comprehensive list of examples of various (I)IoT projects and pilots within international NPPs with short descriptions across the world.
- Includes both pilot projects and research approaches.

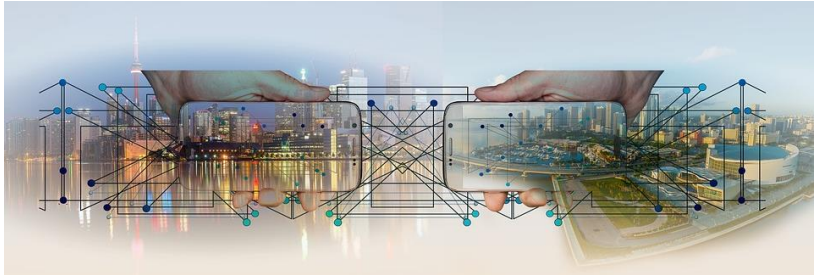
IIoT applications in International NPPs (2/2)

- Partly same challenge: Most of the NPP information is classified and not publicly available. But there are many open examples, like:
  - Equipment monitoring (valves, pumps, motors, leaks, vibration, temperature)
  - Various radiation monitoring system, even with drones
  - Wireless applications in nuclear decommissioning and robotics in NPPs
  - IoT and data platforms
  - Even blockchain pilots/proposals
- *We will hear more insights from GE Hitachi, EDF and AMS Corp. today.*

Section 3 / 4
IIoT applications in other industries

IIoT applications in other industries

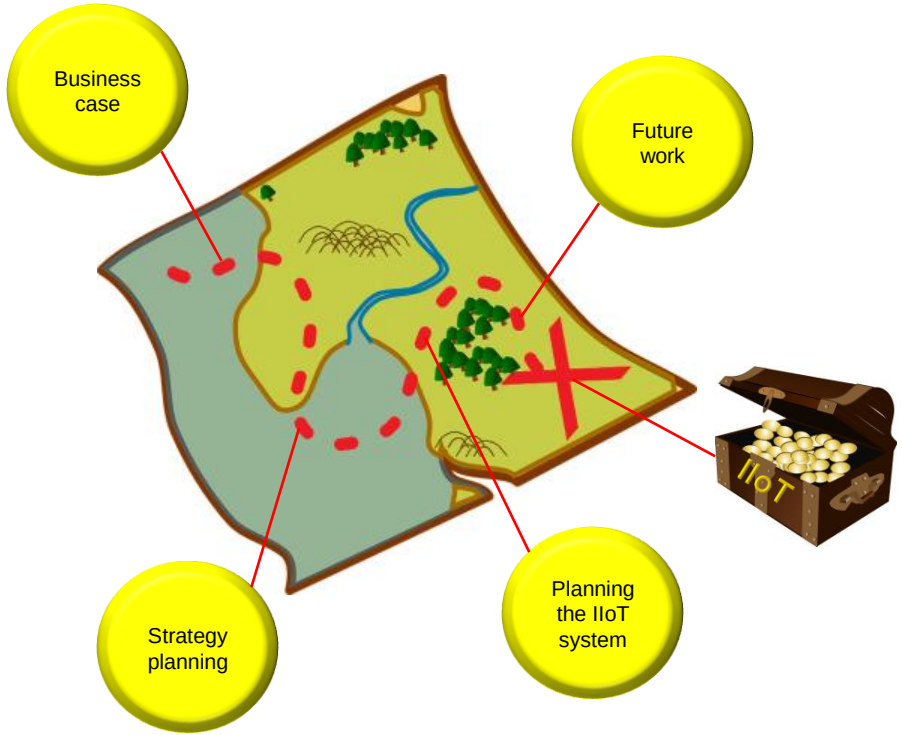
- Brief examples from:
  - Electric power and energy systems
  - Environment, health and safety
  - Maintenance
  - Some Nordic telecom operator IoT examples (as a list)



Section 4 / 4
Summary and final considerations

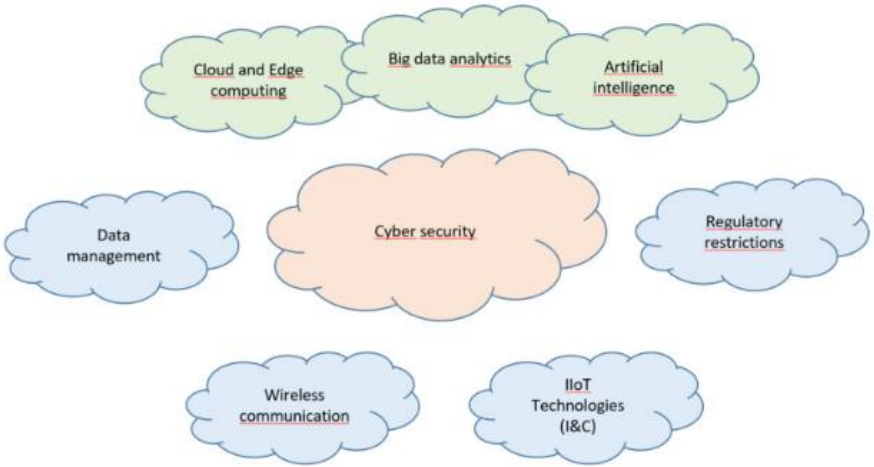
Summary and final considerations

- One single correct way for successful IIoT adoption does not exist.
- The LTO-programs of the NPPs can create a need for IIoT adoption, as the replacement of the old I&C technologies will most likely turn more difficult in the future.



Guidelines for IIoT usage

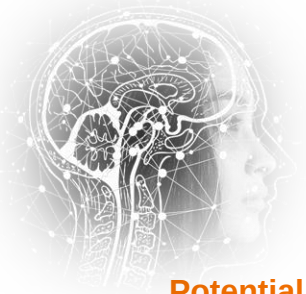
- IIoT consists of many technological sectors.
  →New opportunities but also new threats
- Main gaps to fill:
  1. Integrating IoT solutions into existing business workflows
  2. Managing data
  3. Identifying use cases and applications
- Keep the big picture in mind, even with small experiments.
  →businesses tend to focus too narrowly when thinking about how to use IoT.



Remember

Business case + Strategy planning

Business case



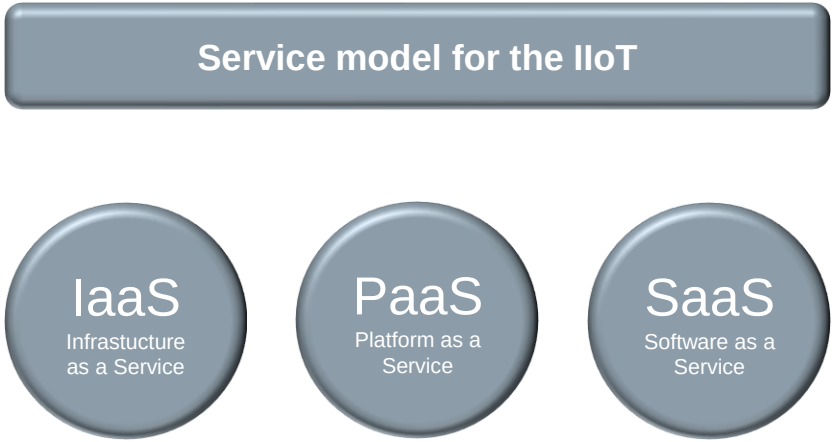
- Business case to support the project needed!
  →IIoT adoption should bring cost savings and/or improved efficiency.
- Do business case and strategy planning parallel in iterative way.
- Missing ”infrastructure” can hinder or slow the IoT project.

Potential starting points for IIoT business case in NPPs

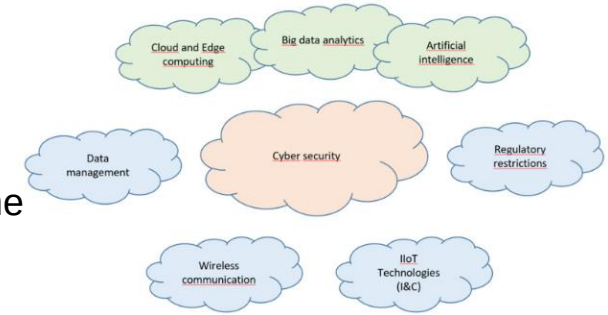
1. Improve internal processes with enhanced monitoring.
2. Bring cost savings with predictive maintenance and analytics.
3. Improve security.
4. Improve safety.
5. Improve resilience.
6. Improve data collection, management and analytics.
7. Increase automation.
8. Track assets.
9. Improve logistics.
10. Replace existing legacy I&C systems in small scale.
11. Replace existing legacy I&C systems in large scale.
12. Create digital twins.

Strategy planning

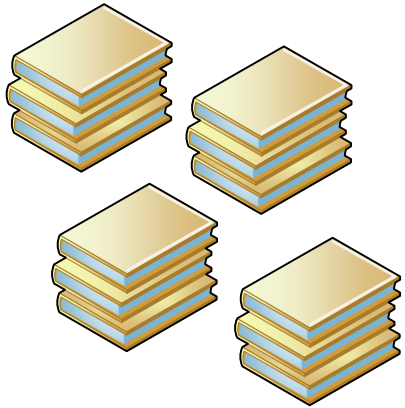
- Changes to the original business processes and IT-strategies need to be carefully evaluated.
- IIoT adoption can impact to the work processes and require changes to them.
- Implementing greater number of IoT use cases often correlates with financial success.



Planning the IIoT system



- Technology and service providers, involved in the design and implementation process, will offer guidelines and tools to help the planning, but the buyer should self be aware of possibilities and pitfalls.
- Lot of offerings for products, devices and services:
  - IBM's Watson, Microsoft Azure, GEH's Predix, Schneider's EcoStruxure, Honeywell's Sentience, Telecom operator's IoT, Amazon Web Services (AWS), Cloud IoT Core, ….
- Toolkits and guidebooks:
  - Industrial Internet Consortium (IIC) - IIoT RFP Toolkit
  - Enterprise IoT: Strategies and Best Practices for Connected Products and Services (book).
  - Industrial Internet Security Framework: Practitioner's Guide.
  - IAEA - Challenges and Approaches for Selecting, Assessing and Qualifying Commercial Industrial Digital Instrumentation and Control Equipment for Use in Nuclear Power Plant Applications.



Thank you

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beyond

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