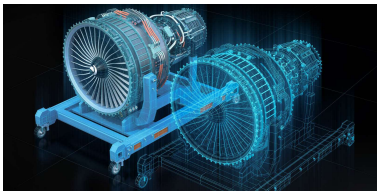
IoT Lecture 5



SensIDL

OPC UA

1

Scaling IoT Systems

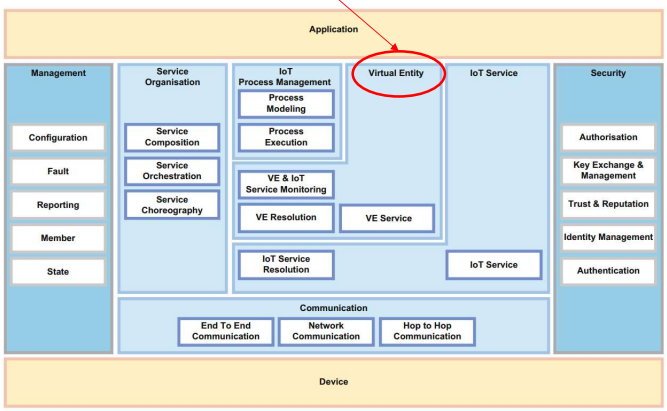
- IoT (academic model)
  - Interested in the virtualisation of physical things

Introduction
- **Lecture**
- Data Driven Modelling

Session 1: Digital Twin
- Digital
- Physical
- Industry 4.0

Session 2: OPC-UA
- Introduction
- Model
- Services

Session 3: Sens IDL
- Model



2

Lecture

School of Engineering
InES Institute of Embedded Systems

- Data Driven Model – oneM2M
  - Mapping onto protocols we know and love so far
- Introduction to the theme Digital Twin
- Introduction to the theme Industry 4.0
- Object Driven Model – OPC UA
  - Service oriented device.
- Semantic Driven Model – Sens IDL
  - Application is concerned with meaning not with communication

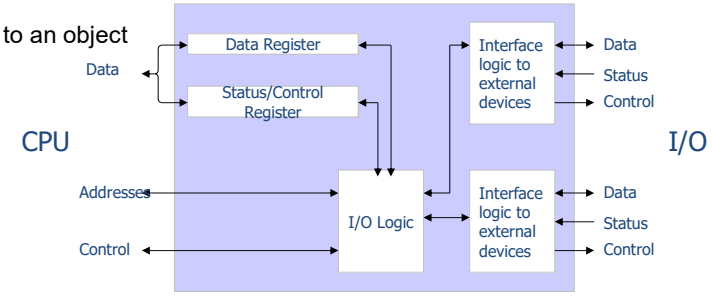
http://www.onem2m.org/images/files/deliverables/TS-0001-Functional_Architecture-V1_6_1.pdf

3

Data Driven Model (1)

School of Engineering
InES Institute of Embedded Systems

- oneM2M and LWM2M
  - Common services interface
  - Large scale device management
  - Follows classic I/O device abstraction
- Access data
  - Read and/or write
  - Execute by writing to an object



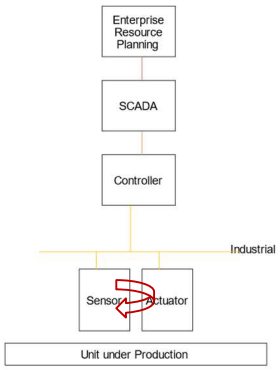
IIoT and privacy control.svg

4

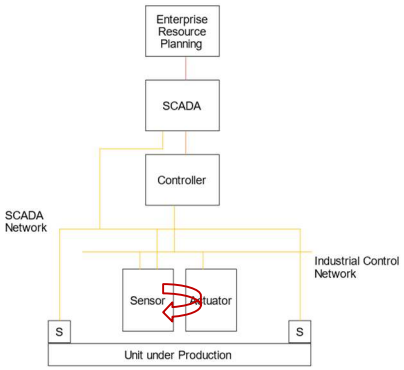
Data Driven Model (2)

School of Engineering
InES Institute of Embedded Systems

- Control Systems
  - Simple abstraction
  - Known in (Supervisory Control and Data Acquisition - SCADA) systems as “data-point”



IIoT and privacy control.svg



IIoT and privacy SCADA.svg

5

Data Driven Model (3)

School of Engineering
InES Institute of Embedded Systems

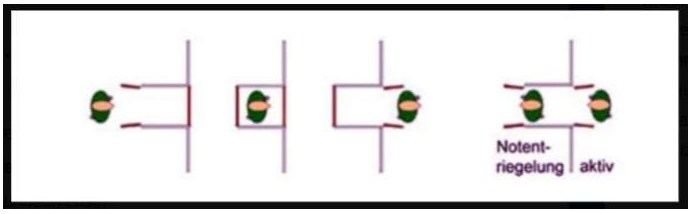
- Device Model
  - Programming model is given by interface
- Application model
  - Implicit in use by developer
    - `if value == x then y`
    - Some subset of the device model
- Problem: Applications don’t scale particularly well
- Problem: Services not well supported

6

Data Driven Modelling – Exercise

School of Engineering
InES Institute of Embedded Systems

- Security Lock-Gates
- Define what data-points are necessary

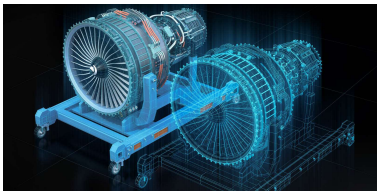


https://www.baunetzwissen.de/sicherheitstechnik/fachwissen/sicherheitsschleusen/kabinenschleusen-164884/gallery-1/1

7

IoT Lecture 5

School of Engineering
InES Institute of Embedded Systems



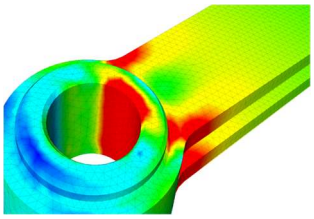
https://job-wizards.com/de/digital-twin-die-doppelte-chance-fuer-innovationsmoeglichkeiten/

8

Digital Twin – the Digital Side

School of Engineering
InES Institute of Embedded Systems

- Most physical “stuff” modelled in Computer Aided Design (CAD)
- Simulation also possible in CAD
  - Finite Element Analysis
  - Object divided up into element
  - Effects of one element on surrounding elements modelled
  - Simulation can show up weak spots
- Problem: big gap between model and real-world failure analysis
- Problem: how can excessive and normal wear-and-tear be modelled
- Idea: Digital Twin -> Industrial Internet of Things



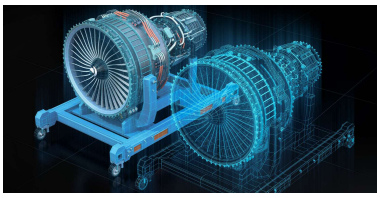
https://www.simscale.com/blog/2019/05/fea-for-beginners/

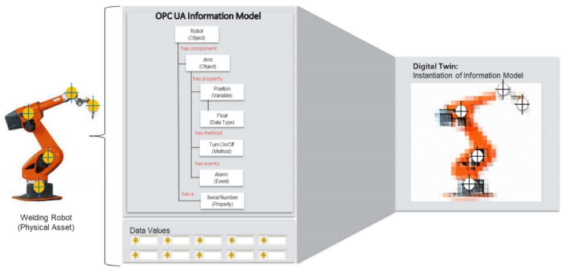
9

Digital Twin – the Physical Side

School of Engineering
InES Institute of Embedded Systems

- Digital Twin is the exact copy – to run-time - of the physical entity
- Problem: how many samples at what sample points adequately describe the physical entity





https://job-wizards.com/de/digital-twin-die-doppelte-chance-fuer-innovationsmoeglichkeiten/
https://opcconnect.opcfoundation.org/2018/08/how-opc-ua-information-modeling-powers-iiot-i4-0-era-products/

10

Practical Example

School of Engineering
InES Institute of Embedded Systems

- Rolls-Royce
  - Used to sell airplane engines
    - Airlines used to service engines themselves
    - Airlines then used to farm out service to third parties (f.i. SRTechnics)
  - Engine
    - Cost ca 16 mil. USD
    - 36k gallons fuel / ca 5k USD per hour

  - Idea – why not sell engine use rather than the engine
    - Services oriented business model
    - Requires efficiency wrt maintenance …

Practical Example (2)

School of Engineering
InES Institute of Embedded Systems

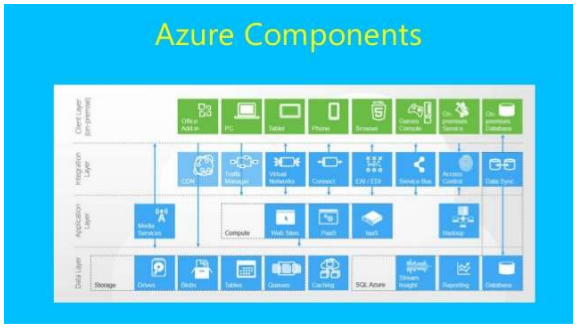
- Each engine equipped with ca 100 sensors
- Transmit information during flight via satellite
- Small errors corrected in-flight
  - ~180 engineers analysing data
- Serious errors repaired on landing by RR-technicians
- + RR – added revenue from know-how
- + airlines
  - per use business model
  - necessary maintenance interruptions only

- Result – 100 sampling points describes the engine in practice

Practical Example (3)

School of Engineering
InES Institute of Embedded Systems

- Data Analysis for RR handled in MS cloud (Azure)



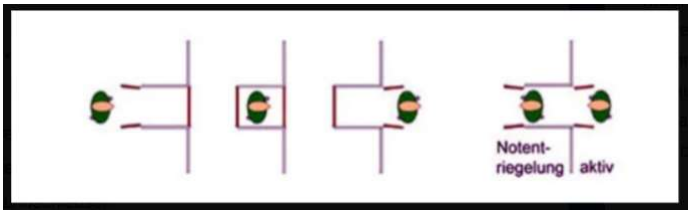
- MS rates the IIoT/Industry 4.0 highly
  - Has integrated OPC-UA via Advanced Message Queuing Protocol (AMQP) (big sister to MQTT)

https://www.linkedin.com/topic/microsoft-azure

Digital Twin – Exercise

School of Engineering
InES Institute of Embedded Systems

- Security Lock-Gates
- Define the Digital Twin

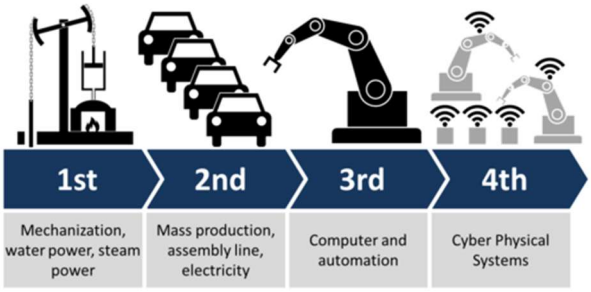


https://www.baunetzwissen.de/sicherheitstechnik/fachwissen/sicherheitsschleusen/kabinenschleusen-164884/gallery-1/1

What is Industry 4.0 (1)

School of Engineering
InES Institute of Embedded Systems

- Interoperability:
  - The ability of machines, devices, sensors, and people to connect and communicate with each other via the Internet of Things (IoT) or the Internet of People (IoP).



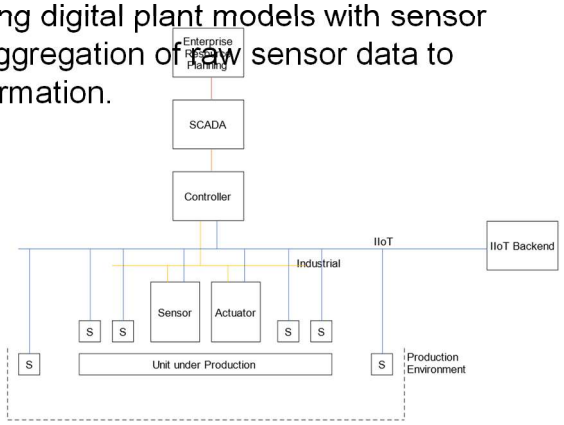
https://en.wikipedia.org/wiki/Industry_4.0

15

What is Industry 4.0 (1)

School of Engineering
InES Institute of Embedded Systems

- Information transparency:
  - The ability of information systems to create a virtual copy of the physical world by enriching digital plant models with sensor data. This requires the aggregation of raw sensor data to higher-value context information.



IIoT and privacy logical.svg

16

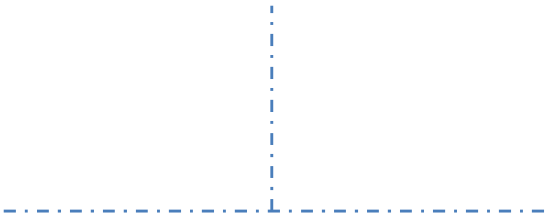
What is Industry 4.0 (2)

- Technical assistance:
  - First, the ability of assistance systems to support humans by aggregating and visualizing information comprehensibly for making informed decisions and solving urgent problems on short notice. Second, the ability of cyber physical systems to physically support humans by conducting a range of tasks that are unpleasant, too exhausting, or unsafe for their human co-workers.
- Decentralized decisions:
  - The ability of cyber physical systems to make decisions on their own and to perform their tasks as autonomous as possible. Only in case of exceptions, interferences, or conflicting goals, tasks are delegated to a higher level.

https://en.wikipedia.org/wiki/Industry_4.0

17

IoT Lecture 5

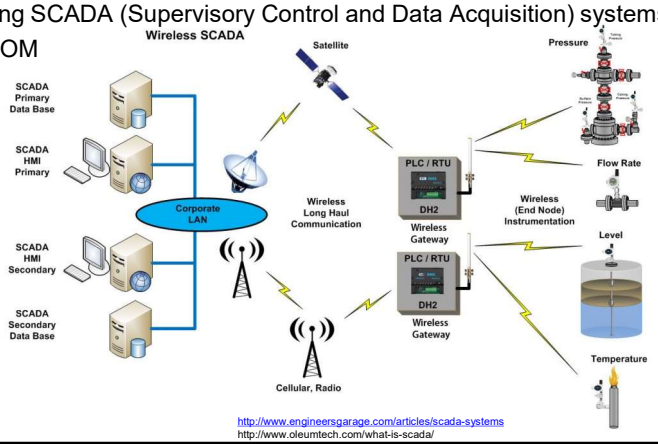


18

What is OPC-UA?

School of Engineering
InES Institute of Embedded Systems

- OPC
  - Open Platforms Communication (https://opcfoundation.org/)
  - Controller to controller communication protocol
  - Used, f.i. in building SCADA (Supervisory Control and Data Acquisition) systems
  - Based on MS DCOM



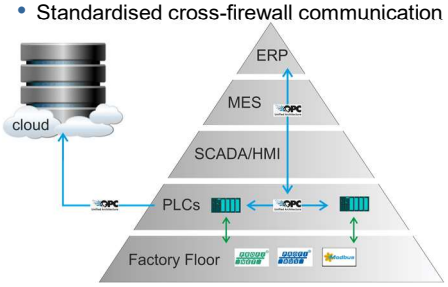
http://www.engineersgarage.com/articles/scada-systems
http://www.oleumtech.com/what-is-scada/

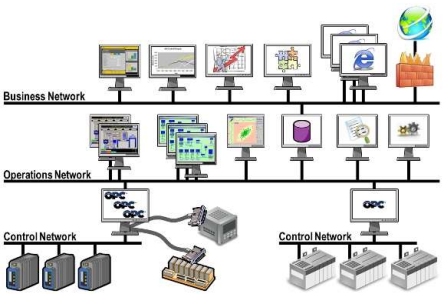
19

What is OPC-UA?

School of Engineering
InES Institute of Embedded Systems

- OPC-UA
  - Drops MS DCOM for XML (Data Access, DA) and web services
  - Embeddable
  - Standardised cross-firewall communication





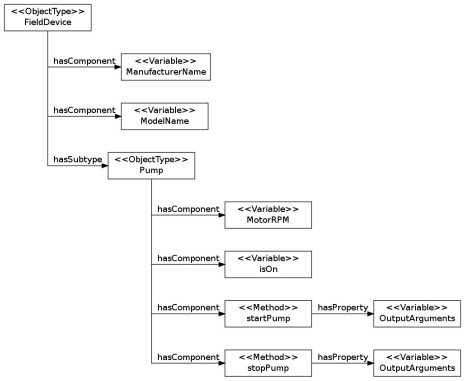
https://opcfoundation.org/products/view/opc-uada-server-for-windows
http://www.automationmedia.com/ARDetail.asp?ID=73

20

OPC-UA Object Model

School of Engineering
InES Institute of Embedded Systems

- Client-server architecture
- Binary protocol - opc.tcp://Server
- Web services protocol (SOAP/HTTP) opc.http://Server



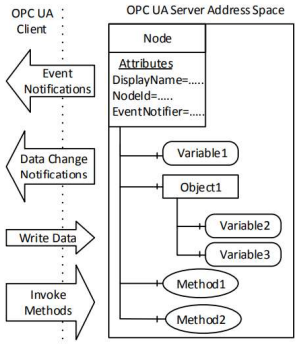


Fig.3. OPC UA nodeclass [27]

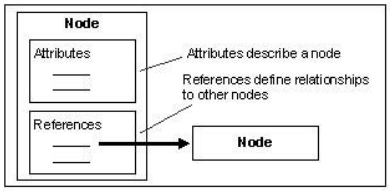
http://open62541.org/doc/current/tutorial_noderelations.html#creating-object-instances/
https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7325527

21

OPC-UA Object Model

School of Engineering
InES Institute of Embedded Systems

- Servers can be aggregated
  - Multiple servers behind the services of a single server



http://open62541.org/doc/current/tutorial_noderelations.html#creating-object-instances/

22

OPC-UA Base Services

School of Engineering
InES Institute of Embedded Systems

- Server offers base services
  - **View** is what the client is allowed to see and is configurable for a class of clients
  - **MonitoredItem** -> similar to CoAP's observe
  - **Method** -> invoke methods

Service Set	Description
SecureChannel Service Set	retrieve endpoint and security configuration to establish a secure connection
Session Service Set	create and administrate user-specific connection between application
NodeManagement Service Set	modify the server's address space (if permitted)
View Service Set	navigate and follow (hierarchical) references in the server's address space, search for and filter information
Attribute Service Set	read and write attributes of (an) node(s), especially the value attribute, but historical data or events as well
Method Service Set	invoke methods which a server provides at the nodes in its address space
MonitoredItem Service Set	create a set of attributes of nodes to be monitored by the server and for which changes should be reported
Subscription Service Set	create, modify, or delete monitored items
Query Service Set	perform a filtered search for information in the server's address space

http://open62541.org/doc/current/tutorial_noderelations.html#creating-object-instances/

23

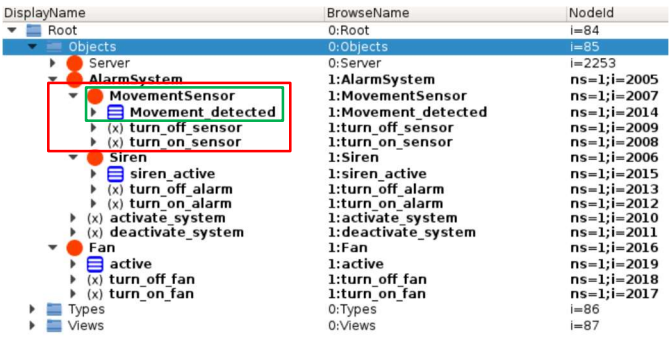
OPC-UA Views

School of Engineering
InES Institute of Embedded Systems

- The use of views – and permissions – can restrict the access to features of devices.
  - Compare to oneM2M where once a device is discoverable all of the features are open.

View supervisor

View operator



http://open62541.org/doc/current/tutorial_noderelations.html#creating-object-instances/

24

OPC-UA Aggregation

School of Engineering
InES Institute of Embedded Systems

- Server offers accesses
  - Data Access – read/write
  - Historical Data Access
- Aggregation methods are also offered

Include	Name	Opt.	Description
☑	Aggregate Subscription – Filter	☐	Supports Aggregate subscription filters which requires at least one of the defined Aggregates is supported as defined in Part 13.
☑	Aggregate Subscription – Interpolative	☑	Supports subscription filter for the Interpolative Aggregate.
☑	Aggregate Subscription – Average	☑	Supports subscription filter for the Average Aggregate.
☑	Aggregate Subscription – TimeAverage	☑	Supports subscription filter for the TimeAverage Aggregate.
☑	Aggregate Subscription – TimeAverage2	☑	Supports subscription filter for the TimeAverage2 Aggregate.
☑	Aggregate Subscription – Total	☑	Supports subscription filter for the Total Aggregate.
☑	Aggregate Subscription – Total2	☑	Supports subscription filter for the Total2 Aggregate.
☑	Aggregate Subscription – Minimum	☑	Supports subscription filter for the Minimum Aggregate.
☑	Aggregate Subscription – MinimumActualTime	☑	Supports subscription filter for the MinimumActualTime Aggregate.
☑	Aggregate Subscription – Minimum2	☑	Supports subscription filter for the Minimum2 Aggregate.
☑	Aggregate Subscription –	☑	Supports subscription filter for the MinimumActualTime2 Aggregate.

http://open62541.org/doc/current/tutorial_noderelations.html#creating-object-instances/

25

OPC-UA Future

School of Engineering
InES Institute of Embedded Systems

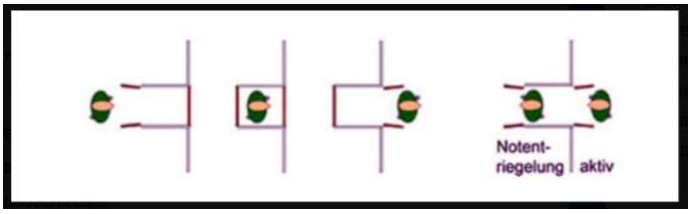
- New features
  - **Heartbeat**
  - **Buffering of data –** for lossy networks
  - **Redundancy –** two servers do the same thing
- Requirement of the automation industry
  - Pub-Sub model

26

OPC –UA – Exercise

School of Engineering
InES Institute of Embedded Systems

- Security Lock-Gates
- Make an Object-Model of the Security Gates



https://www.baunetzwissen.de/sicherheitstechnik/fachwissen/sicherheitsschleusen/kabinenschleusen-164884/gallery-1/1

27

IoT Lecture

School of Engineering
InES Institute of Embedded Systems

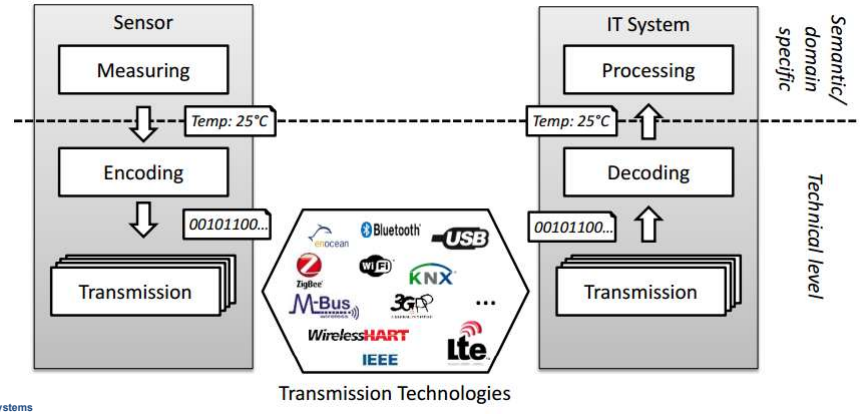
SensIDL

28

SensIDL (1)

School of Engineering
InES Institute of Embedded Systems

- Generic framework for sensor communication interfaces
  - (http://sensidl-project.github.io/SensIDL/)
- Let application developer operate on the semantic level

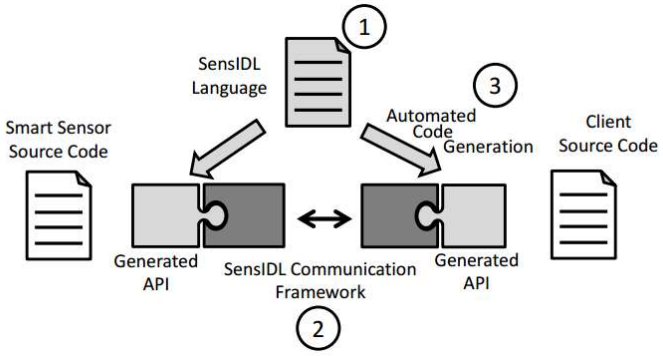


29

SensIDL (2)

School of Engineering
InES Institute of Embedded Systems

- Provide a model of the system in SensIDL language
- On top of a generic communication API define the sensor specific communication
- Generate code for client and sensor and implement.

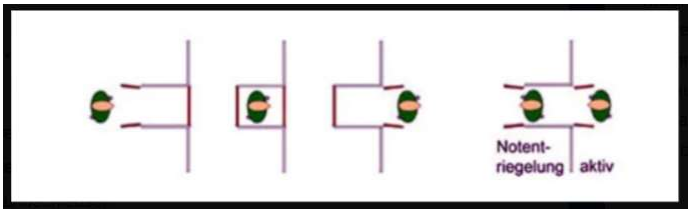


30

Sens IDL – Exercise

School of Engineering
InES Institute of Embedded Systems

- Security Lock-Gates
- Make a semantic Model of the Security Gates



https://www.baunetzwissen.de/sicherheitstechnik/fachwissen/sicherheitsschleusen/kabinenschleusen-164884/gallery-1/1