

# **Smart Buildings Perccom Seminar Lappeenranta, Finland**

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# Vision of ubiquitous computing

- **Remote control & management**
  - Ubiquitous access to all devices



# Building / facility control & management

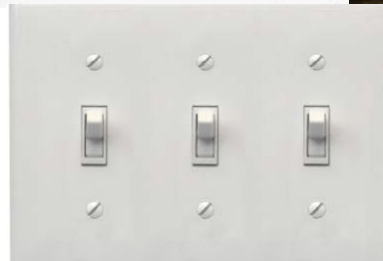
- What are we looking for ?
  - Green, smart, intelligent buildings:





# Building / facility management

- What's the situation in SME's / @ home?



# Design goals for facility control

- Energy savings (Gas / oil / electricity)
- Enhanced comfort
- Enhanced security (feeling)
- Automation of repeating tasks
- Context dependent activation
- Remote control

# Is this necessary ?

- Do we NEED all this ? Well .....
  - Do you need to have a mobile phone ? Yes ?
    - Can't you wait until your at home?
  - Do you need to have an air condition ?
    - My grand-ma also hadn't had one ;)
  - Do you need to have ABS/ESP in the car ?
    - Henry Ford didn't know these concepts ....
- => We are used to have comfort, and once we got it, we don't want to miss it

# Serious issues behind this

- Energy is a source that gets more expensive and fossil resources are getting rare
- The number of developed households is increasing
  - India, China, etc.
- The average consumption of energy per household is increasing
  - More stand-by electronics, more comfort-technology
- Climate is changing (being more extreme)
  - Increased use of air conditions, heaters, etc.

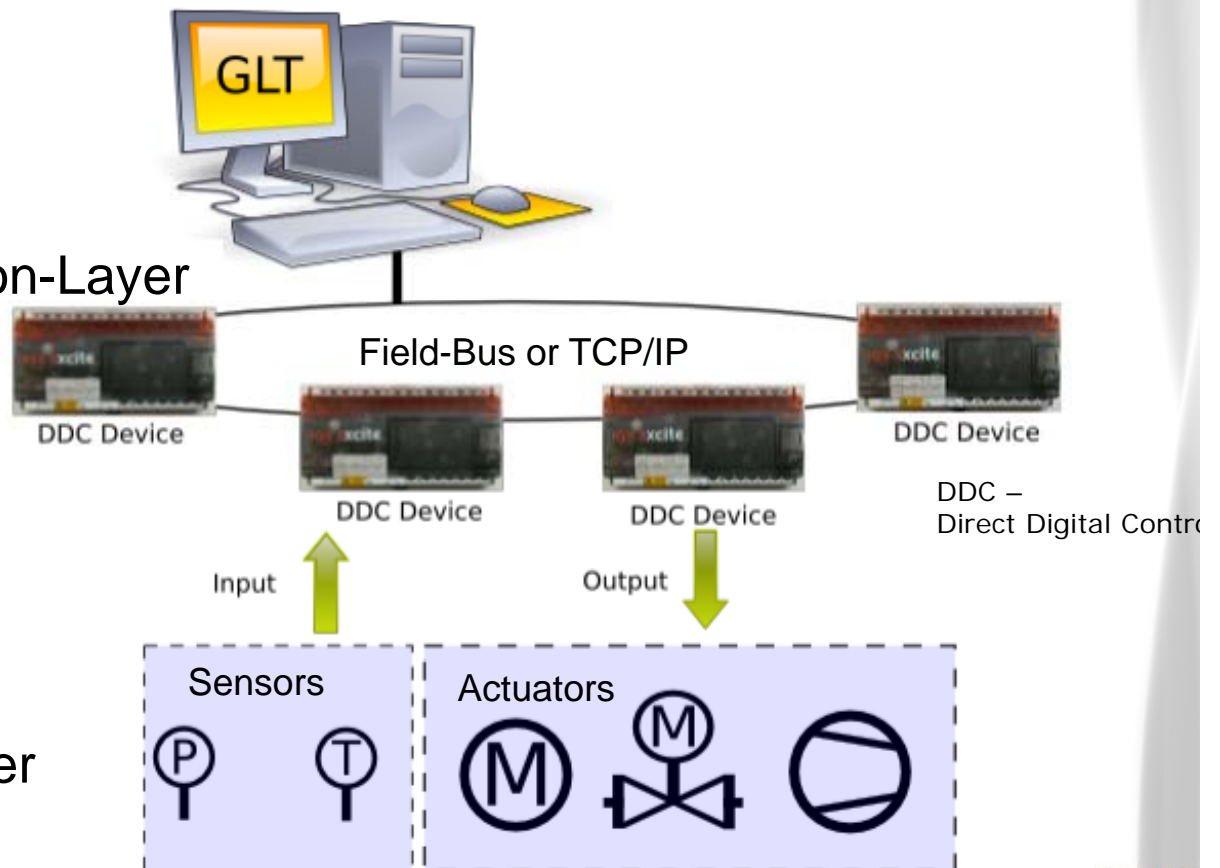
# Automation & Management

- Logical architecture

Management-Layer

Automation-Layer

Field-Layer





# Which technology to choose

- Control and automation networks & protocols:
    - C-Bus
    - Universal Powerline Bus
    - Lonworks
    - X10
    - ONE-NET
    - EIB/KNX
    - EHS
    - ZigBee
    - EnOcean
    - SCS BUS – OpenWebNet
    - FS20, HomeMatic
    - OneWire (1-Wire)
    - .....
- => Many of them on the automation-layer or towards field-layer

# KNX / European Installation Bus

- KNX standardized by ISO/IEC 14543
  - OSI-based network communications protocol
  - For intelligent buildings
  - KNX is the successor to, and convergence of, three previous standards:
    - European Home Systems Protocol (EHS),
    - BatiBUS
    - European Installation Bus (EIB or Instabus)
  - KNX is administered by the KNX Association
- KNX is approved as an open standard to:
  - International standard (ISO/IEC 14543-3)
  - Canadian standard (CSA-ISO/IEC 14543-3)
  - European Standard (CEN EN 50090 and EN 13321-1)
  - China Guo Biao(GB/Z 20965)

# KNX in use

- Can you buy it ?
  - Yes, but quite expensive devices
- Are they everywhere available ?
  - Well, in (e.g.) Germany known as EIB-Devices
- Is there standard / public KNX-Software
  - Standard-software: yes; Public/open: partly
- Is it affordable for „normal“ End-users?
  - NO!

# X10 Technology

- X10 international & open industry standard
  - for communication among electronic devices used for home automation = *domotics*
  - Primarily uses power line wiring
  - Signals involve brief radio frequency bursts representing digital information
  - Wireless radio based protocol transport is also defined: 310MHz (US), 433MHz (EU)
  - X10 was developed in 1975 by Pico Electronics of Glenrothes, Scotland



# X10 Protocol

- X10 List of commands:

| Code    | Function         | Description   |
|---------|------------------|---|
| 0 0 0 0 | All units off    | Switch off all devices with the house code indicated in the message                 |
| 0 0 0 1 | All lights on    | Switches on all lighting devices (with the ability to control brightness)           |
| 0 0 1 0 | On               | Switches on a device  |
| 0 0 1 1 | Off              | Switches off a device   |
| 0 1 0 0 | Dim              | Reduces the light intensity   |
| 0 1 0 1 | Bright           | Increases the light intensity   |
| 0 1 1 1 | Extended code    | Extension code  |
| 1 0 0 0 | Hail request     | Requests a response from the device(s) with the house code indicated in the message |
| 1 0 0 1 | Hail acknowledge | Response to the previous command  |
| 1 0 1 x | Pre-set dim      | Allows the selection of two predefined levels of light intensity                    |
| 1 1 0 1 | Status is on     | Response to the Status Request indicating that the device is switched on            |
| 1 1 1 0 | Status is off    | Response indicating that the device is switched off                                 |
| 1 1 1 1 | Status request   | Request requiring the status of a device  |

– Not much beyond switching lights

# X10 useability

- Can you buy it ?
  - Yes, and basic switches are pretty cheap
- Is there standard / public X10-Software
  - Standard-software: yes; Public/open: yes
- Is it useable ?
  - Well, in Europe: no (due to electric wiring)
  - 2nd:no, due to 433MHR range (very crowded)
  - The standard X10 power line and RF protocols lack support for encryption, and can only address 256 devices.

# LonWorks

- LonWorks - networking platform specifically created for the needs of control applications
- Built on a protocol created by **Echelon Corporation** for networking devices over
  - twisted pair, powerlines, fiber optics, and RF
- In 1999 communications protocol (LonTalk) was submitted to ANSI as a standard for control networking (ANSI/CEA-709.1-B)
- ANSI/CEA-709.1 has been accepted as the basis for
  - IEEE 1473-L (in-train controls)
  - AAR electro-pneumatic braking systems for freight trains
  - IFSF (European petrol station control)
  - SEMI (semiconductor equipment manufacturing)
  - in 2005 as EN 14908 (European building automation standard)

# Is LonWorks out there ?

- Yes:
  - By 2010 ~ 90 million devices with LonWorks
  - Manufacturers in building, home, street lighting, transportation, utility, and industrial automation have adopted the platform
  - Statics are scarce, but the public sector uses it
  - It's used for:
    - embedded machine control, municipal and highway/tunnel/street lighting, heating and air conditioning systems, intelligent electricity metering, subway train control, stadium lighting and speaker control, security systems, fire detection and suppression, and newborn location monitoring and alarming



# Useability / Availability

- Is it good for End-Users ?
  - No: very specific controller Devices
  - No simple switches / home appliance
  - Only specific IP-Gateways, Hardware-based Web-Servers in embedded controllers
  - Needs mainly a separate twisted pair network
- Can it be used in Europe ?
  - In principle yes, but most devices/controllers are available for 110V (US)

# The Challenge for the End-User

## Which system to use / buy?

So, what shall we do, now  
that we can do everything?

- Bottom-up or
- Top-Down ???

Bruce Mau,  
Author of "S,M,L,XL"



## Bottom-up, use ONE system Standard-based solutions

- **KNX / EIB-Systems**
  - **Siemens Synco-Living**
    - Siemens own Product-Line
    - Protocol kompatibel to KNX
    - Only Siemens devices can be used
    - Heating/AirCondition/Lighting/Security
    - No Weather-Station, no brightness, no Voice-Commands, ....
    - Siemens Pricing ☹

# Standard-based solutions

- KNX / EIB-Systems
  - Siemens KNX-Gamma + KNX RF
    - EIB-based product line for office automation
    - Typical elements: Light-Switches/Dimmers, AirCondition/Heating, Security (IR-Sensors), Control-Panels
    - Many Software-Tools available, also Open-Source / Linux-based
    - Usually needs KNX-Bus, only partial KNX-RF
    - Touch-Displays for Visualization
  - Other Manufacturers also built KNX/EIB-Systems, but not in Germany/Switzerland ☺

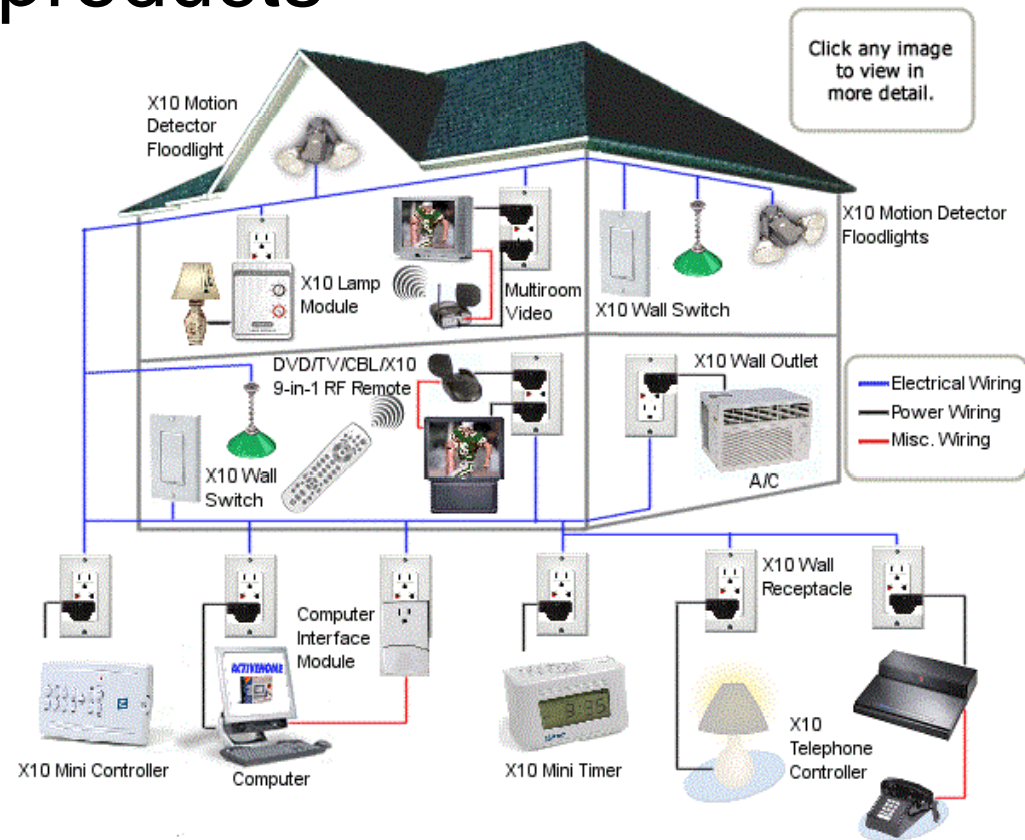


# Standard-based solutions

- X10 Products
  - Many „Standard“ X10 Elements out there
  - X10-stores are available
  - X10-RF & X10-Powerline can be used
  - Security & Surveillance, Switches & Remote Controls, Control-Panels & IP-based Software
  - But: Nearly all products are for the US-market
  - X10-RF (as sold in many stores) is only allowed in the US-RF-bands: NOT in the EU

# X10-store.com

- Example of products



# Non-Standard solutions (1)

- EnOcean Alliance & Wireless
  - RF-System for Measuring & Switching
    - Also sold by Siemens & others
  - Bridges to KNX/EIB available
  - 868MHz (EU) & 315MHz (US)
  - Trying to get „green“ by self-powered / solar modules
  - The only really **WORKING** sensors **without** batteries
  - Germany based technology: EnOcean GmbH

# Non-Standard solutions (2)

- HomeMatic / FS20
  - 868MHz based RF-system
  - Built by an Electronic discounter (ELV/Conrad)
  - HM (FM, encrypted), FS20 (AM, not encrypted)
  - HM: pretty expensive, but looks the same like FS20
  - Specific RF-PC interfaces and specific software
  - FS20: is THE unofficially used Consumer HomeControl System in Germany (as it is sold by electronic discounters) & it basically can do „everything“
- InterTechno
  - 433 MHz based RF-system used for switches/dimmers



## Top-Down approach: Hey, I'm an End-User, I don't care

- Well, so ?
  - You need ONE Management-Interface for all the appliances
- OK, so you are rich or a company?
  - Yes: ok, go for Siemens/single technology solution
  - Well, not really: hmm, now it gets difficult
    - Do you want to stay in the limits of one „cheaper“ technology (FS20, EnOcean, etc.) ?
      - Yes: Ok, go for them, and use their Software
      - No: Well, now we have a Problem .....

# The End-User issue

- Typically you have bought/rented a house/premises and don't want to (or can't) put a new bus-system in the walls
- But: You have Ethernet/IP „everywhere“

⇒ You need a wireless control-system that can be extended by using Ethernet

- You want to integrate different technologies ?

⇒ You need a Management-System that is open & flexible, and can integrate other systems

⇒ Typically an Open-Source solution

# Home Automation Management

- Beyond specific solutions (Siemens, EnOcean, ELV, ....)
- Some really good open-source solutions are out there
  - Many are targeted to specific needs
  - Many are specific to one OS
  - Only a few ones are really flexible
  - Different levels of integration
    - Web-TV, Video-Cams, Security, etc.
    - Sauna-ovens in Summer-Cottages, etc.

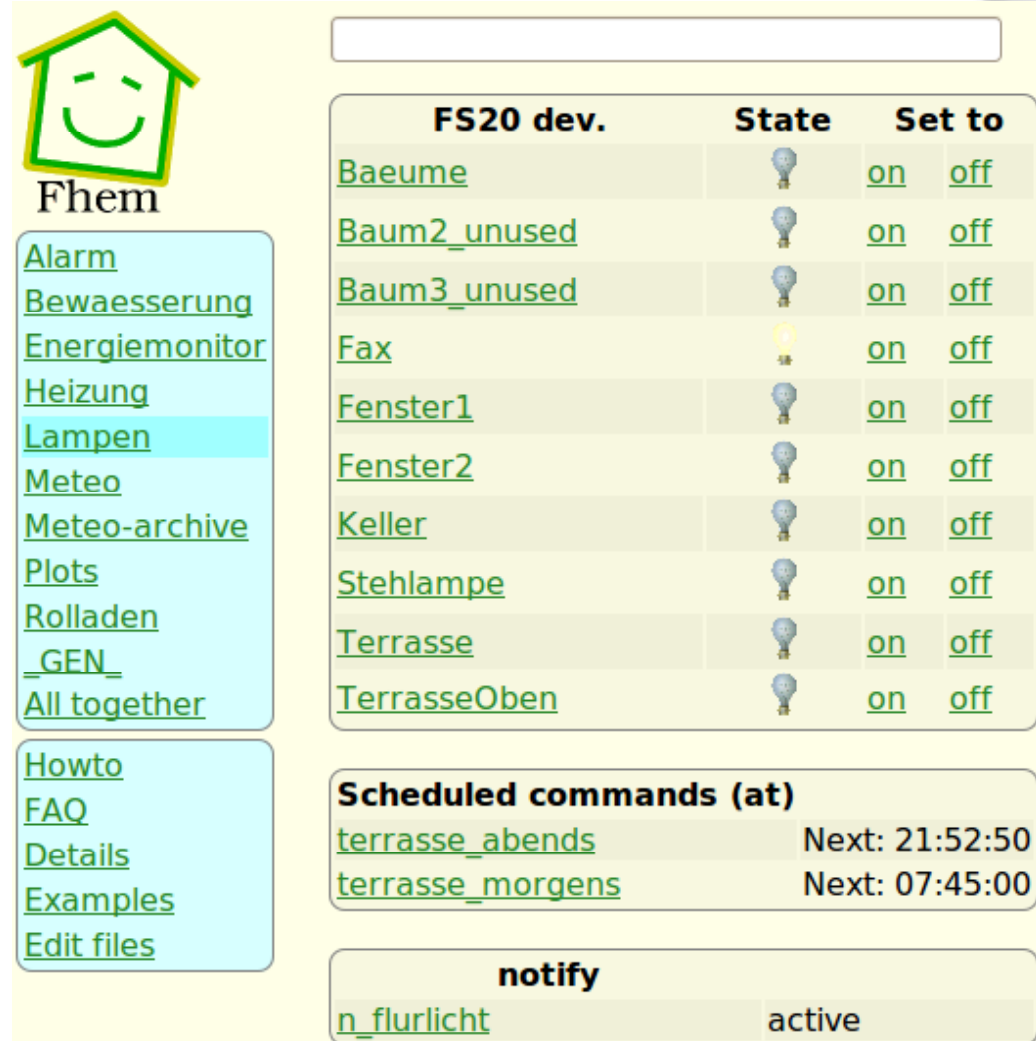
# HomeAutomation with FHEM



- FHEM: Open-Source Project
  - FHEM is a GPL'd PERL server for home automation
  - It is used to automate some common tasks in the household like switching lamps / shutters / heating / etc. and to log events like temperature / humidity / power consumption
  - FHEM started with FS20 technology
  - BUT: Integration is evolving: X10, EnOcean, Dallas 1-Wire, AllNet IP-Switches, different Weather Stations, KNX, HomeMatic, InterTechno, IRDA, ...

# FHEM Project

- FHEM is a Management software, with different front-ends
- Integrated: FHEMWEB



The screenshot shows the FHEMWEB web interface. At the top left is a green house icon with a smiley face and the text 'Fhem'. Below it is a sidebar menu with links: Alarm, Bewaesserung, Energiemonitor, Heizung, Lampen (highlighted in cyan), Meteo, Meteo-archive, Plots, Rolladen, \_GEN\_, and All together. Below the sidebar are two more sections: 'Howto' with links for FAQ, Details, Examples, and Edit files. The main content area has a search bar at the top. Below it is a table with columns 'FS20 dev.', 'State', and 'Set to'. The table lists various devices like Baeume, Baum2\_unused, Baum3\_unused, Fax, Fenster1, Fenster2, Keller, Stehlampe, Terrasse, and TerrasseOben, each with a lightbulb icon in the State column and 'on'/'off' in the Set to column. Below the table is a section 'Scheduled commands (at)' with two entries: 'terrasse\_abends' with 'Next: 21:52:50' and 'terrasse\_morgens' with 'Next: 07:45:00'. At the bottom is a 'notify' section with 'n\_flurlicht' and 'active'.

| FS20 dev.                    | State | Set to                                 |
|------------------------------|-------|--|
| <a href="#">Baeume</a>       |       | <a href="#">on</a> <a href="#">off</a> |
| <a href="#">Baum2_unused</a> |       | <a href="#">on</a> <a href="#">off</a> |
| <a href="#">Baum3_unused</a> |       | <a href="#">on</a> <a href="#">off</a> |
| <a href="#">Fax</a>          |       | <a href="#">on</a> <a href="#">off</a> |
| <a href="#">Fenster1</a>     |       | <a href="#">on</a> <a href="#">off</a> |
| <a href="#">Fenster2</a>     |       | <a href="#">on</a> <a href="#">off</a> |
| <a href="#">Keller</a>       |       | <a href="#">on</a> <a href="#">off</a> |
| <a href="#">Stehlampe</a>    |       | <a href="#">on</a> <a href="#">off</a> |
| <a href="#">Terrasse</a>     |       | <a href="#">on</a> <a href="#">off</a> |
| <a href="#">TerrasseOben</a> |       | <a href="#">on</a> <a href="#">off</a> |

**Scheduled commands (at)**

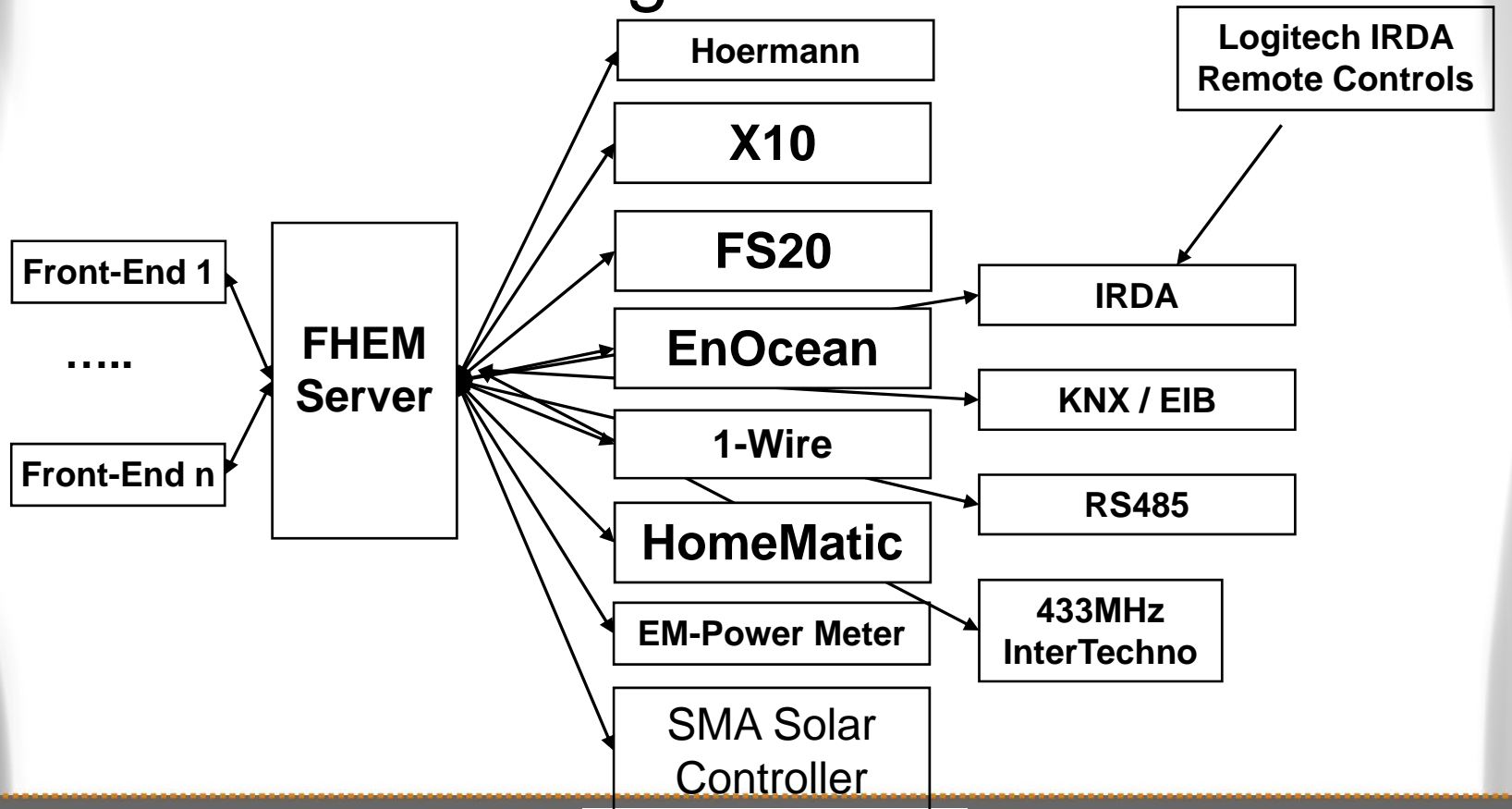
|                                  |                |
|----------------------------------|----------------|
| <a href="#">terrasse_abends</a>  | Next: 21:52:50 |
| <a href="#">terrasse_morgens</a> | Next: 07:45:00 |

**notify**

|                             |        |
|-----------------------------|--------|
| <a href="#">n_flurlicht</a> | active |
|-----------------------------|--------|

# Why is FHEM so flexible ?

- FHEM is a mediating server

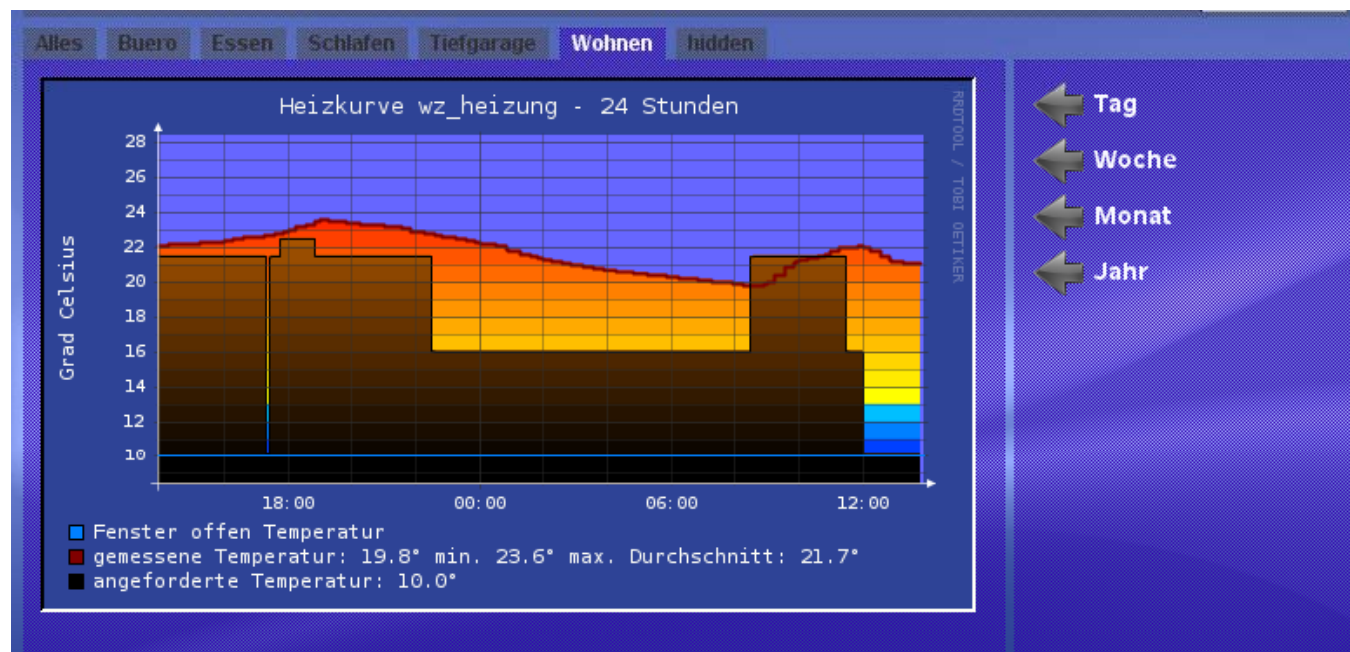




# FHEM Front-Ends

- The idea is to enable multiple front-ends for the same Server
  - Several different web-solutions
    - Perl, PHP, JScript, Java-Servlets
    - Using XML-Output from FHEM
    - Using JSON-Lists from FHEM
    - Requesting direct in-/output via Telnet
  - Solutions for Mobiles
    - Android / iPhone (based on Web-Browsers)
    - Native iPhone App available (FHEmobile)
    - Android Smart-pad solutions

# Front-End Example, MyHCE



# Front-End Example, fheME

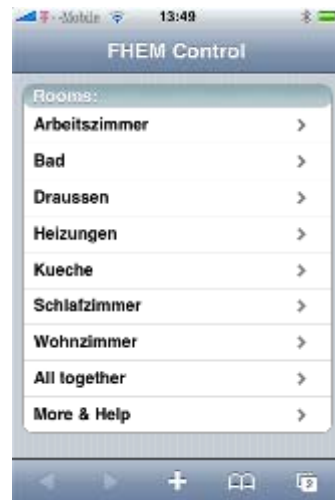
The screenshot displays the fheME web interface, which is used for controlling a desk lamp system. The interface is divided into several sections:

- Top Bar:** Features the fheME logo on the left and a 'Fhem' status indicator with a light bulb icon on the right.
- Control Panel:** Located in the center, it includes three vertical sliders for 'Schreibtisch', 'Ambient', and 'Heater' lighting. To the left of these sliders are three buttons labeled 'Voll', 'Aus', and 'Default', each with a light bulb icon. To the right is a large circular clock face with numbers 1 through 24, and a green arrow pointing to the current time, 19:45. Below the clock are icons for a sun and two green arrows.
- Editing Section (Fhem editieren):** Located at the bottom left, it contains a form with the following fields:
  - Server:** Eee
  - Name:** Schreibtisch
  - Type:** FS20
  - Specific:** 2341 56
  - Model:** FS20 DUA 'Fhem speichern' button is at the bottom of this section.
- Device Selection Section (Bitte Device auswählen):** Located at the bottom right, it includes a 'Fhem neu anlegen' button and a table of available devices:

| Eee          |      |
|--------------|------|
| FHZ1         | FHZ  |
| Door         | FS20 |
| Schreibtisch | FS20 |
| Ambient      | FS20 |
| Heater       | FS20 |

# Front Front-End Example, iPhone

- Different iPhone Front-Ends are available
  - These examples are running as a Web-App



# Hardware Interfaces

- Using open devices:
  - Busware CUL/CUNO + Firmware





# Open Devices

- Using flexible Hardware (Atmel based)
  - Busware CUL/CUNO
    - for FS20 / HomeMatic, InterTechno, OneWire
  - Busware CUNOV2
    - for FS20 / HomeMatic, InterTechno, OneWire, IRDA, RS485
  - Busware EUL
    - for EnOcean
  - Busware TUL
    - for KNX / EIB

=> The Firmware is also an OpenSource Project



# Specific Devices

- OneWire – USB Bridges
- KNX/EIB Servers
- ....
- Need specific FHEM-Modules to interact
  - Write your own, and you can connect, whatever you like

# So, what can I do with it ?

- FS20 Devices:
  - Switches/Dimmers (Actuator)
  - Window-Shutters/Shade-rollers
  - Heater-Controller, Room-Heating Management
  - Window/Door-Open Sensor
  - IRDA-Movement Sensor
  - Water/Smoke/Gas Sensor
  - Weather Station (Temp, Wind, Rain, Snow Hum.)
  - Brightness Sensor
  - Ground-Movement Sensor
  - Wall-mounted Switch (Sender)
  - Voice-Commander (Sender)
  - Sensor-Touch Field (Sender)
  - Water-Circulation Management (Heating)
  - Marquise/ Terrace-Shade Opener/Shutter
  - Cistern (Water Reservoir) measuring
  - And many more specific devices + technologies (X10, ...)

# FHEM, what is it?

- A Perl based Server for HomeAutomation
- It runs single-threaded but maybe multi-processed
- Its main loop resides in fhem.pl
- Modules implement devices, etc.
  - /FHEM (modules dir.)
  - 00-98\_... Different modules for different devices
  - 00\_devices are hardware-interfaces
  - 99 are support modules (and loaded at first)
- Uses an .cfg file to store configuration

# What can I do ?

- Define devices
  - Hardware-Interfaces
  - Switches, Dimmers, etc.....
- Define schedules, events, scripts
- Use it via Front-Ends
- Automate your tasks
- Control it from everywhere

# How to start ?

- Start by installing a FHEM Server
  - Hardware-Interfaces are available
  - Embedded Servers are available
- FHEM is hosted on SourceForge
  - [www.fhem.de](http://www.fhem.de) (stable version)
  - SVN tree in SourceForge for bleeding edge
- Debian / Ubuntu package
  - or tar-ball, or ZIP file
- Perl is needed (with CPAN support)

# Where to look

- [Commandref.html](#)
  - THE FHEM reference manual
- [FHEM Web-Site, FHEM.DE](#)
- [FHEM-Wiki](#)
- [FHEM Forum](#)



# What's in the pipe

- Widgets for Flat-Screen-TVs
  - Based on the Yahoo-Widget-Engine / Google-TV
  - Home Automation on the TV
- Widgets for Windows 7
- Using the Users Context
  - Automatic detection of right profile
- Connection to solar-systems
  - Cooperation with SMA (Kassel)

# Conclusion

- Home automation is THERE
  - But End-Users don't buy it, because of:
    - They don't trust the system
    - too closed systems
    - mostly limited to one technology
    - they have to do programming
- ⇒ Not really out of the box (planning of busses, ...)
- ⇒ Not really cheap (Standardized solutions)
- ⇒ Not easy to operate (Need technicians to install)
- ⇒ Start with an easy, open, out of the box system, that you can extend with parts from discounters

# What's the target?

- Each group needs to get acquainted with FHEM
- Each group has to build a setup
- Each group has to build a scenario
- Each group has to give a presentation about:
  - One protocol for home automation
  - FHEM itself (the system, front-ends, etc.)
  - Your scenario
  - Your setup
- Each group has to provide a short report

# What to do next (1)?

- Explain/plan the setup in the room
- Split in 4 - 6 groups (3-4 persons)
- Select your desired server platform
  - Raspberry Pi (Debian Linux, embedded)
  - TuxRadio (Debian Linux, embedded)
  - Ubuntu with CUL/CUNO
- ! Each Server needs different handling to start up !

# What to do next (2)?

- Connect devices / configure devices
- Build a scenario & setup
- Measure energy consumption (electric meters)
- Calculate savings of your scenario
- Make presentations & reports

# Thank you !

odroegehorn@hs-harz.de



# References

- Siemens Home Automation:  
[http://w1.siemens.ch/web/bt\\_ch/de/products\\_systems/building\\_comfort\\_hvac/home\\_and\\_building\\_automation/home\\_automation\\_system/Pages/home\\_automation\\_system.aspx](http://w1.siemens.ch/web/bt_ch/de/products_systems/building_comfort_hvac/home_and_building_automation/home_automation_system/Pages/home_automation_system.aspx)
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- X10 Initiative: [www.X10.com](http://www.X10.com)
- LonWorks / Echelon: [www.echelon.com](http://www.echelon.com)
- KNX/EIB Overview: <http://www.eib-home.de/>
- Busware GmbH, [www.busware.de](http://www.busware.de)
- FHEM Project, [www.fhem.de](http://www.fhem.de)
  - Wiki: [www.fhemwiki.de](http://www.fhemwiki.de); Google-Group, ....
- EnOcean Alliance, [www.enocean-alliance.org](http://www.enocean-alliance.org)
- Echelon Inc., [www.echelon.com](http://www.echelon.com)
- ELV GmbH, [www.elv.de](http://www.elv.de)
- Conrad GmbH, Discounter, [www.conrad.com](http://www.conrad.com) (several countries)