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Visions to Products

Generic Sensor Interface Description Language for Wireless Sensor Communication

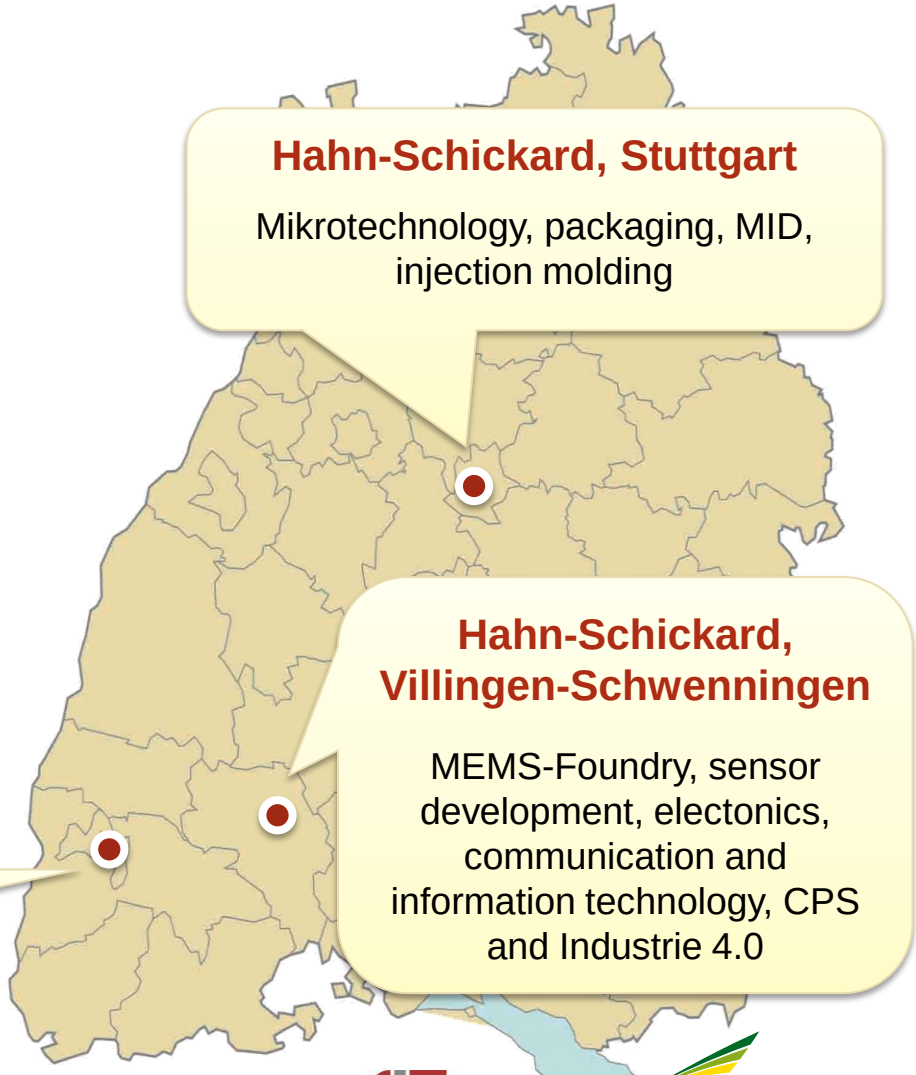
Dr. Christoph Rathfelder

Hahn-Schickard,
Villingen-Schwenningen

Hahn-Schickard

Foundation for Applied Research

- Budget 2015: ~ 17,5 Mio. €
  (~ 5 Mio. € Industry)
- Employes 2015: 152 FTE
- Certified DIN EN ISO 9001:2008
- Part of Innovationsallianz Baden-Württemberg



Hahn-Schickard, Stuttgart

Mikrotechnology, packaging, MID, injection molding

Hahn-Schickard, Villingen-Schwenningen

MEMS-Foundry, sensor development, electonics, communication and information technology, CPS and Industrie 4.0

Hahn-Schickard, Freiburg

Lab-on-a-Chip design + foundry, bio chemical micro analysis, micro electronics

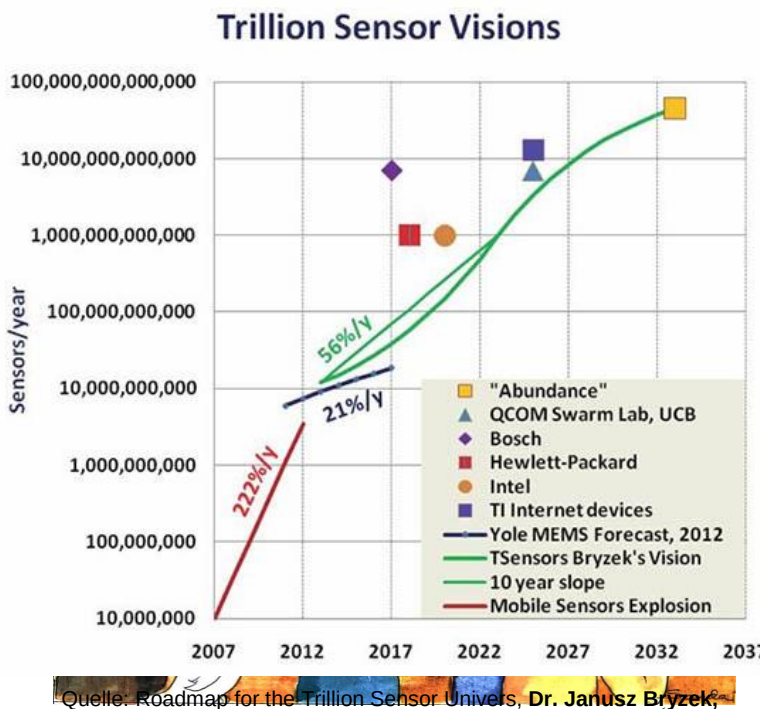
Motivation

Communication requires

- A common understanding
- A common language

Continuing growth of connected and communicating sensors

- Industrie 4.0
- Smart Home
- Internet of Things



Quelle: Roadmap for the Trillion Sensor Univers, **Dr. Janusz Bryzek**, Fairchild Semiconductor, Chair of TSensors Summit

Examples

Indoor localisation

Examples

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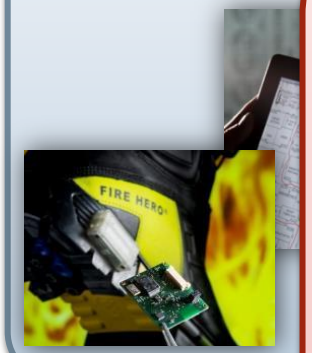
Indoor loca

Monitoring and gesture recognition

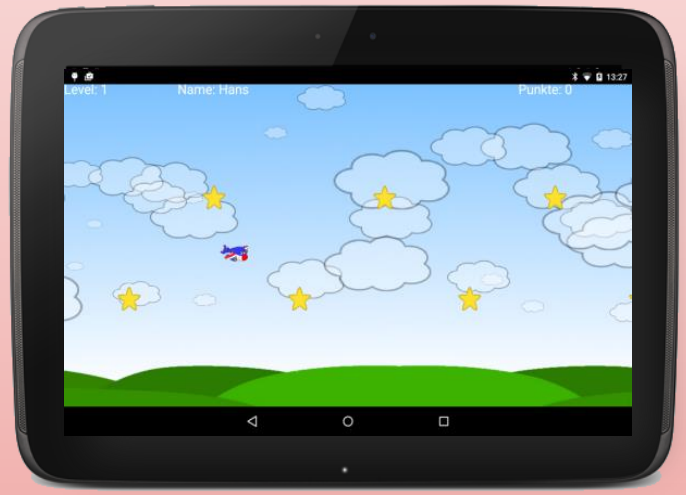
Examples

Indoor localisation



Monitoring and gesture

Increasing motivation by gamification



Examples

Indoor localisation

Monitoring and gesture

Increasing motivation by
mification

Energy harvesting integrated into a show

Examples

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Indoor localisa

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fication

Energy har
integrated int

Intelligent tooth space

Examples

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Indoor locali

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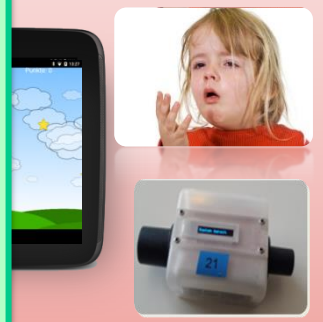

Energy ha
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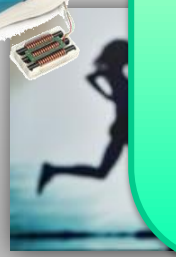
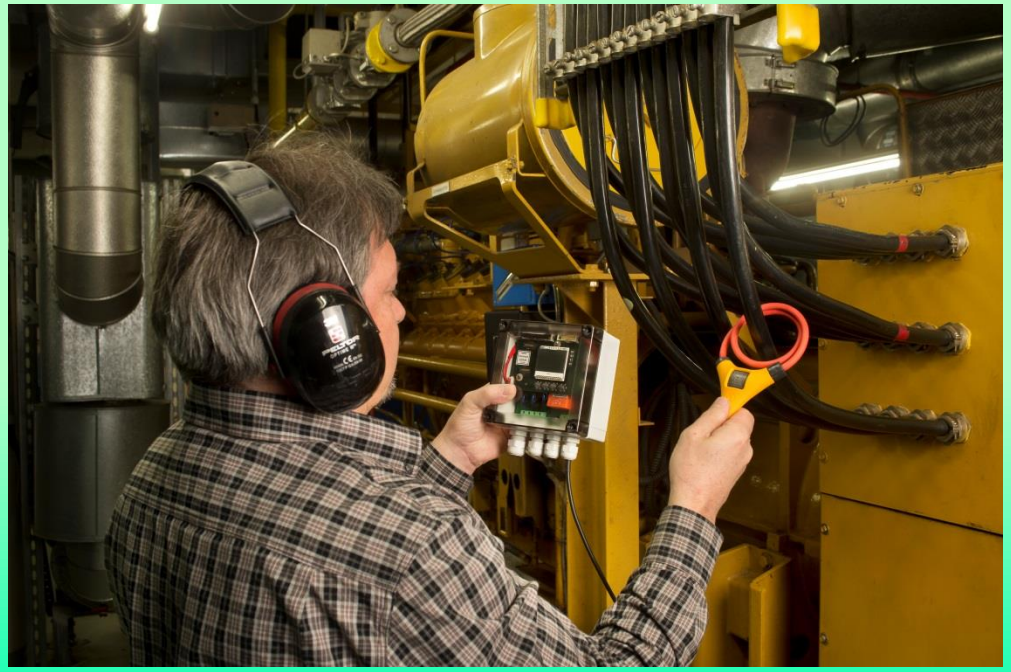


Sensors systems for production



Sensor systems on the shop floor
Indistrie 4.0

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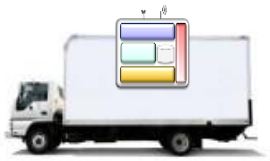
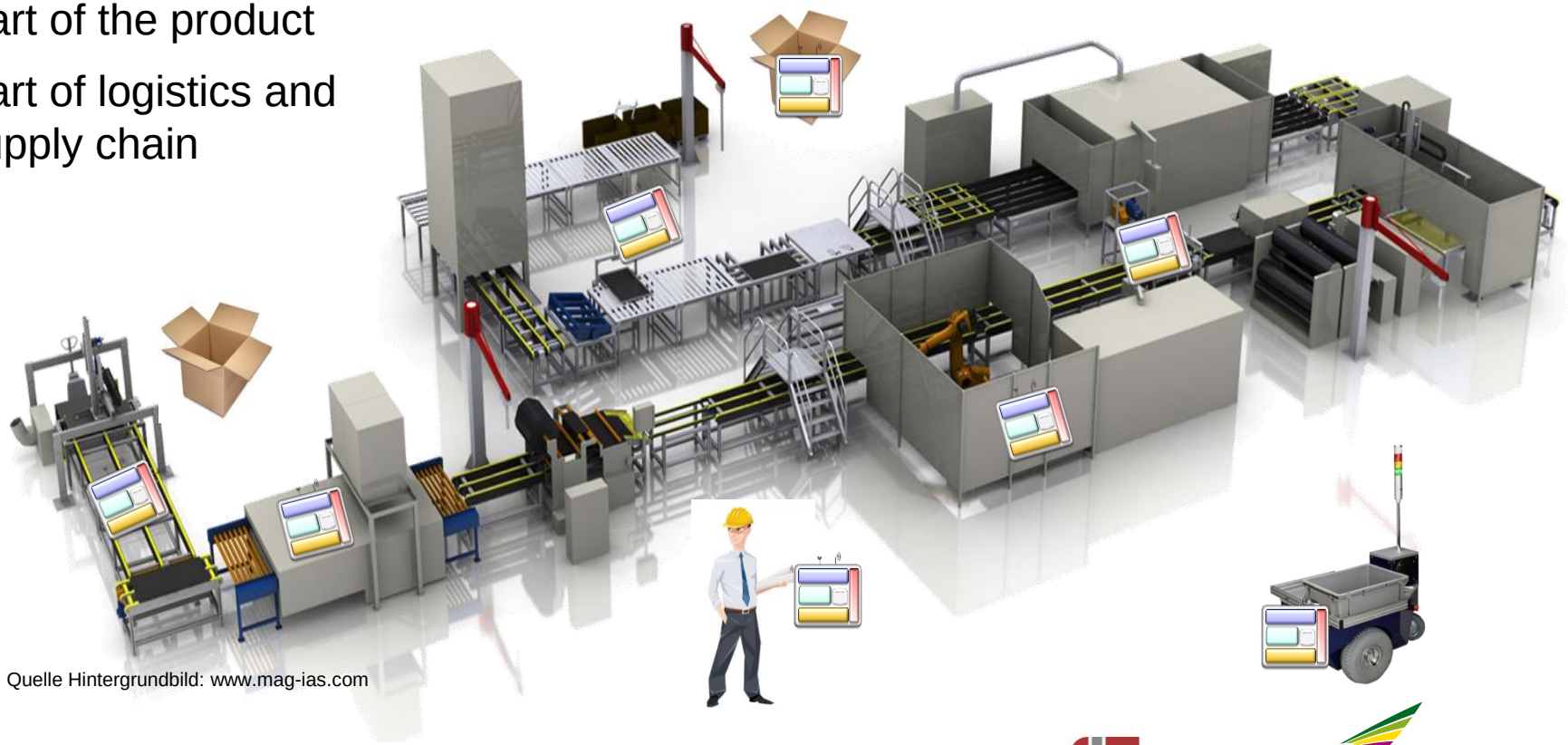
- Sensors and actors integrated in the environment
- Mobile units moving on the shop floor
- Production machines and facilities
- Part of the product
- Part of logistics and supply chain





Quelle Hintergrundbild: www.mag-ias.com

Modular sensor design

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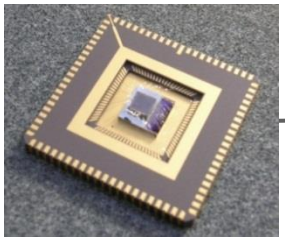
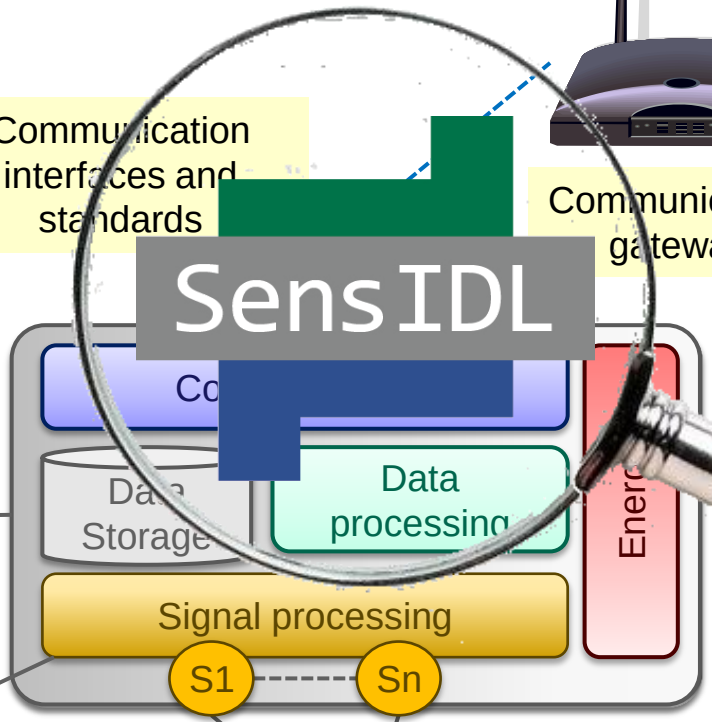
Apps and visualisation

Communication interfaces and standards

Communication gateway

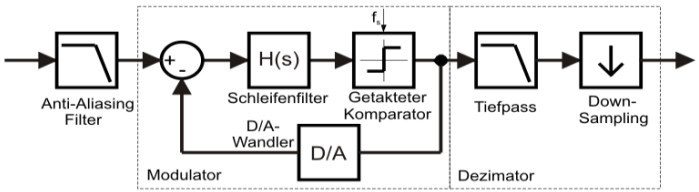
Micro electronics and integration

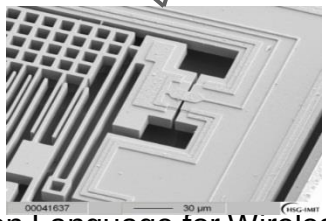




Energy Harvester

Readout Curcuit
Low Power / Low Voltage
Delta-Sigma Technology





MEMS-Sensor design

SensIDL

Sensor Interface Description Language

http://www.sensidl.de

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FZI

Gefördert durch:

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aufgrund eines Beschlusses des Deutschen Bundestages

IGF-Vorhaben: 18363 N

SensIDL

- **A software toolbox for sensor developer**
- **Simplifying the implementation of communication interfaces**

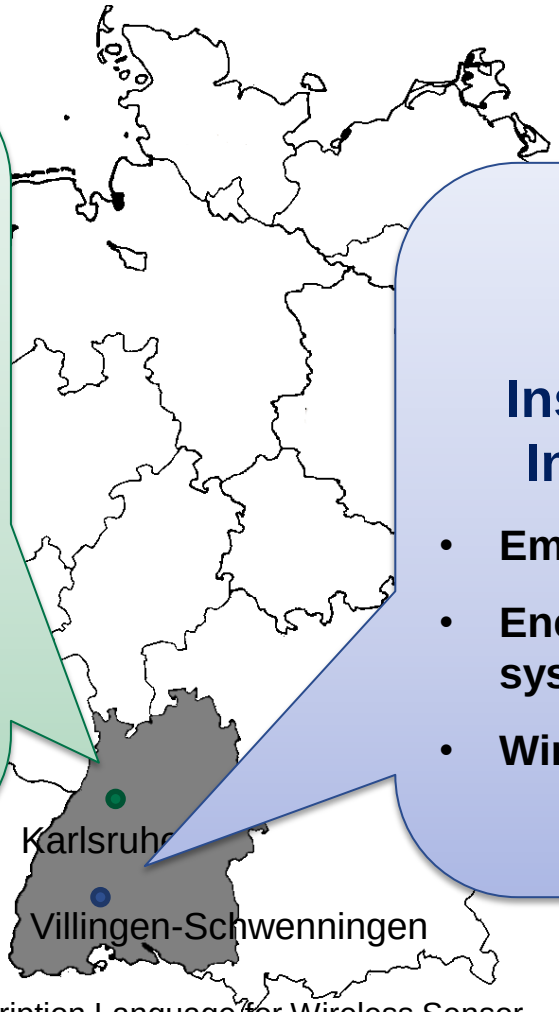
Image source: http://blog.conqueryourdebt.org/2013/08/14/how-to-prepare-for-unexpected-medical-costs/toolbox-with-tools-skrewdriver-hammer-handsaw-and-wrench/

Cooperating research institutes

FZI

FZI Forschungszentrum Informatik

- **Software Engineering**
- **Software architecturs**
- **Model driven development**
- **House of Living Labs**



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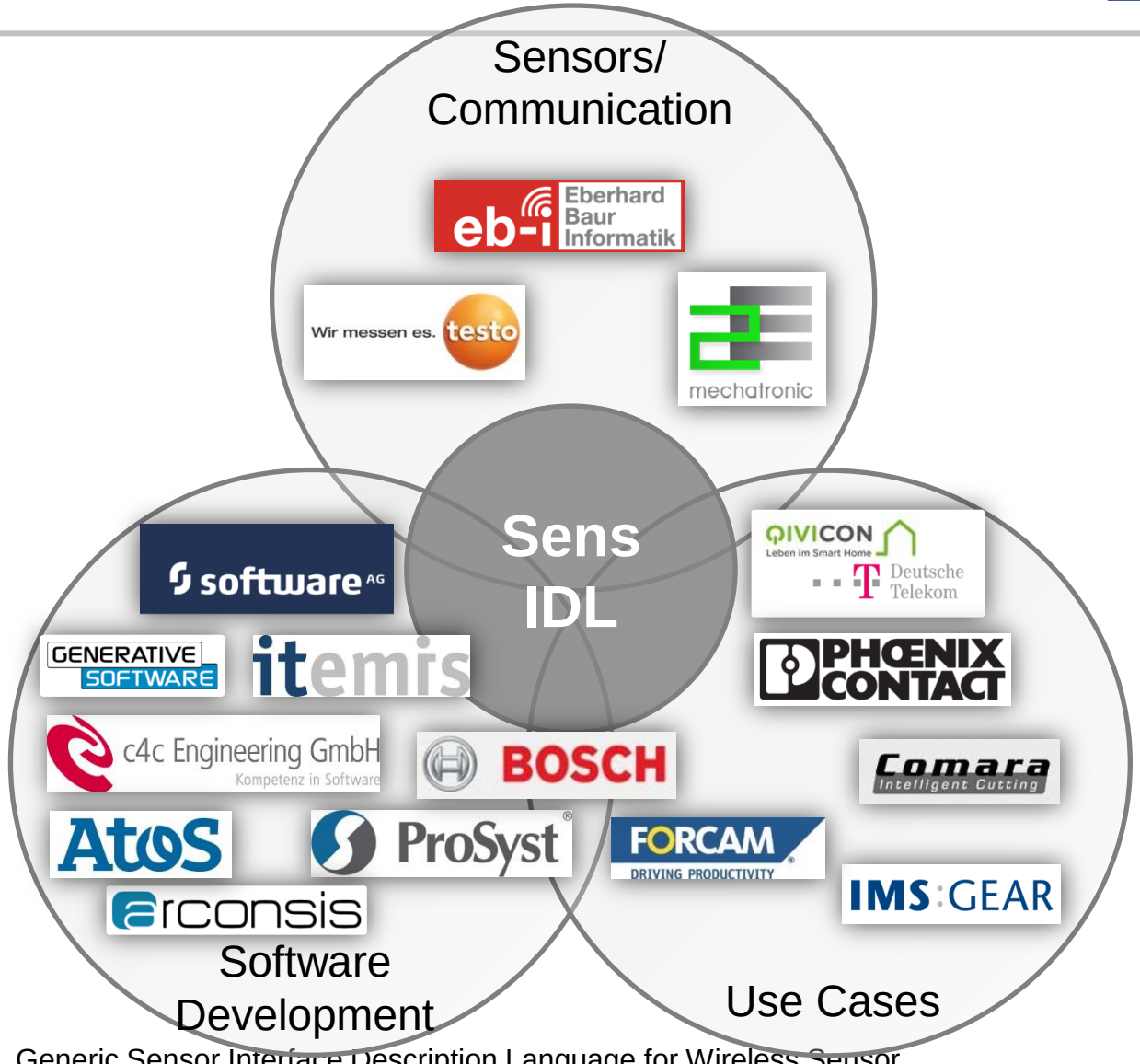
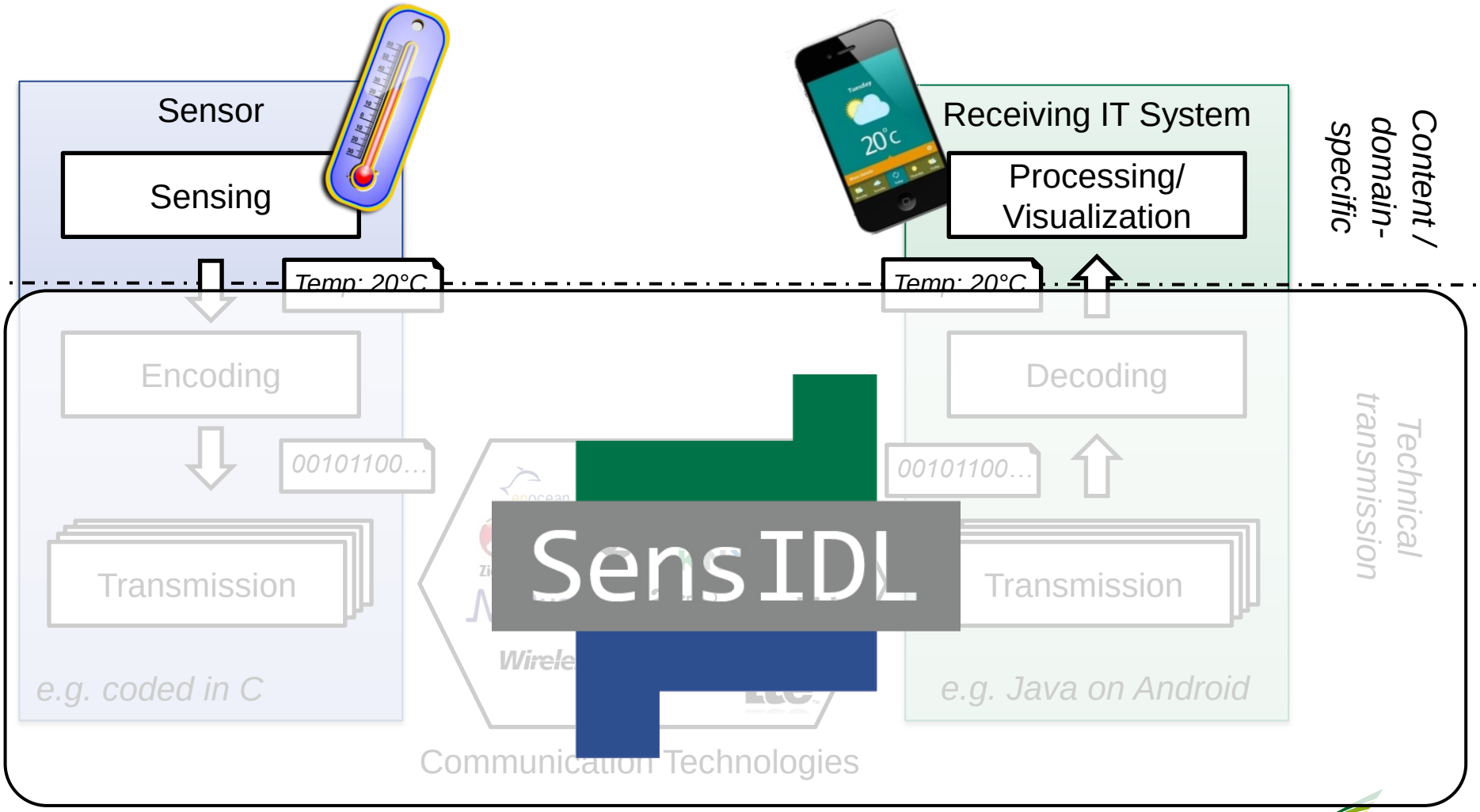
Institut für Mikro- und Informationstechnik

- **Embedded software**
- **Energy efficient sensor systems**
- **Wireless communication**

Industrial Accompanying Committee



The long Way from Sensors to IT Systems



Objectives of SensIDL

Support for both developer roles

- Sensor and embedded developer
- Data processing within the receiving IT system

Simplification and automation of development steps

- Tool support
- Generation of code
- Documentation with additional value

Increase of efficiency and quality

- Automation of recurring tasks
- Focusing on application-specific details

Expected SensIDL Results

5 Integrated tool chain

1 SensIDL Interface Description Language

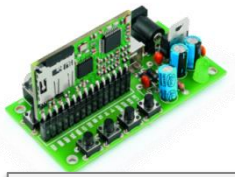
Interface description

3 SensIDL Code Generators

Source code smart sensor

Automated code generation

Source code receiver



specific API

2 SensIDL Communication framework

specific API

4 Reference demonstrator

Central Question to be Answered

SensIDL

FZI Hahn Schickard

Interface description language

- Which information needs to be modeled?
- Abstraction of implementation- and platform-specific details

Reference demonstrator

- Beeing representative for different apllication domains (e.g. Smart Home and Industrie / Production)
- Basis to derive code generators

Communication

- How to transmit data in a generic and efficient way?

Code generators and automation

- Identification of recurring code fragments?
- Identification of recurring development tasks?

SensIDL Toolchain

Used Technologies within the SensIDL Development Tool

SensIDL Tool

- Eclipse-bases plugins
- Integrated tool chain

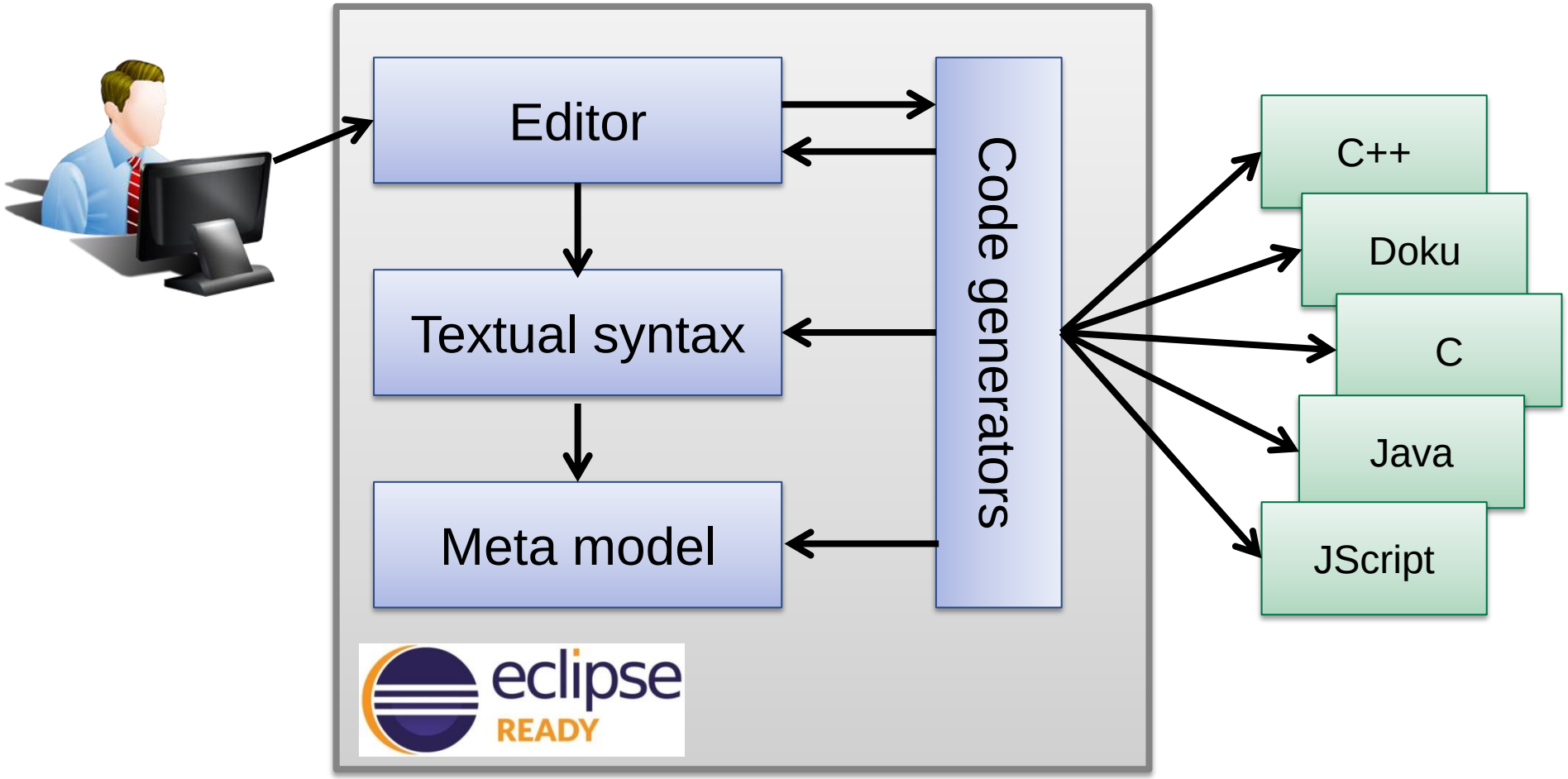
SensIDL Language

- Model / language for describing sensor data
- Textual editor based on Xtext
  - Eventually additional graphical editor

SensIDL Code Generators

- Code templates based on Xtend
- Automated code generation

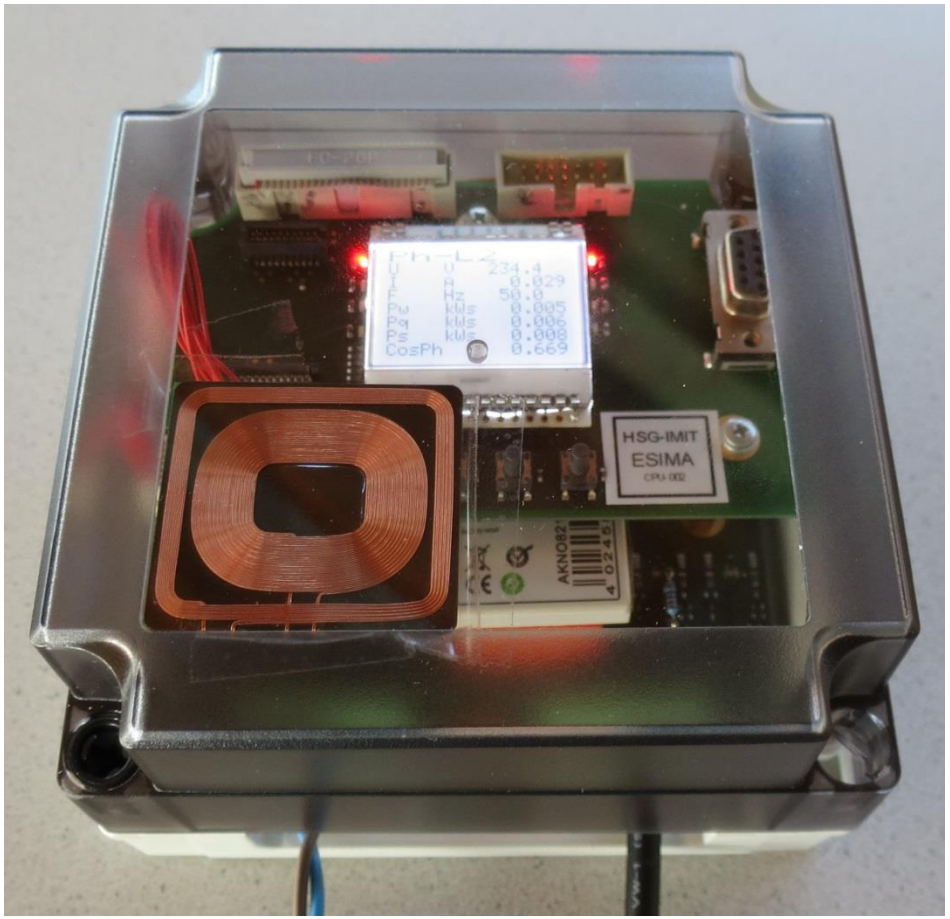
Architecture overview



Example system E-Meter

E-Meter measures electricity

- Designed for larger production machines (> 10kW)
- Installable without interrupting the system
- Modular wireless communication supporting different standards
- Transmitting collected data each second



Documentation based on Excel

Excerpt:

Datenstrukturen E- Meter: Von Sensor --> Datenbank (Messwerte)

Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7	Byte8	Byte9	Byte10	Byte11	Byte12	Byte13	Byte14			
Gerätetyp (dezimal)	Record-Typ (dezimal)	Data	Data	Data	Data	Data	Data	Data	Data	Data	Data	Data	Messung	Beschreibung	Messrate1/s	Übertragungsrate (Häufigkeit) 1/s
10 (E-Meter)	1	U-L1 (Vrms) (signed int16) (LSB -- MSB)		I-L1 (Arms) (float) (LSB -- MSB)				P-L1 (Wrms) (float) (LSB -- MSB)				cos Phi L1 signed int8 (ohne Einheit)	Messung Nr. (int8)	Phase L1	1	1 Oder auf Anfrage Backend-Syste,
10 (E-Meter)	2	U-L2 (Vrms) (signed int16) (LSB -- MSB)		I-L2 (Arms) (float) (LSB -- MSB)				P-L2 (Wrms) (float) (LSB -- MSB)				cos Phi L2 int8 (ohne Einheit)	Messung Nr. (int8)	Phase L2	1	1 Oder auf Anfrage Backend-Syste,
10 (E-Meter)	3	U-L3 (Vrms) (signed int16)		I-L3 (Arms) (float)				P-L3 (Wrms) (float) (LSB -- MSB)				cos Phi L3 int 8 (ohne Einheit)	Messung Nr. (int8)	Phase L3	1	1 Oder auf Anfrage Backend-Syste,
10 (E-Meter)	4	x		I-N (Arms) (float) (LSB -- MSB)				x				cos Phi L3 int8 (ohne Einheit)	Messung Nr. (int8)	Nulleiter Strom	Nur wenn vorhanden 1	(nur wenn vorhanden) 1 Oder auf Anfrage Backend-Syste,
10 (E-Meter)	5	W-L1 (kWh) (float) (LSB -- MSB)				W-L2 (kWh) (float) (LSB -- MSB)				W-L3 (kWh) (float) (LSB -- MSB)				Bezogene Energiemenge L1,L2,L3	1	Nur auf Anforderung (siehe Record 30)
10 (E-Meter)	6	(signed int16) (LSB -- MSB)		(signed int16) (LSB -- MSB)		(signed int16) (LSB -- MSB)		(signed int16) (LSB -- MSB)		(signed int16) (LSB -- MSB)		(signed int16) (LSB -- MSB)		Nich definiert	x	Nur auf Anforderung (siehe Record 30)

U-L1 (Vrms) (signed int16) (LSB -- MSB)	I-L1 (Arms) (float) (LSB -- MSB)	P-L1 (Wrms) (float) (LSB -- MSB)	cos Phi L1 signed int8 (ohne Einheit)

SensIDL Editor

emeter.sidl

```
1  sensorInterface eMeter /**Interface for devices measuring electronic current.*/ {
2        encoding: SENSIDL_BINARY, endianness: BIG_ENDIAN, alignment: 1 BIT
3        sensorData {
4           dataSet Conductor uses Info /**Data description of Conductor*/{
5               recordType as UINT8 value= "1"/**Distinct type for this data set.*/
6               voltage as INT16 in V
7               current as FLOAT in A
8               power as FLOAT in W
9               powerFactor as UINT16 in Dimensionless adjusted by linear mapping [0;255]=> [0;1] /
10              identicator as UINT8 /**Identifier to correlate measurements for different conducto
11           }
12
13          dataSet NeutralConductor uses Info /**Data description of NeutralConductor*/ {
14              recordType as UINT8 value= "4" /**Distinct type for this data set.*/
15              current as FLOAT in A
16              powerFactor as UINT16 in Dimensionless
17          }
18
19          dataSet Energy uses Info /**Data description of Energy*/ {
20              recordType as UINT8 value= "5" /**Distinct type for this data set.*/
21              l1 as INT16 in kW /**Energy amount for conductor L1.*/
22              l2 as FLOAT in kW /**Energy amount for conductor L2.*/
23              l3 as FLOAT in kW /**Energy amount for conductor L3.*/
24          }
```

Code Generation Example C

Conductor.h

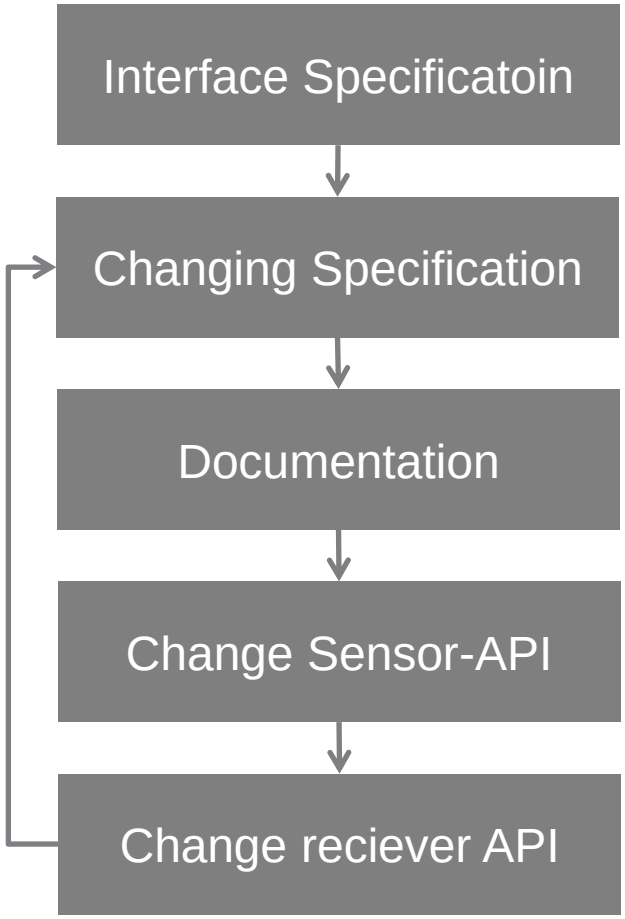
```
#include <stdint.h>
#include "eMeterUtility.h"

typedef struct
{
  uint8_t recordType;
  uint8_t identicator;
  int16_t voltage;
  float current;
  float power;
  uint16_t powerFactor;
  uint8_t deviceType;

} Conductor;
extern Conductor conductor;

/**
* @Initialization of the Conductor
dataset
*/
void initConductor(Conductor* p);
...
```

Conductor.c

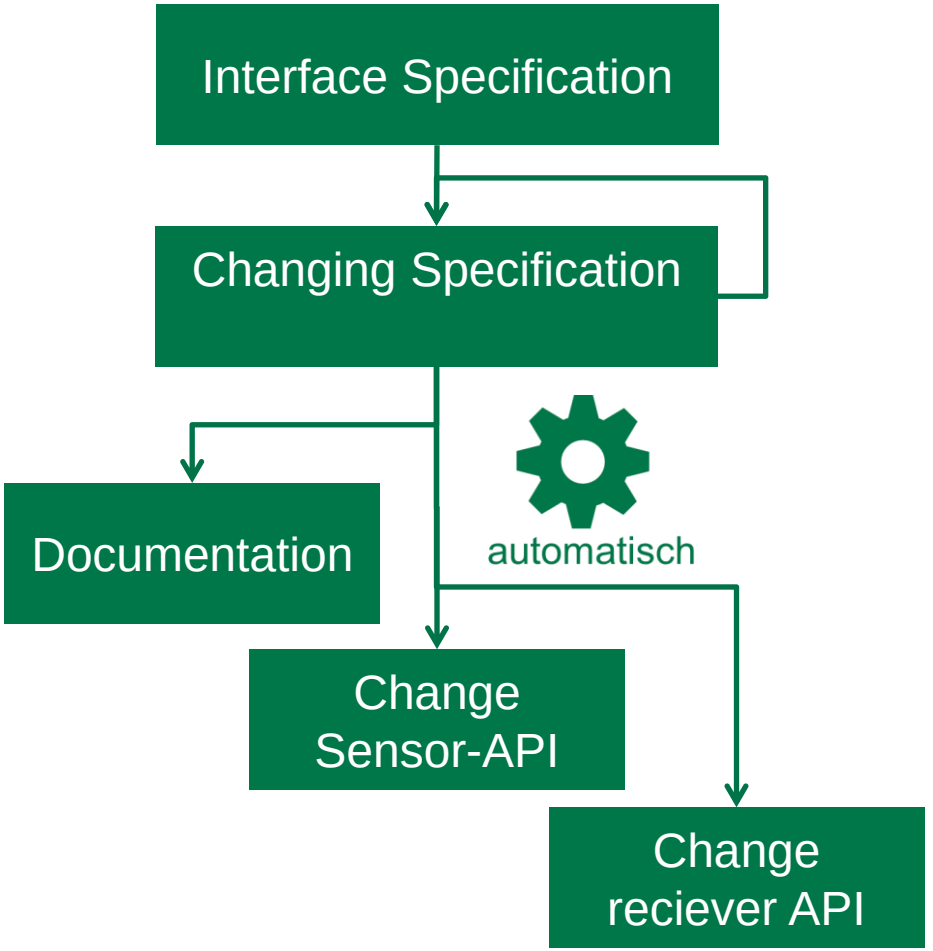
```
#include "Conductor.h"

Conductor conductor;

void initConductor(Conductor* p) {
  p->recordType = 1;
  p->deviceType = 40;
}

uint8_t
get_Conductor_recordType(Conductor* p)
{ return p->recordType; }

void
set_Conductor_recordType(Conductor* p,
uint8_t recordType ) {
 p->recordType = recordType;
}
...
```

Benefits of the model-driven approach

Withour SensIDL:



With SensIDL:



SensIDL Summary

SensIDL tooling

- Formal description of sensor interfaces
- Automated generation of soure code
- Open-source tooling based on eclipse
  - http://www.sensidl.de
- Model-driven approach

View on GitHub

Outlook

- Initial funding until November 2016
- Applications in different use cases
- Cooperation with other projects
  - e.g. Eclipse Vorto

Forschungsnetzwerk Mittelstand
Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Summary and Conclusion

Challenges

- Integration and interoperability of sensor systems is essential
- More than enough communication standards available
- Smart sensors require smart and efficient communication

Outlook

- Software engineering approaches can be transfered to embedded sensors
- Model-driven techniques can help

Questions?

http://www.sensidl.de

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R&D Sensors & Systems

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