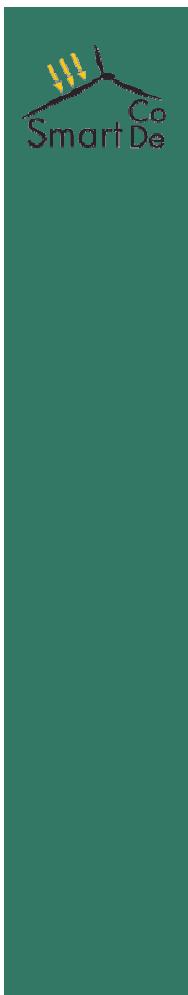


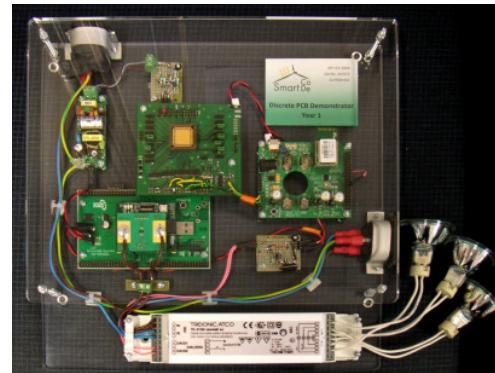
# The SmartCoDe Node Functional Prototype

Author: Edgar Holleis,  
Tridonic GmbH & Co KG  
Date: 12.10.2011



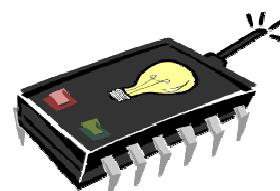
## SmartCoDe Progress

Year 1:  
Discrete prototype

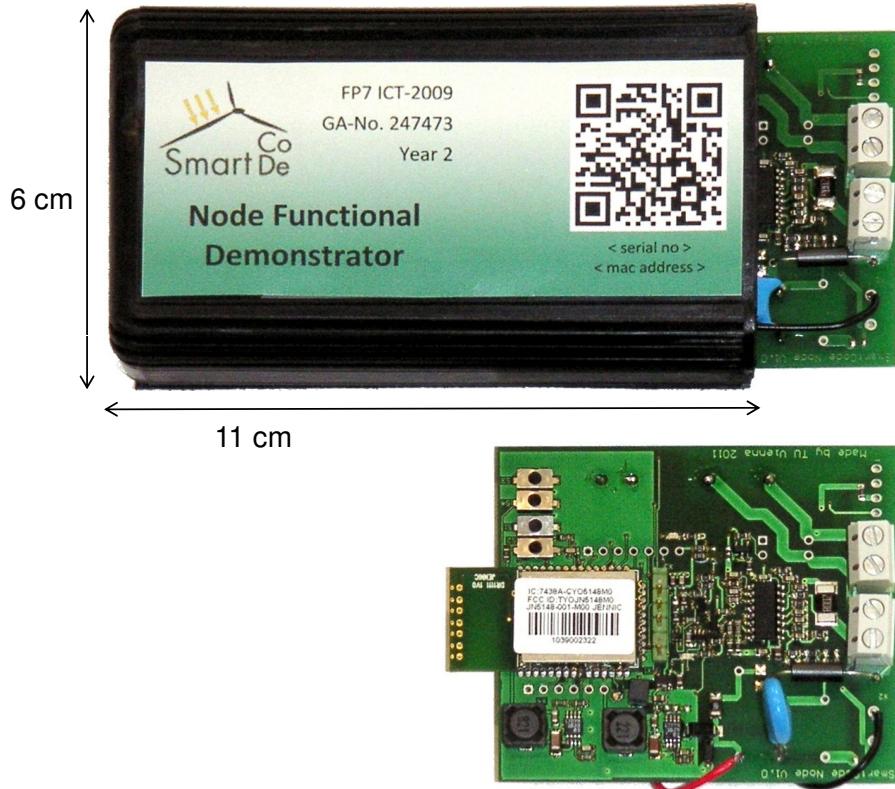


Year 2:  
Functional prototype  
Demonstrator

Year 3:  
System on chip prototype



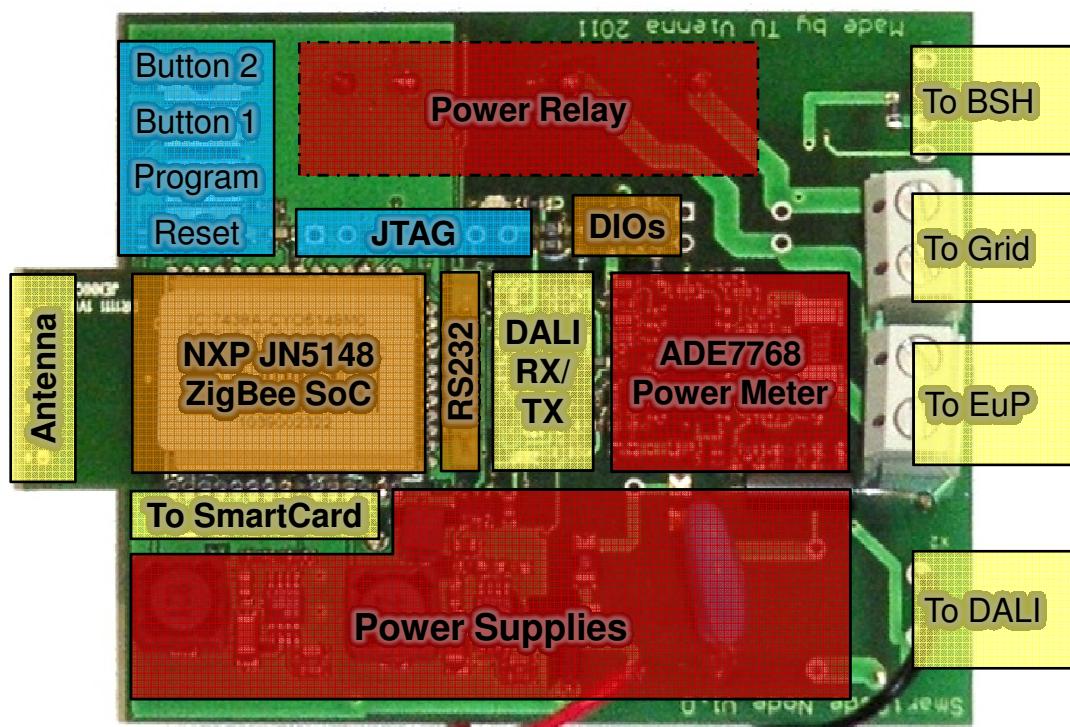
## Finished Functional Prototype



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## Finished Functional Prototype



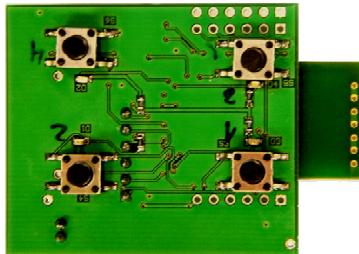
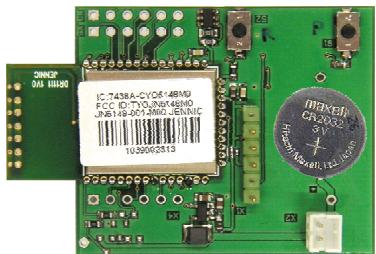
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## Functional Prototype Versions & Periphery

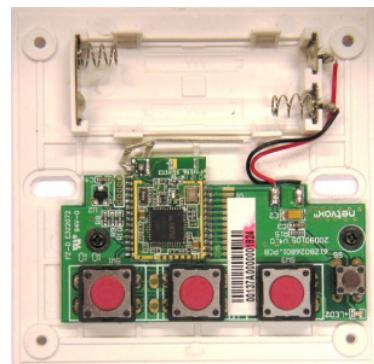
### Energy Management

- › Power meter
- › Power relay
- › White box control interface
- › Remote temperature sensor node



### Lighting Demonstration

- › DALI interface
- › DALI supply: 6 mA (1 sensor + 1 ballast)
- › Remote light switch



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## Energy Management Unit & Coordinator Node



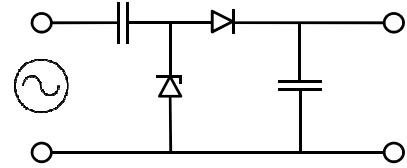
- › Monitor & supervise consumption
- › Calculate cost functions from forecasts & grid tariff
- › Network management

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## Power Supply

- › Non-insulated
- › Capacitive topology:  
 $230 \text{ V}_{\text{AC}} \rightarrow 43 \text{ V}_{\text{DC}}$
- › Buck converter:  
 $43 \text{ V} \rightarrow 3.3 \text{ V}$
- › Max load: 200 mW, overall efficiency:  $\sim 70\%$
  
- › Pros:
  - Realistic test bed for SmartCoDe SoC
  - Low cost, robust & state of the art
- › Cons:
  - Need to isolate all I/O and maybe antenna
  - Need to isolate human interface elements
  - Always consumes maximum load on primary side



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## NXP JN5148

### Transceiver

- › 2.4 GHz, IEEE 802.15.4
- › AES & MAC accelerator
- › Time of flight ranging
- › RX: -95 dBm, 17.5 mA
- › TX: 2.5 dBm, 15.0 mA



### CPU

- › 32 bit, 32 MHz RISC
- › 128 kB ROM
- › 128 kB RAM
- › External Flash (512 kB)
- › 11 mA @ 32 MHz
- › Sleep: 3.5  $\mu\text{A}$  – 0.1  $\mu\text{A}$
- › Usual peripherals

### Software

- › ZigBee 2007 PRO
- › Profiles: HA, SE, ...
- › Multithreaded OS
- › GCC based tool chain
- › Over the air upgrade

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## Why ZigBee?



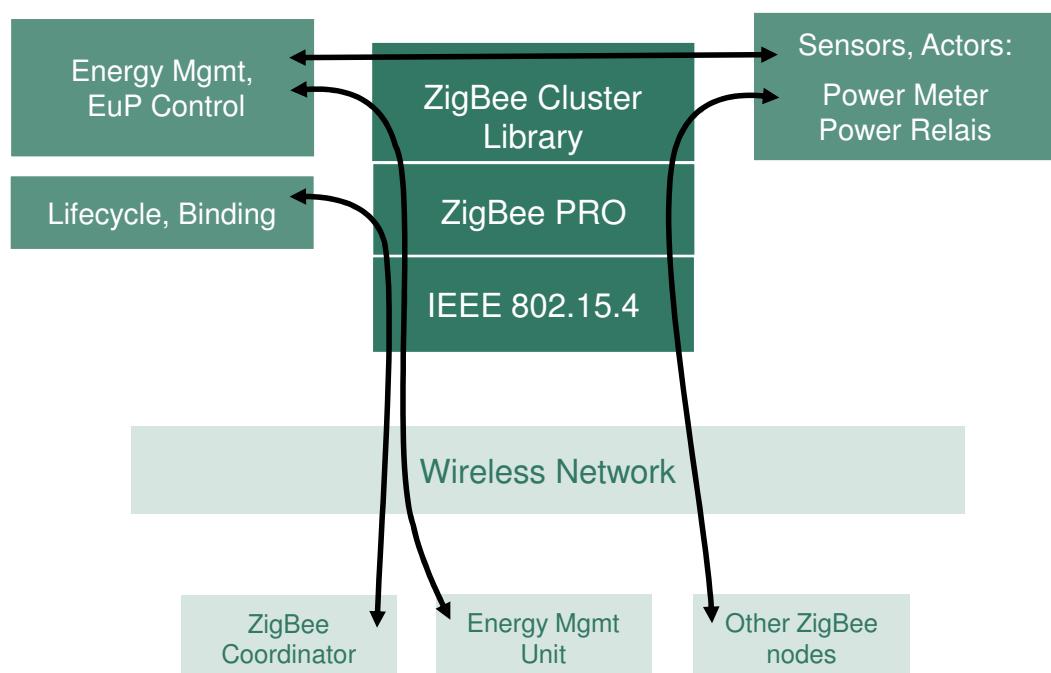
### Pros:

- › Ecosystem, tools, commercially available devices
- › Standard application protocols to build on
- › Cryptographic building blocks to build on
- › Network management (discovery & binding protocols)
- › Straight forward to put data on the network (using discoverable standard protocols)

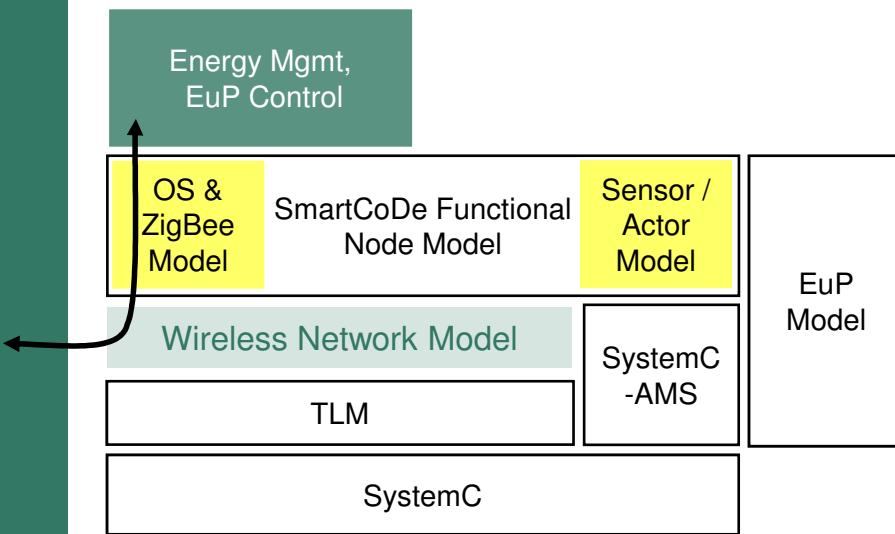
### Cons:

- › Large and complex standard
- › Hardware requirements (for routers)

## Software Overview



# SystemC Based Simulation Environment



Simple porting between simulation environment and hardware

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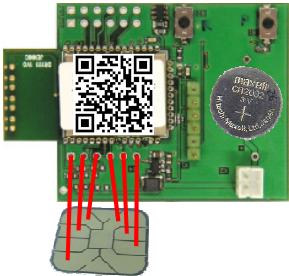
## Supported Data Services

|                         | Role                         | Clusters                     |
|-------------------------|------------------------------|------------------------------|
| SmartCoDe Node          | Metering Device              | Simple Metering (S)          |
|                         | Mains Power Outlet           | On/Off (S)                   |
|                         | Temperature Sensor Client    | Temp. Measurement (C)        |
|                         | Temperature Sensor           | Temp. Measurement (S)        |
|                         | SmartCoDe EuP                | <b>SC Demand Control (C)</b> |
|                         | SmartCoDe Schedule UI Client | <b>SC Schedule (C)</b>       |
|                         |                              | Time cluster (C)             |
| Temperature Sensor Node | Temperature Sensor           | Temp. Measurement (S)        |
| Schedule UI Node        | SmartCoDe Schedule UI        | <b>SC Schedule (S)</b>       |
| SmartCoDe EMU Node      | SmartCoDe EMU                | <b>SC Demand Control (S)</b> |
|                         |                              | Simple Metering (C)          |
|                         |                              | Time cluster (S)             |

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## Advancing the State of the Art in Security



- › Locally rooted chain of trust (no certification authorities)
- › Efficient out of band key exchange
- › Applicable to small and large networks
  
- › Security chip (Infineon SLE77) optional
- › Security chip improves tamper resilience

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Thank you for your attention!