>makeSense

Easy Programming of Integrated Wireless Sensor Networks

How many processes in your company benefit from sensor data from the physical world? Which of them change something in the physical world?

How much money do you spend on automation of buildings, warehouses, logistics?

Wireless Sensor Networks might be the affordable technology you were looking for. But aren't they hard to configure? Complicated to integrate with your backend systems?

The results of the makeSense research project can help to ...

- Save on the software side of wireless sensing and actuation
- Model processes to be run in the network, compile and deploy them on your own
- Easily adapt them when needed
- Effectively integrate physical processes with business processes

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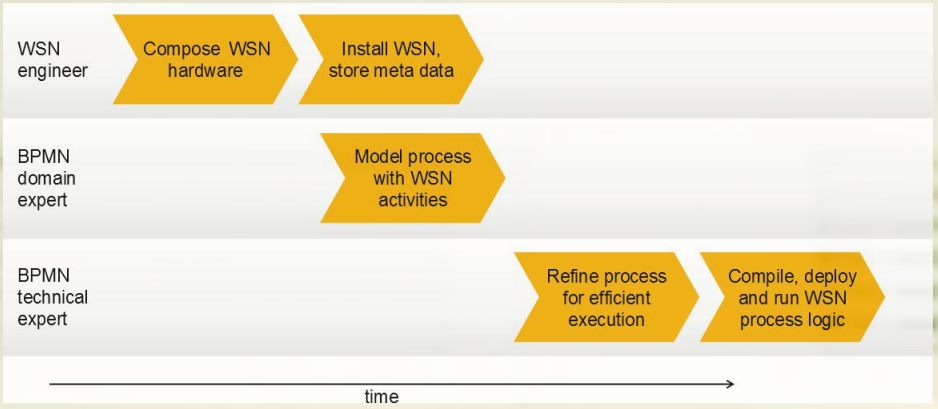
Learn how makeSense can help program distributed control and automation systems and read about an example of how to save money in building automation inside this brochure

Partially funded by:

Information Society Technologies

SEVENTH FRAMEWORK PROGRAMME

MakeSense is a European research project with three academic and two industrial partners that produced development tools allowing business domain experts to model logic for Wireless Sensor Networks. You can benefit from the results of this project, as they enable you to **define complex control and automation logic yourself** without needing to know techncial details and to rely on costly external services. Read about our **example use case on building automation** and learn about potential **cost savings.**



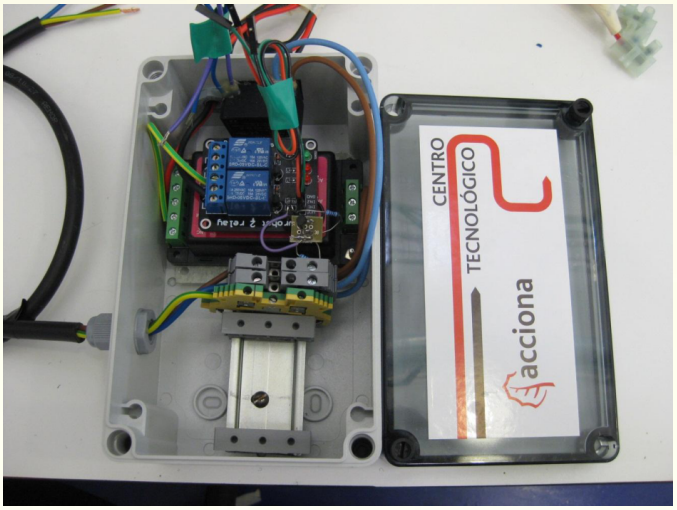
The makeSense Development Process

But first, watch our introductory video now to get a first impresion of the project:

https://www.youtube.com/watch?v=n4ospuvPrWA

Wireless Sensor Networks in Building Automation

Many employees spend a lot of their time in meetings. Quite often, meeting room reservations in companies are made, changed, or canceled on short notice which makes it extremely difficult to ensure adequate or avoid unnecessary room ventilation. Installing a Wireless Sensor Network (WSN) can ensure suitable ventilation without having to control the air conditioning manually. WSNs consist of autonomous sensors and actuators that are battery-powered and form wireless ad-hoc networks communicating without the need for expensive cabling. However, WSNs are still exceedingly difficult to program, since the programming requires WSN experts and is very time-consuming.



Wireless Sensor Node

In the future, technologies developed within the makeSense research project will **facilitate the programming of WSNs and their integration with business processes.** Processes involving WSNs can be changed easily and flexibly according to company-wide regulations. A business process expert will not need to become a WSN expert, since he can model the WSN logic visually in an established industry standard for process modeling. This will lower the required development expertise and costs, and in our scenario also will increase the energy savings as the ventilation is optimized. Whenever a meeting room reservation is cancelled or no attendance is detected, the ventilation system will automatically shut down, since there is no need for air conditioning. This will reduce the energy consumption of companies and help them become more sustainable. Also, the organization's business systems will be informed about actual meeting attendance, allowing for more precise charging and accounting of room costs.

Ventilation of meeting rooms is just one example of a broad range of application scenarios for the technology developed in makeSense. Any business process that uses environmental sensor data or drives actuators can benefit from the approach, for example in the areas of *supply chain management; environment, health and safety; and enterprise asset management.*

BPMN Business Process

The makeSense approach comprises a chain of development tools that are used to create the application logic for both WSN and the surrounding business process that makes use of it.

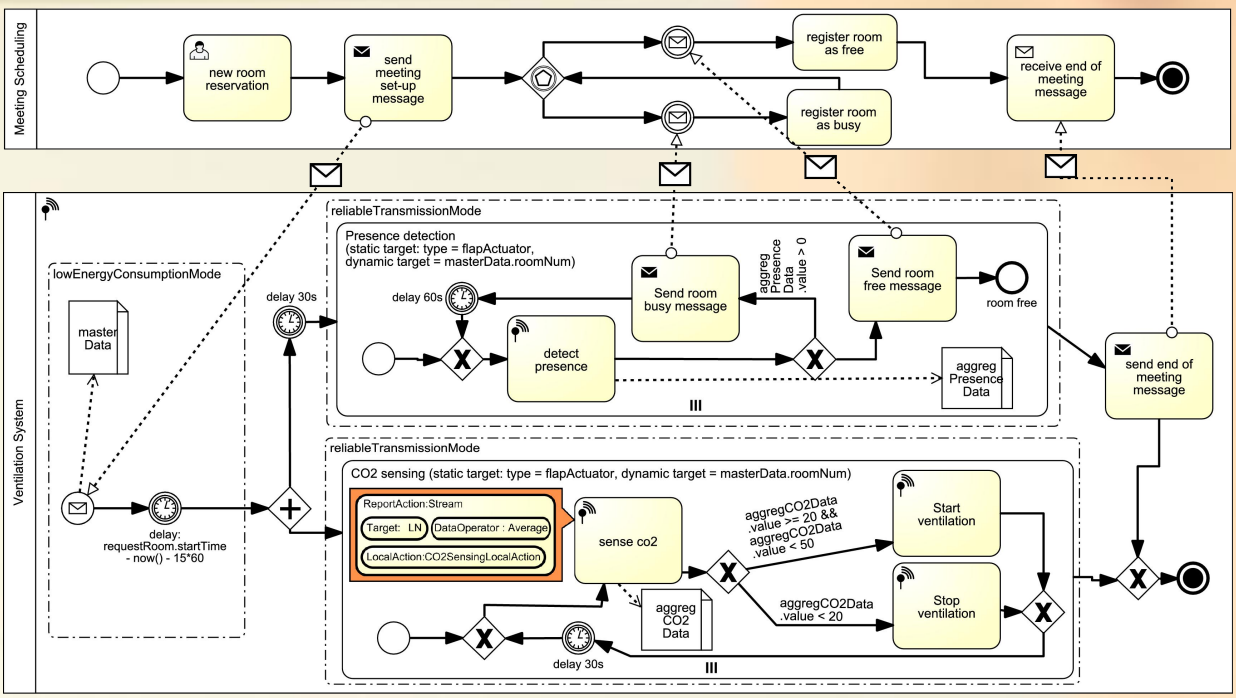
High-level Programing of Wireless Sensor Networks

WSN applications must efficiently handle sensor and actuator operations, data processing and storage, and communication because the execution environment on the individual nodes is severely constrained with limited storage, processing power, communication bandwidth and latency, and battery energy. The research community developed many alternative approaches to operate in this challenging environment: efficient network protocols on all layers and algorithms to optimize distributed data processing and storage.

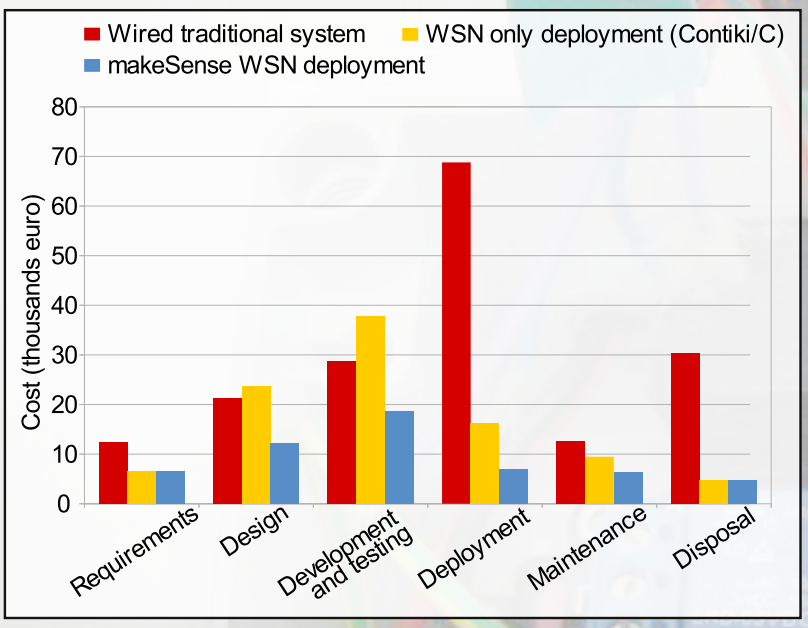
The makeSense project introduces a categorization of these approaches: meta abstractions. They provide a unified facade for most existing WSN programming abstractions and a well-defined API to import their functionality in makeSense. The meta abstractions are integrated into a **macro programming language,** that can be used to program at a high level of abstraction by composing the functionality of the individual abstractions. We provide a compiler that translates the macro code to executable C code to be deployed and ran on the WSN nodes. In addition to the logic itself, the macro language also allows to define run-time optimization goals, e.g., to specify if the sensor nodes should rather maximize their battery lifetime or provide maximum responsiveness, and the ability to switch between the goals at any point during execution. Beyond the level of macro programming, makeSense even allows domain experts that are not familiar with WSNs to visually model a holistic application, adding an overarching business process to the embedded WSN logic. A model compiler developed in makeSense compiles the description of the business process and the WSN logic into macro code. For the modeling of the business process, the industry standard business process modeling notation (BPMN), is used.

Business Process Modelling

The makeSense development process is based on a formal description of a deployed or planned WSN system. An expert on the business scenario can directly use business process modelling notation (BPMN) for modelling both, the overarching business process and the embedded process part that runs in the WSN. The result is a first, descriptive, but not yet executable model of the application. In the next step, a process developer will refine the process by adding technical attributes, defining the data structures to be exchanged, and models the logic executed in the WSN by using a dedicated task type. This WSN task links to another model for the WSN logic that is based on meta abstractions, a classification of algorithms used in WSNs that provide a common API for each class of functionality. The project developed a model compiler that translates the part of the executable BPMN model



Example Business Process and Technical Process- Ventilation of Meeting Rooms



Cost Split into Life Cycle Phases

that is supposed to run in the WSN into an intermediate macro language that is easily compiled down to executable C running on the WSN nodes.

Estimated Cost Savings for End Users

The makeSense tool chain allows easier programming of Wireless Sensor Network applications. But what cost reduction can you expect when deploying a makeSense system? To give an impression, we calculated the cost for a typical building automation system comprising 30 sensors or actuators and some control logic. In the Figure at the top we show the calculated cost for this deployment over the whole life cycle in current market prices for material, services and labor, split by life cycle phases. Three versions of the calaculation were done for (1st) a conventional, wired system, (2nd) a system using wireless sensor networks that are programmed in low-level C, and (3rd) a system that uses the makeSense programming approach. MakeSense technology clearly came out ahead. While we estimated a **conventional system** to cause costs of around **€180.000,** and a **state-of-the-art WSN system** still to sum up to **€105.000,** the same deployment with **makeSense technology** would only require a **€60.000** investment.

Tool Chain

The makeSense tool chain (see Figure below) allows for modelling of the WSN logic in BPMN. As described earlier, a model compiler generates code in an intermediate macro language. Alternatively to modelling, the macro language can also be used directly. A macro compiler further generates C code that is eventually compiled into executable code to be run on WSN nodes.

Usability

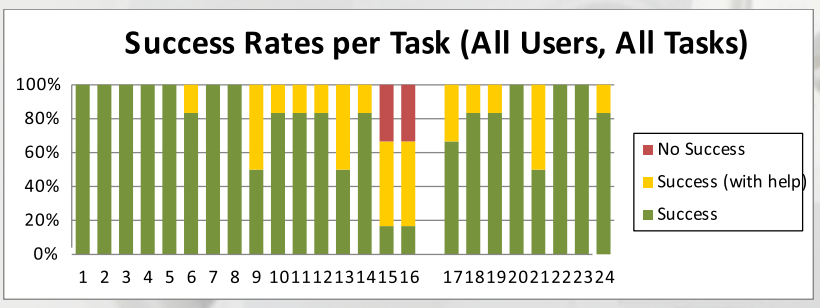
To verify the ease of the makeSense modeling approach, we asked people who have not been involved in the project to model an application that acquires sensor data and, based on the sensor readings, controls an actuator (in 24 small steps). After a short training session of less than one hour, most of the participants were able to create a model that worked as expected. The graph on bottom left shows the participants' success rates.

Further Information

Do you want to take a deeper dive into the technology to find out what is in there for you? You can download a tutorial package that contains a complete modeling environment, compilers and a WSN simulator. Download it today from

http://project-makesense.eu/¬
tutorial/makeSense-tutorial.zip

makeSense Tool Chain



Results of User Study on Usability of the Model Editor

Do you have questions?

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