



**TEK5530 - Measurable Security for the Internet of Things**

# **L1 – Introduction**

György Kálmán,  
UiO/DNB  
gyorgy.kalman@its.uio.no

Josef Noll  
UiO  
josef.noll@its.uio.no

<https://its-wiki.no/wiki/UNIK4750>, #IoTSec, #IoTSecNO

# Overview



- Expectations
- Lecture overview
- Exam
- Topic introduction

## Expected outcome:

- Describe application-driven security and establish challenges of sensor-driven systems
- Provide industrial examples, e.g. Smart Grid and automatic meter readings
- Establish application-driven security goals as well as the semantics of your system

- Be able to describe the security impact of components and sub-systems
- Perform a multi-metrics analysis to measure the system security
- Analyse application goal versus system security, be able to describe differences and mitigation solutions
- Be able to analyse and present own thoughts on a scientific paper
- Group work with distribution of workload

# UNIK4750: Lecture plan



- 17.01 L1: Introduction
- 24.01
  - L2: Internet of Things
  - L3: Security of IoT + Paper list
- 31.01
  - L4: Smart Grid, Automatic Meter Readings
  - L5: Service implications on functional requirements
- 07.02
  - L6: Technology mapping
  - L7: Practical implementation of ontologies
- 14.02
  - L8-9: Paper analysis with 25 min presentation
- 21.02 --- Winter holiday
- 28.02
  - L10: Logical binding - industrial example
  - L11: Multi-Metrics Method for measurable Security
- 07.03
  - L12: Multi-Metrics Weighting of an AMR sub-system
  - L13: System Security and Privacy analysis
- 14.03
  - L14: Real world examples - IoTSec infrastructure – possible quest lecture
  - L15: Real world IoT service evaluation group work
- 21.03
  - L16: Cloud basics and cloud architecture
  - L17: Cloud security, IoT and service examples from AWS
- 28.03
  - L18: Selected recent topics from IoT security
  - L19: Wrap-up of the course
- 04.04 ---- No lecture, prepare for exam, consultation possibility
- 11.04 ---- No lecture, prepare for exam, consultation possibility or Exam (depending on what we agree on)
- 18.04 ---- Easter holiday, no lecture
- 25.04 ---- Exam (depending on decision about exam on the 11th)

# Department of Technology Systems



UiO : Institutt for teknologisystemer

Det matematisk-naturvitenskapelige fakultet



Long and nice history on communications and the birth of internet

Was home of the first ARPANET link to Europe made possible by internet-pioneer Pål Spilling, whom we lost a year ago.



Cooperation with the Kjeller-Institutes

First implementation of OLSR routing protocol

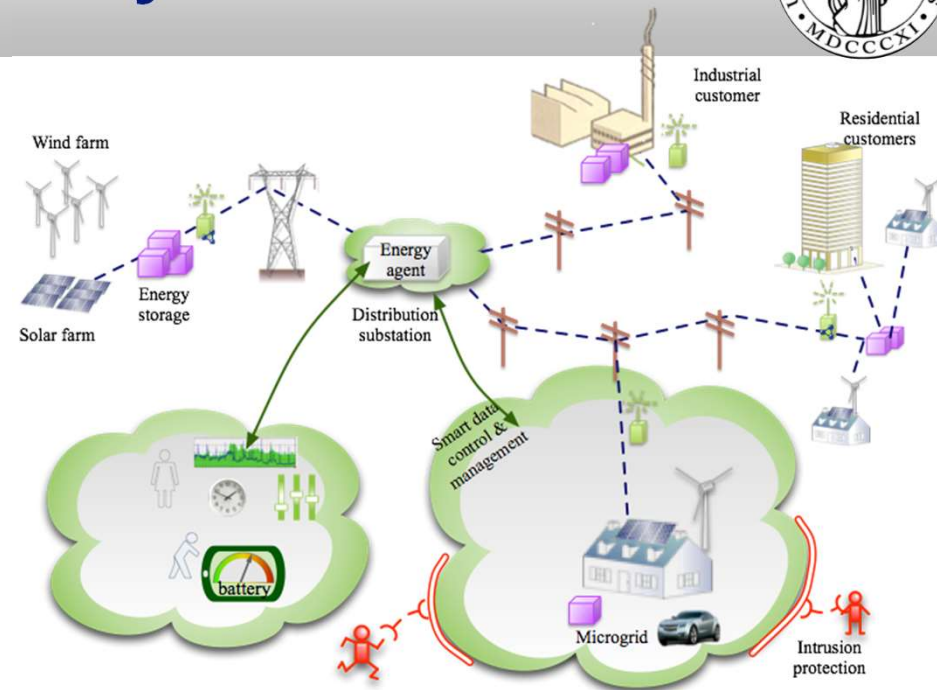
# The threat dimension



- Ukraine blackout
- Surveillance camera DDoS
- AMS attack surface
- Exploiting cloud-elasticity
- Smart home – Always online
- Autonomous vehicles
- Ransomware
- Unauthorized resource usage (e.g. mining)
  
- Worth reading:
  - OWASP Internet of Things project  
[https://www.owasp.org/index.php/OWASP\\_Internet\\_of\\_Things\\_Project](https://www.owasp.org/index.php/OWASP_Internet_of_Things_Project)
  - Amazon Web Services IoT  
<https://aws.amazon.com/iot/>

# L1 - L3: Introduction to security

- This first part will provide the introduction into the Internet of Things (Lecture 1 - L2), with industrial examples
  - Smart Grid and automatic metering system (AMS)
  - Smart Homes with sensors
  - Wireless System upgrade of cars
- Lecture 3 will further address potential security threats, through the example of the smart electricity grid.



- Smart grid with prosumers
- Various control mechanisms
- Attack scenarios
- Critical infrastructure

Knowledge and collaboration space

<http://IoTSec.no> - #IoTSec, #IoTSecNO



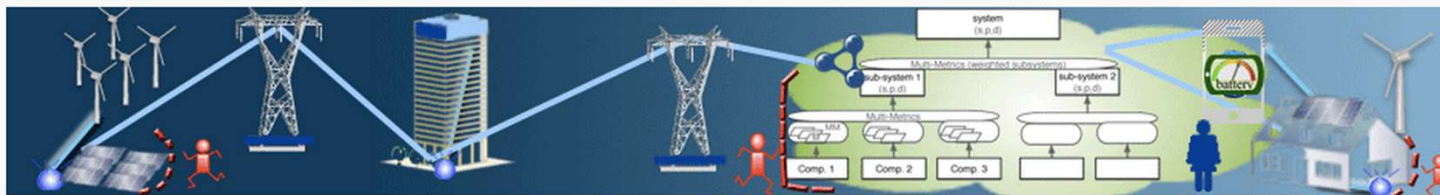
Home

Research Areas

Security Centre

Publications

About us



The IoTSec - Security in IoT for Smart Grids initiative was established in 2015 to promote the development of a safe and secure Internet-of-Things (IoT)-enabled smart power grid infrastructure. The Research Project received funding from the Research Council of Norway (RCN) to contribute to a safe information society.

IoTSec addresses the basic needs for a reliable and efficient, uninterrupted power network with dynamic configuration and security properties. It addresses in addition the needs of businesses and end users of additional IoT services by exploring use cases for value-added services with the intent to design the building blocks for future services that consider the necessary security and privacy preconditions of successfully deployed large-scale services. IoTSec will apply the research in the envisaged Security Centre for Smart Grids, co-located with the Norwegian Centre of Excellence (NCE Smart).

## About

The IoTSec initiatives drives Research for secure IoT and Smart Grids

#iotsecno



Josef Noll

@josefnoll

11 Nov

NCE Smart Partnerkonferansen med @KristinHalvorsen og Nasjonalt senter for Sikkerhet



«Open World Approach»  
everything that is not  
declared closed is open



TEK5530



#IoTSecNO

Jan 2019, György Kálmán, Josef Noll

# Internet of Things Security



## Energy sector tops list of US industries under cyber attack, says Homeland Security report

12 March, 2015 at 6:38 PM Posted by: Jeremy Cowan

Washington, DC. March 12, 2015 — A report issued today by the US Department for Homeland Security says that in 2014 the Industrial Control Systems Cyber Emergency Response Team (ICS-CERT) responded to 245 incidents reported by asset owners and industry partners.

The energy sector, says *Jeremy Cowan*, led all others again in 2014 with 79 reported incidents, followed by manufacturing at 65 and worryingly healthcare at 15 reported incidents. ICS-CERT's continuing partnership with the Energy sector reportedly provides many opportunities to share collaborate on incident response efforts.



## Power Grid Cyber Attacks Keep the Pentagon Up at Night

A detailed look at why computers running the U.S. electrical infrastructure are so vulnerable to digital threats

By Michael McElfresh and The Conversation | June 8, 2015

*The following essay is reprinted with permission from The Conversation, an online publication covering the latest research.*

It's very hard to overstate how important the US power grid is to American society and its economy. Every critical infrastructure, from communications to water, is built on it and every important business function from banking to milking cows is completely dependent on it.



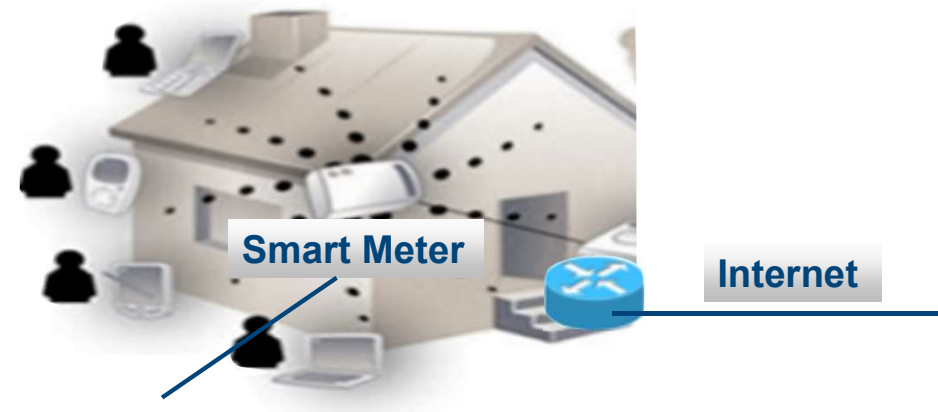
*Scott Wylie/Flickr*

Jan 2019, György Kálmán, Josef Noll



# L4-L5 Security and Privacy challenges

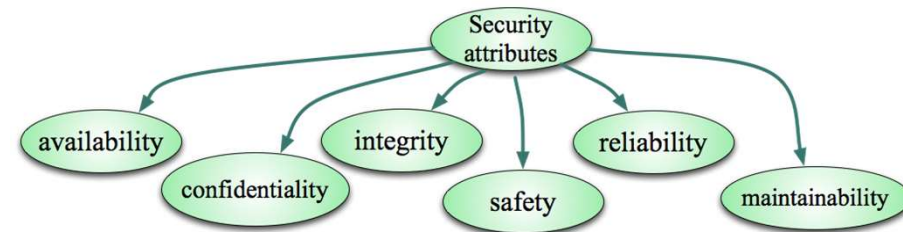
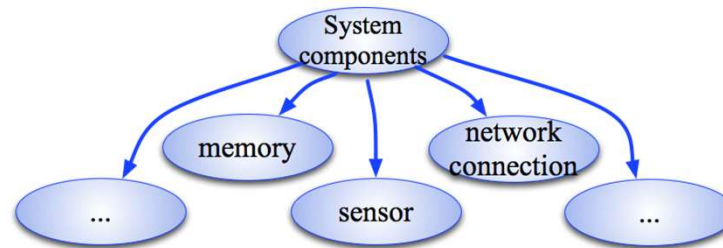
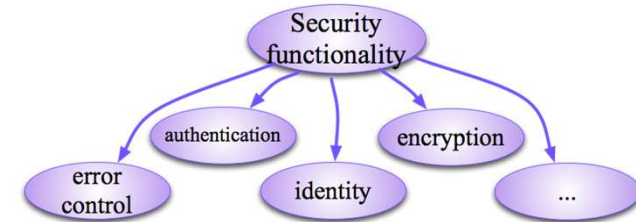
- Example: automatic meter reading (AMR) and -system (AMS) - Insurance
- Mapping from functional requirements towards mapping into technology.
- Example: translation of privacy requirements - can somebody see from my meter reading if I'm at home
- Legislation questions – GDPR and others



[source: [seminaronly.com](http://seminaronly.com)]

# L6-L7 Machine-readable descriptions

- Describe a system based on security attributes
- Introduction to the Semantic Web
  - Ontologies
- Rules & Reasoning
  - make decisions



# L8-L09 - Paper presentation

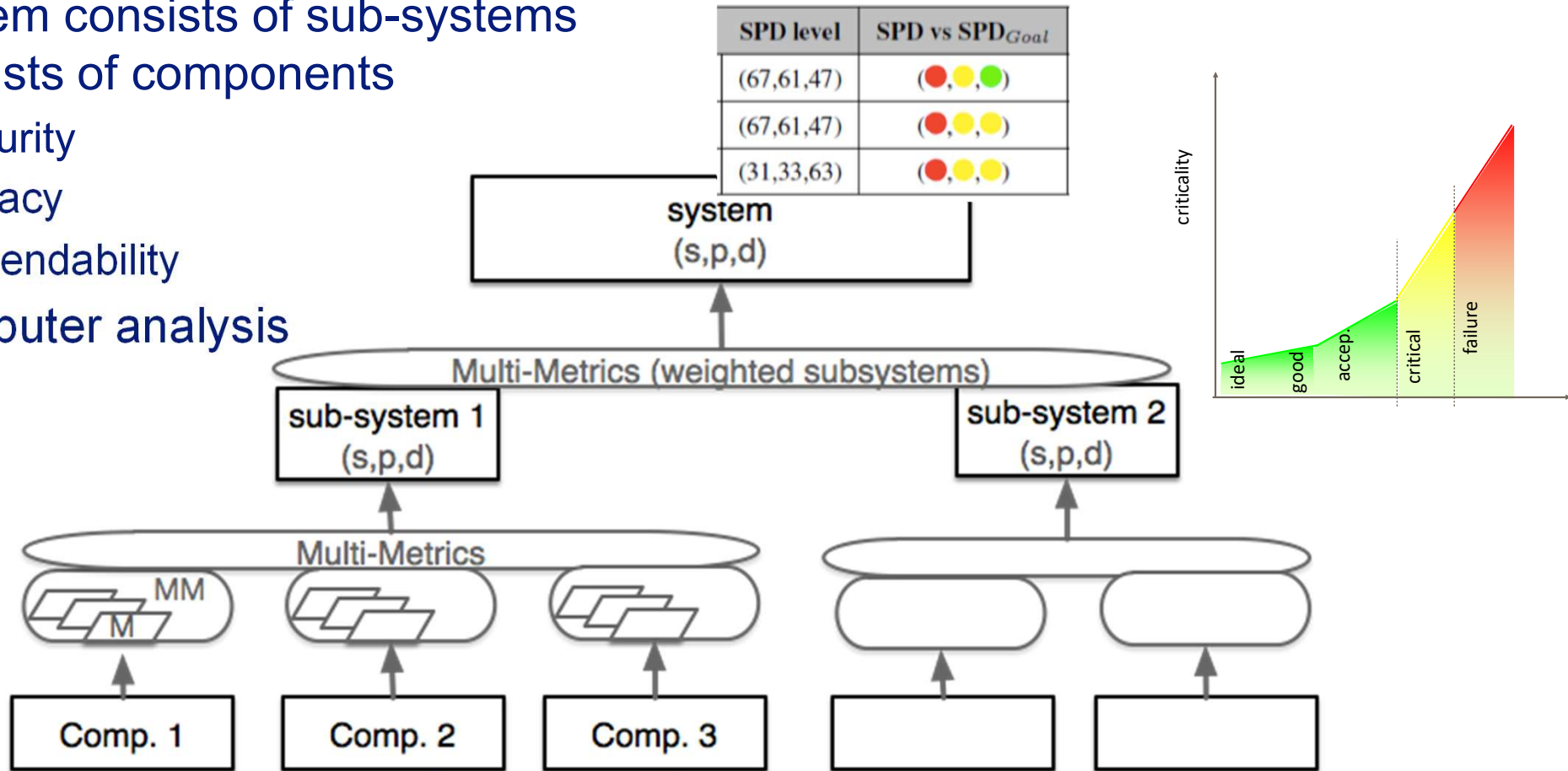


- Methodology:
  - Select (or search) for scientific papers
  - Present the paper
  - Discuss issues which you find interesting
- Outcome
  - Personal:
    - ✂ Learn to read and present scientific literature with own thoughts
    - ✂ Be able to hold a presentation with time limits and active audience
  - Course
    - ✂ Get a fresh overview of the newest available research challenges and selected surveys of the field of the course
    - ✂ Learn from how others are making their presentations
    - ✂ Learn to ask questions

# L10-L13: Multi-Metrics method

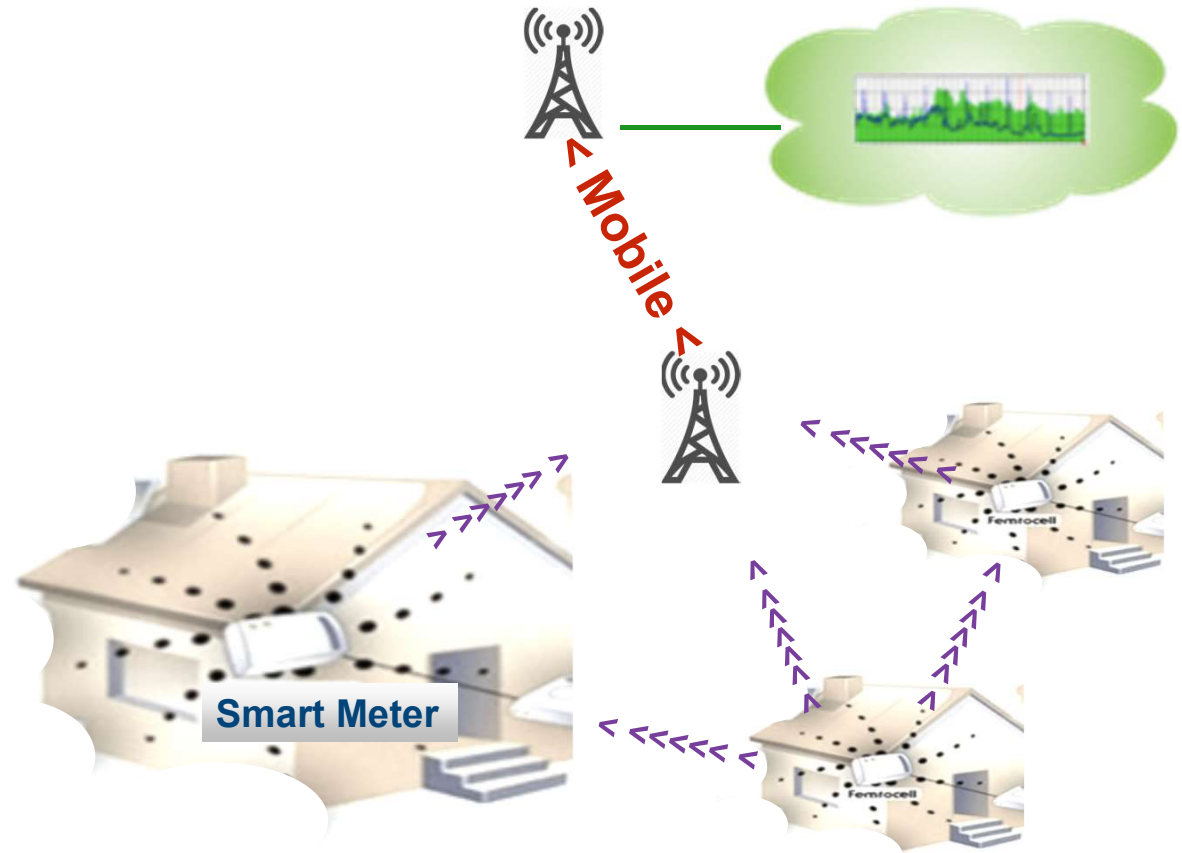


- System consists of sub-systems
- consists of components
  - security
  - privacy
  - dependability
- Computer analysis



# L14 – L15 Real World Examples

- Real world examples
  - taken from industry, e.g. Smart Meter
  - billing,
  - Controlling
- An overview on cloud security with examples from AWS
- Your own analysis
  - select system of choice
  - perform an analysis
  - group work of 2-3 persons



[source: [seminaronly.com](http://seminaronly.com)]

# L16 – L17 – Cloud security



- An introduction to AWS and AWS IoT will be given with relevant security infrastructure components

# L18 – L19 – Recent news and Wrap-up



- L18: what has happened since we started in January
- L19: Wrap-up, what you can expect on the exam

# UNIK4750 exam

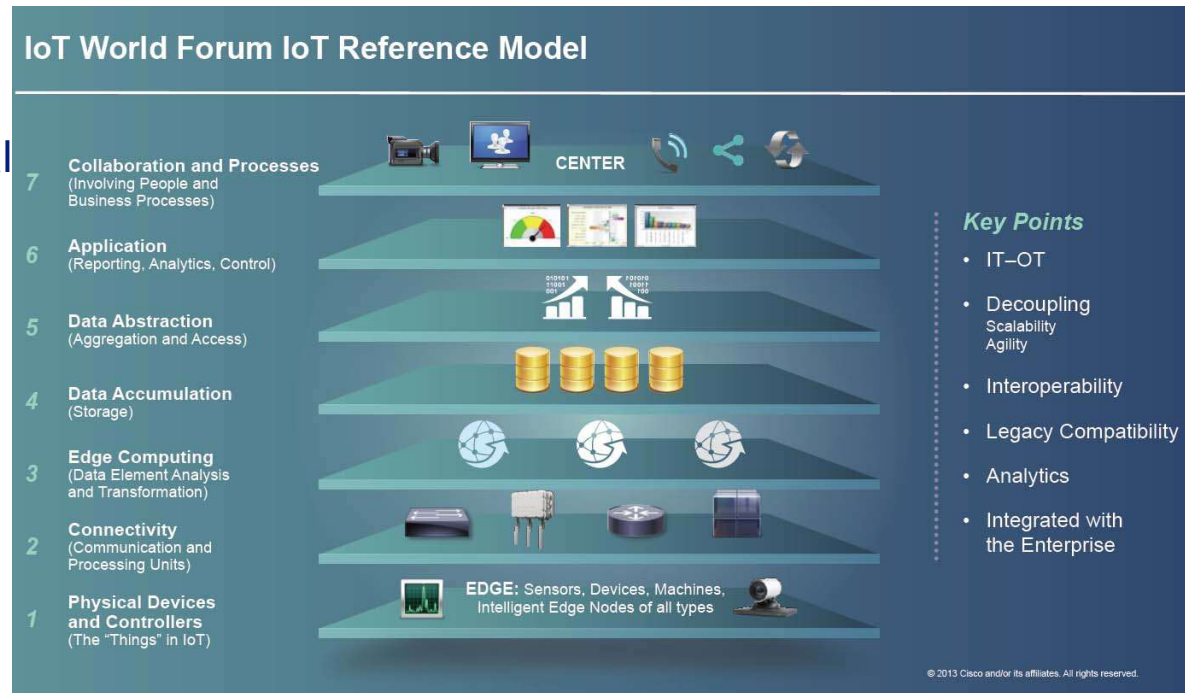


- The final grade is based on
  - a portfolio assessment (40%)
  - an oral exam (60%).
- Portfolio
  - paper presentation
  - group work
- Oral exam
  - explain your group work
  - questions to the group work
  - topics of the course



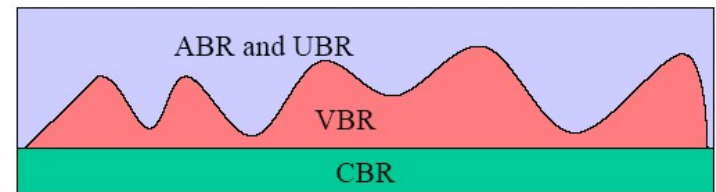
# Internet of Things

- Heading toward a fully connected world
- In a more focused way, in this course we speak about industrial internet of things
- The substantial difference is, that these systems have a physical dimension
- Considered as the next industrial revolution
- Automation to a new connectivity level – the internet is coming to automation
- Main challenges: how to join the physical and the logical world, how to achieve interoperability in a heterogeneous and conservative industry?



# Internet as we know it

- Intelligence in the end nodes
- Best effort traffic
- Infrastructure = network equipment
- Operated by IT or telecom
- No direct physical dimension
- Mostly built to serve human-generated traffic
  
- QoS: best effort, adopted to the human consumer: 10s of ms of drop is not a problem, stable delay is accepted, majority of applications are bursty
- Reaction time in 0.5-1s range
- Stochastic → services do exploit this (like Erlang-B formula for capacity estimation or lossy compression in nearly everything)
- High availability allows switchover in seconds



# Automation as we know it

- Centralized intelligence
- Traditionally operated as islands by operations
- Direct connection with the physical world
- Is made for information gathering and processing by machines
- Has a lag of approx. 15-20 years, but cost pressure is reducing it
- Still current questions: what happens if one has to share infrastructure with others, how to operate a link with long step-out distance, use of Java
- Economic press leads to adoption of internet-based services which *require* a paradigm change



Mine (Boliden)

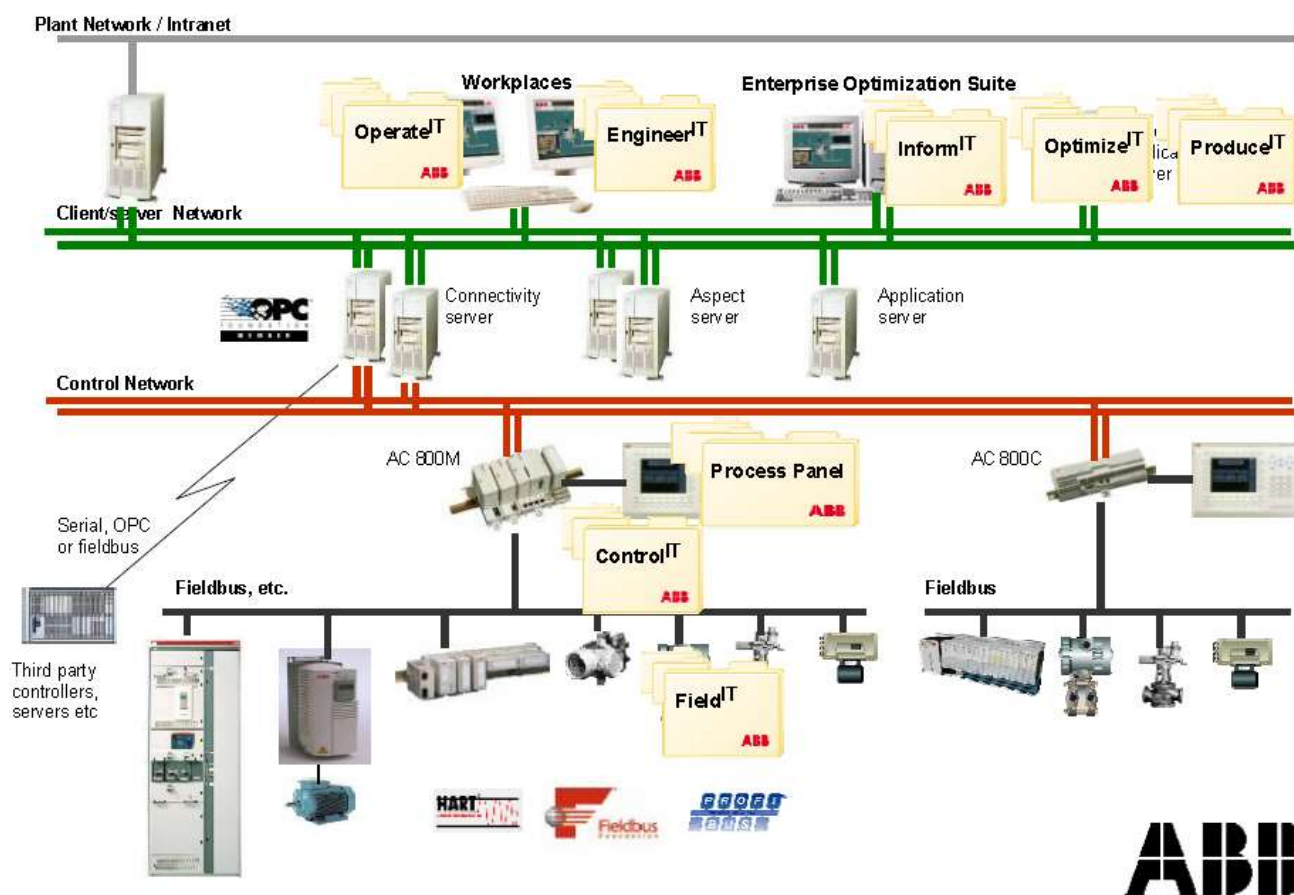


ABB robots



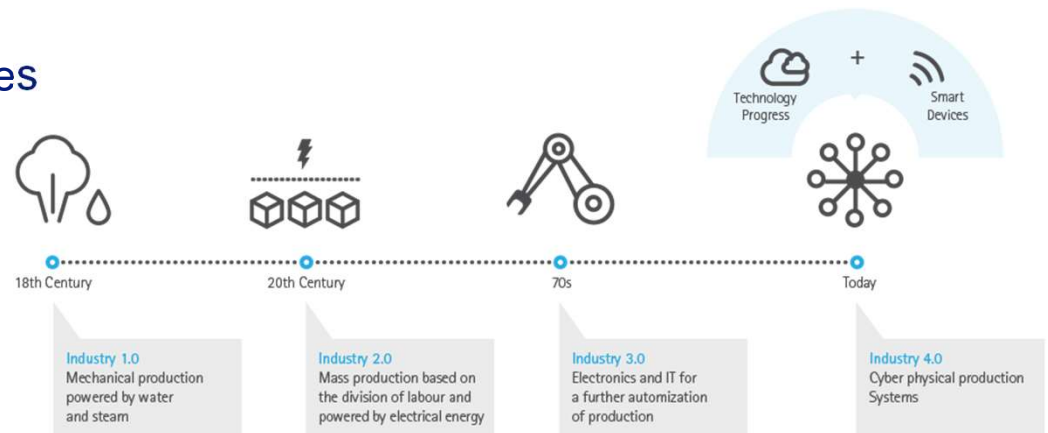
<http://www07.abb.com/images/libraries/provider104/Extended-Automation/control-room-consolidation-by-abb.png?sfvrsn=1>

# Typical traditional industrial network



## Merging these two

- Internet is the infrastructure – sensor, actuator, controller not on the same physical network any more
- "dissolves" the automation system in the internet
- Automation processes run over an unknown communication infrastructure
- Network communication gets physical impact
- Automation meets real internet-type deployment
- Already happening
- The real value of IoT: data.  
Cloud and big data will enable new services
- Challenges of security related to cloud services



<http://prd.accenture.com/microsites/digital-industry/images/digital/industrial-infographic-large.png>



## Interesting challenges

- Architecture: physical impact, end-to-end resource reservation, discovery, safety, security and privacy
  - Governance, interoperability, standardization
  - Managing risk in a system with impact on both logical and physical level
  - Provide QoS over a best effort infrastructure – with a price pressure
- 
- Aggregation of data: here lies the added value, enables novel services and higher efficiency
  - Distribution of intelligence: make the automation system more internet-like: intelligence in the end-nodes. Support it with the recent it trends of cloud and big data. Challenge for traditional automation mindset.
  - Open architectural model
  - Security concerns are a critical barrier for wide scale adoption of IoT
  - Cloud and IoT
- 
- See when IT has arrived to the phone industry. Or when IT has arrived into telco backhaul. IT is arriving to automation.

# IoT services



- Enabled by wide scale data gathering
- Monitoring of massive systems
- Real-time insight to processes
- Observation of systems
- Performance measurement and optimization
- Proactive and predictive methods
- To serve the automation goals, the services provided must be: scalable, distributed, have a real reference to the physical world (e.g. time), must ensure security and privacy of the users
- Just using existing security solutions is not leading to secure IoT deployments
- Composed by IT, operations and the IoT enabled objects
  
- \* Following slides are from the presentation of Mikhail Kader, DSE, Cisco, presented on the ITU Workshop on “ICT Security Standardization for Developing Countries”

# Connected Rail Operations \*



Cost savings, improved safety, superior service



# Smart City \*



## CONNECTED TRAFFIC SIGNALS

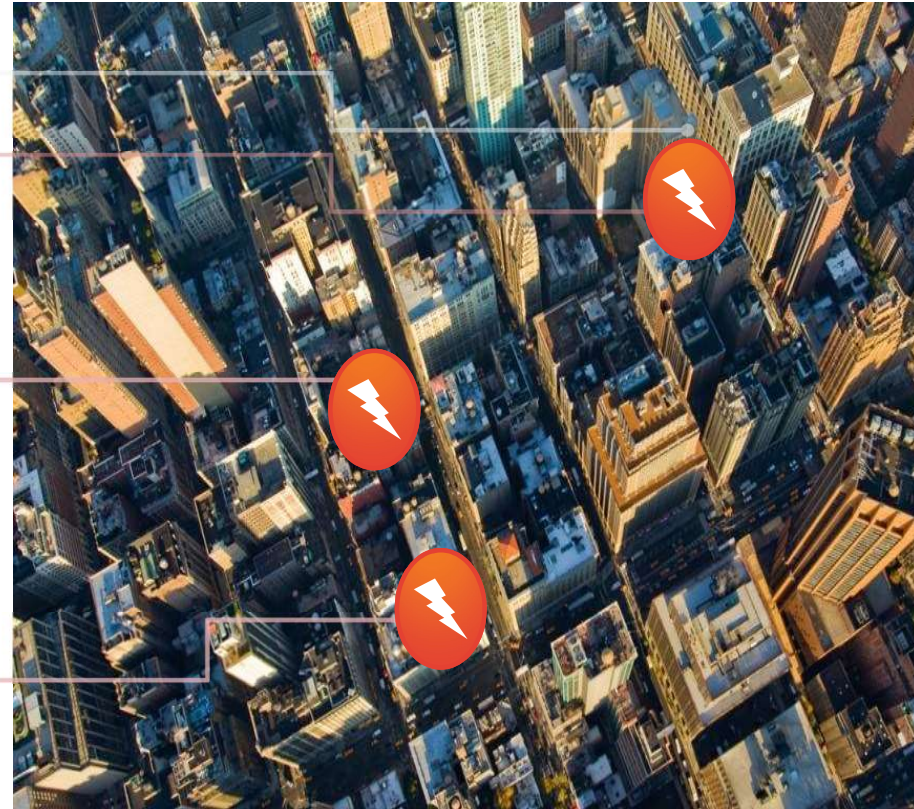
- + Reduced congestion
- + Improved emergency services response times
- + Lower fuel usage

## PARKING AND LIGHTING

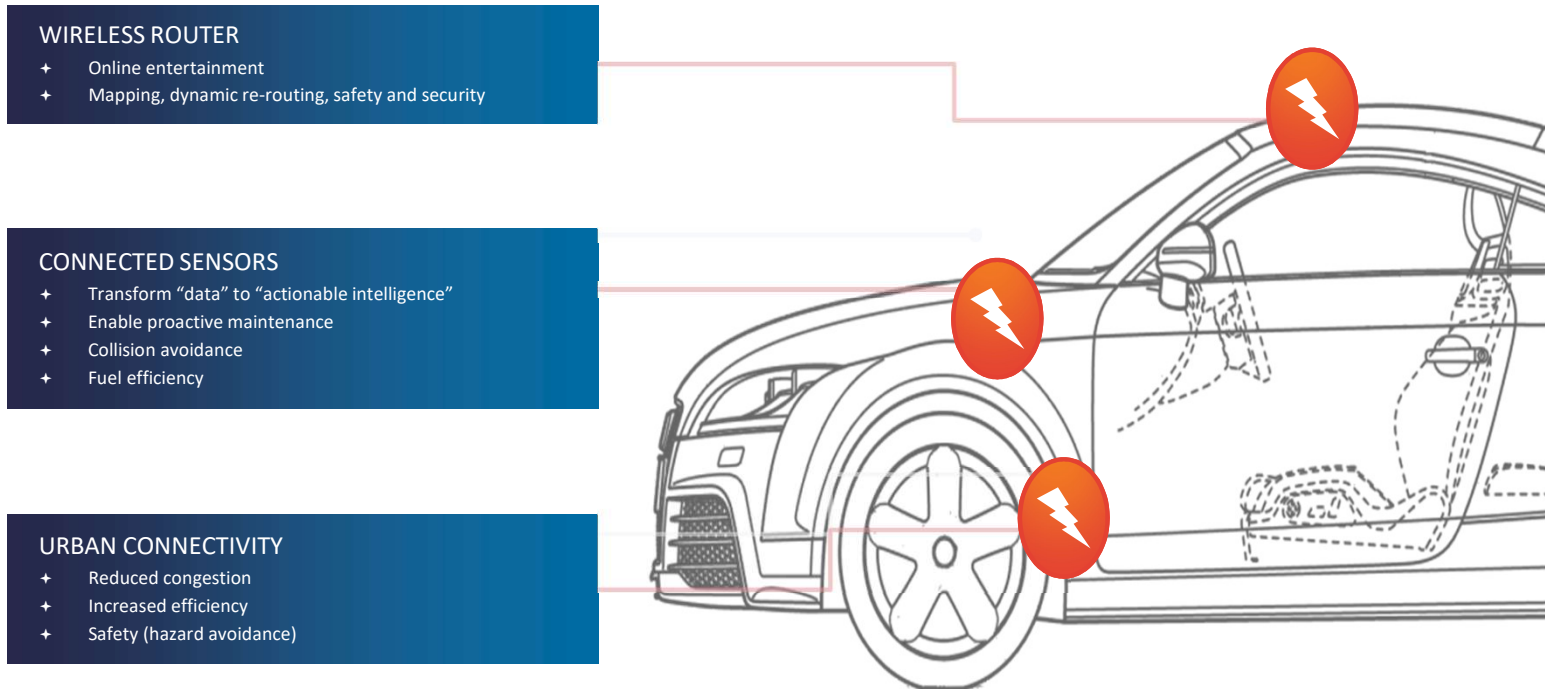
- + Increased efficiency
- + Power and cost savings
- + New revenue opportunities

## CITY SERVICES

- + Efficient service delivery
- + Increased revenues
- + Enhanced environmental monitoring capabilities



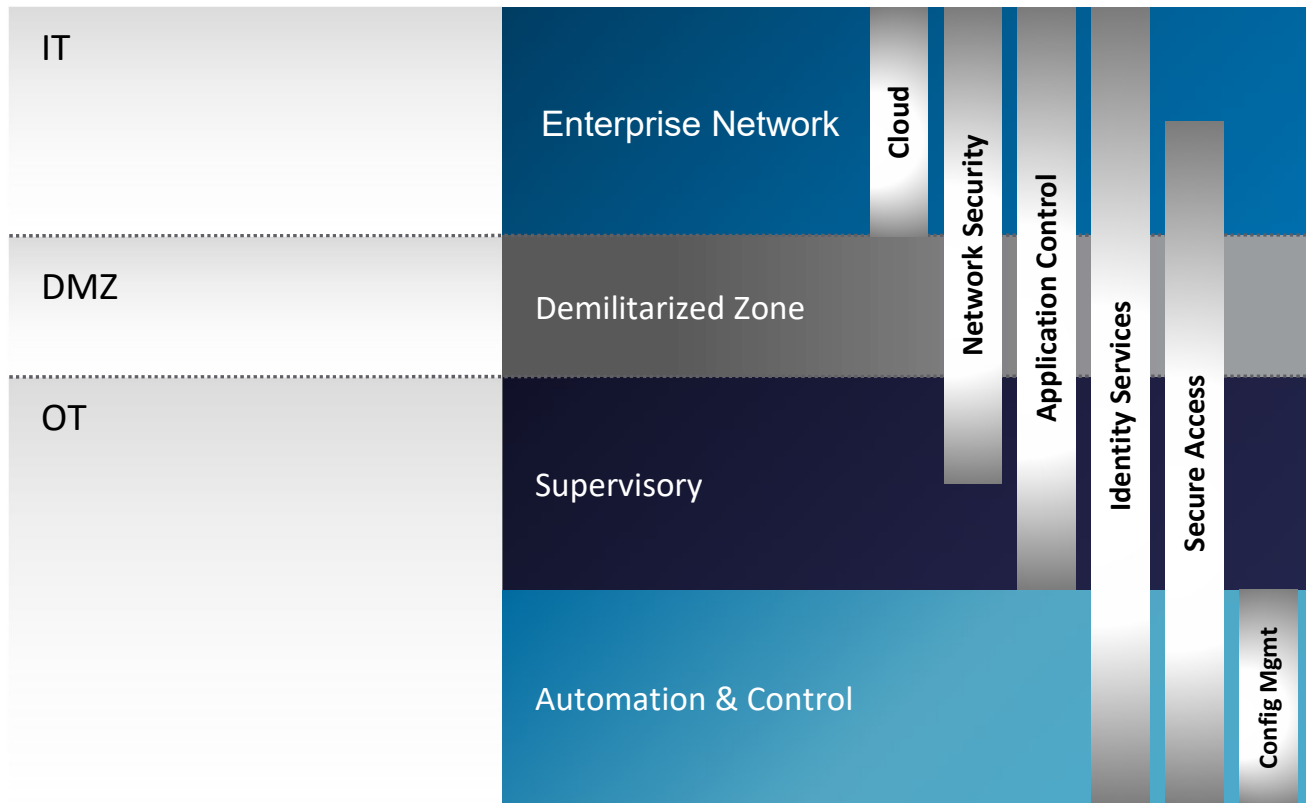
# The Connected Car \*



# IoT Expands Security Needs \*



# IT/OT Converged Security Model \*



# IT and OT are Inherently Different \*



## ● IT

- Connectivity: “Any-to-Any”
- Network Posture: Confidentiality, Integrity, Availability (CIA)
- Security Solutions: Cybersecurity; Data Protection
- Response to Attacks: Quarantine/Shutdown to Mitigate

## • OT

- Connectivity: Hierarchical
- Network Posture: Availability, Integrity, Confidentiality (AIC)
- Security Solutions: Physical Access Control; Safety
- Response to Attacks: Non-stop Operations/Mission Critical – Never Stop, Even if Breached



# What Can Lead to Breach in IoT Networks?

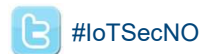
- What can't?
  - Billions of connected devices
  - Secure and insecure locations
  - Security may or may not be built in
  - Life cycle mismatch between IT and automation devices
  - Installed base
  - Clash between IT and OT, IT has to accept the traffic
- Any node on your network can potentially provide access to the core

# L1 Conclusions



- Overview over lectures
- Explanation of portfolio and exam
- Introduction to topic blocks
- Discussion

[Source of starred slides: Monique Morrow, Cisco]



Jan 2019, György Kálmán, Josef Noll