

Home Automation - Smart Buildings - Perccom Intensive Course Lappeenranta, Finland

Prof. Dr. Olaf Drögehorn
Software Engineering & Internet Technologien
Vice–Rector for ICT / E–Learning
Harz University of Applied Sciences

Vision of ubiquitous computing

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



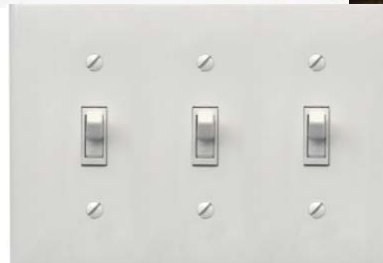
Building / facility control & management

- 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.

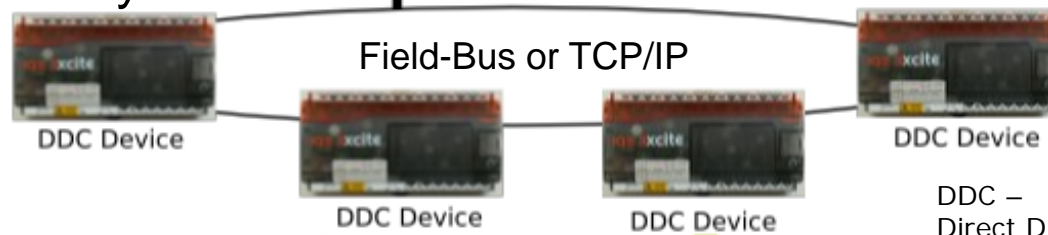
Automation & Management

- Logical architecture

Management-Layer



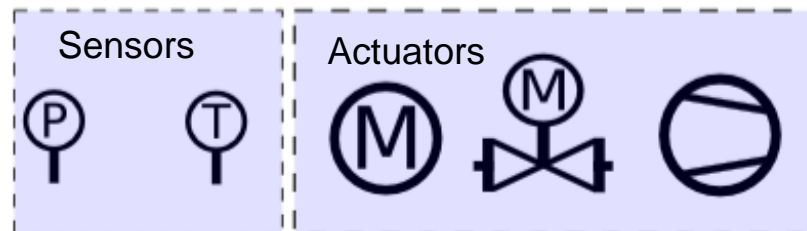
Automation-Layer



DDC – Direct Digital Control



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

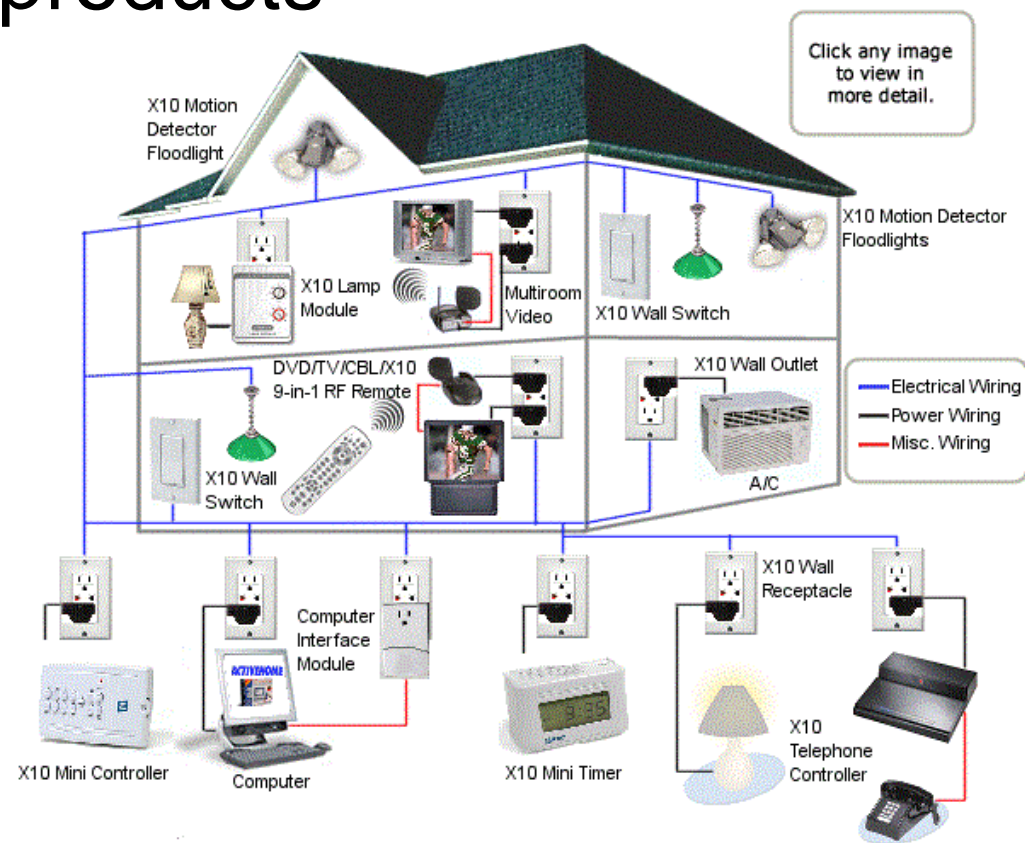
- **KNX / EIB-Systems**
 - Siemens KNX-Gamma + KNX RF
 - EIB-based product line for office automation
 - Typical elements: Light-Switches/Dimmers, AirCondition/Heating, Security (IR-Sensors), Control-Panels
 - Many Software-Tools available, also Open-Source / Linux-based
 - Usually needs KNX-Bus, only 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

The End-User issue: what to buy?

- Germany is the largest HomeAutomation market in Europe
- Most systems (standard-based & proprietary) are available there:



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 interface. At the top left is a house icon with a smiley face and the text 'Fhem'. Below it is a navigation menu with links: Alarm, Bewaesserung, Energiemonitor, Heizung, Lampen (highlighted), Meteo, Meteo-archive, Plots, Rolladen, _GEN_, and All together. Below the menu are links for Howto, FAQ, Details, Examples, and Edit files. On the right, there is a search bar and a table of device states for 'FS20 dev.'. The table has columns for device name, State (represented by a lightbulb icon), and Set to (with 'on' and 'off' links). Below the table is a section for 'Scheduled commands (at)' with two entries: 'terrasse_abends' (Next: 21:52:50) and 'terrasse_morgens' (Next: 07:45:00). At the bottom, there is a 'notify' section with 'n_flurlicht' set to 'active'.

FS20 dev.	State	Set to
Baeume		on off
Baum2_unused		on off
Baum3_unused		on off
Fax		on off
Fenster1		on off
Fenster2		on off
Keller		on off
Stehlampe		on off
Terrasse		on off
TerrasseOben		on off

Scheduled commands (at)

terrasse_abends	Next: 21:52:50
terrasse_morgens	Next: 07:45:00

notify

n_flurlicht	active
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FHEM, what is it?

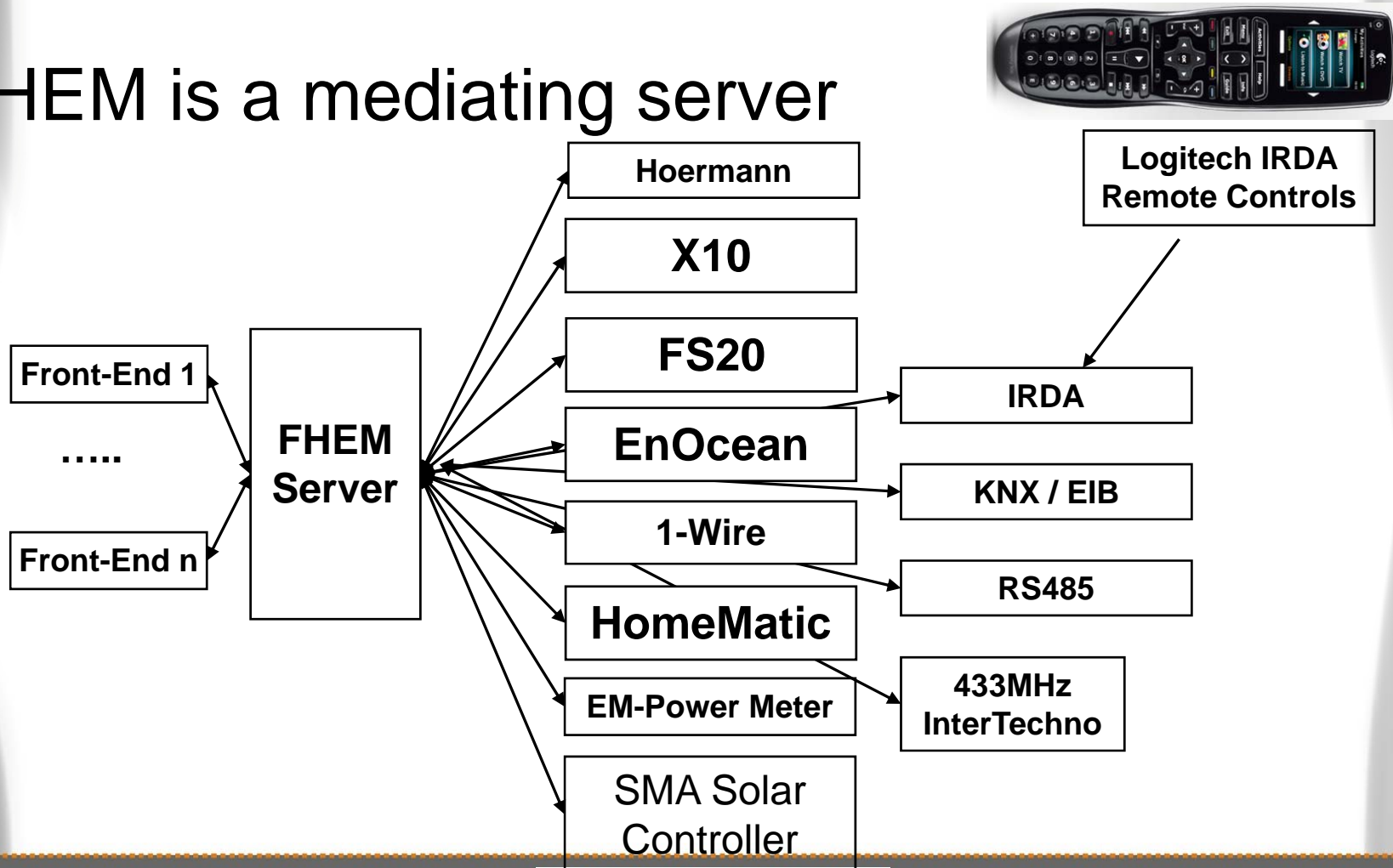
- A Perl based Server for HomeAutomation
- It runs single-threaded but maybe multi-processed
- Its main loop resides in fhem.pl
- Modules implement devices, etc.
 - /FHEM (modules dir.)
 - 00-98_... Different modules for different devices
 - 00_devices are hardware-interfaces
 - 99 are support modules (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

Why is FHEM so flexible ?

- FHEM is a mediating server



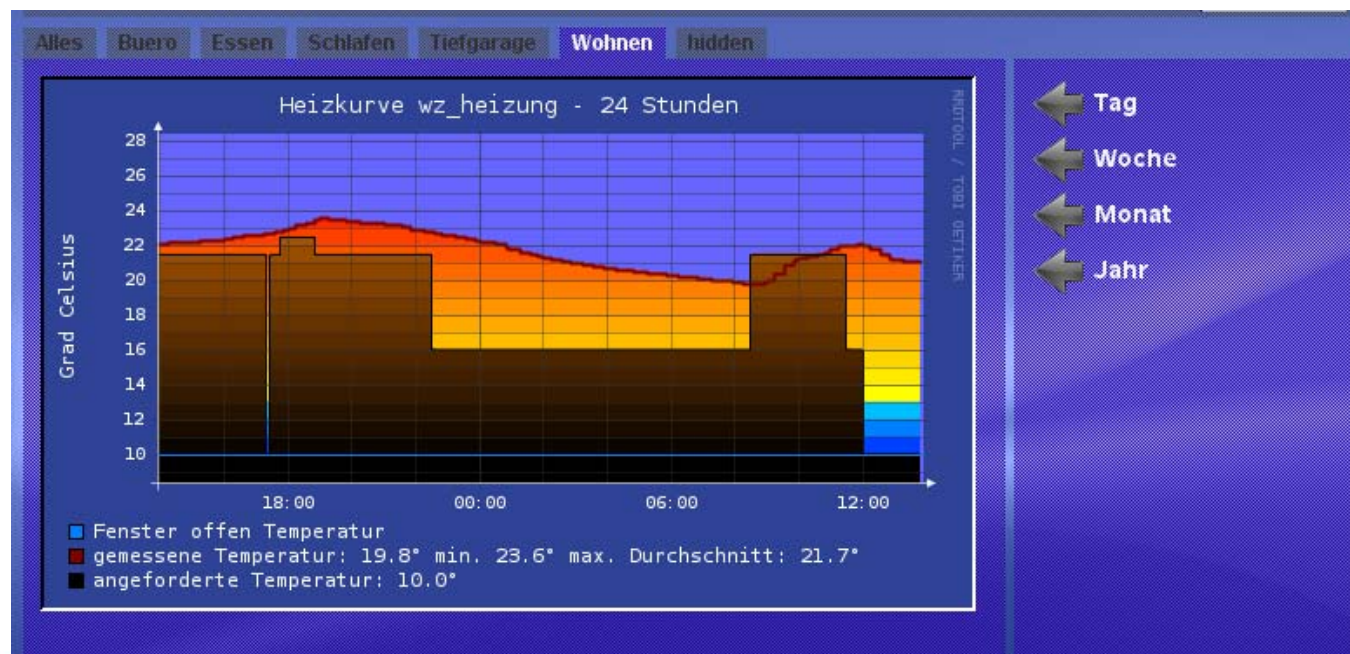
FHEM Front-Ends

- 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

myHCE - my Home Control Edition

The interface features a top navigation bar with icons for home, camera, and weather. Below this are tabs for 'Alles', 'Buero', 'Essen', 'Schlafen', 'Tiefgarage', 'Wohnen', and 'hidden'. The main area contains four control buttons with yellow circular indicators: 'Alle Aktoren', 'Lampe Fenster', 'Beleuchtung', and 'Lampe Sideboard'. A panel on the right is labeled 'keine Thermostate'.



Front-End Example, fheME

The screenshot displays the fheME web interface. At the top, there is a header with the fheME logo and a 'Fhem' label. Below the header, the main control area is divided into several sections:

- Control Panel:** On the left, there are three buttons labeled 'Voll', 'Aus', and 'Default', each with a lightbulb icon. To the right, there are three vertical sliders for 'Schreibtisch', 'Ambient', and 'Heater', each with a lightbulb icon at the top and a blue square indicating the current level.
- Temperature Gauge:** A circular gauge on the right shows a temperature of 19.45. The gauge has a sun icon and two green arrows pointing up, indicating heating or cooling status.

Below the main control area, there is a configuration section titled 'Fhem editieren:' with the following fields:

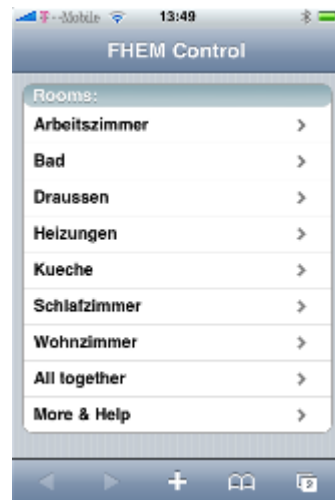
- Server:** Eee
- Name:** Schreibtisch
- Type:** FS20
- Specific:** 2341 56
- Model:** FS20 DU

At the bottom of the configuration section is a 'Fhem speichern' button. To the right of the configuration section, there are buttons for 'register settings' and 'reset Servers'. Below these, there is a section titled 'Bitte Device auswählen:' with a sub-section 'Fhem neu anlegen'. This section contains a table of devices:

Fhem neu anlegen		
Eee		
FHZ1	FHZ	[icon]
Door	FS20	[icon]
Schreibtisch	FS20	[icon]
Ambient	FS20	[icon]
Heater	FS20	[icon]

Front Front-End Example, iPhone

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



Open Hardware Interfaces

- Using open devices for OSs:
 - 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

Open Device Platforms

- Linux-based Systems with FHEM & Hardware-Interfaces for
 - for FS20 / HomeMatic, InterTechno, OneWire, IRDA, RS485
 - for EnOcean
 - for KNX / EIB
 - ModBus, MBus, W-Mbus
 - MAX!
 - Z-Wave
 - S0-Interfaces

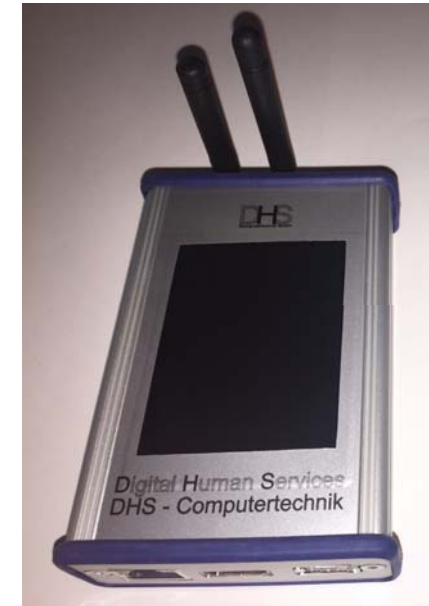
=> Based on OpenSource Distributions

Open Device Platforms

- HomeManager + Pigator



- TuxRadio v2



- Raspberry + CoC AddOn

- TuxRadio v1



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 (1)?

- 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, ...)

So, what can I do with it (2)?

- HomeMatic 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)
 - Sensor-Touch Field (Sender)
 - Water-Circulation Management (Heating)
 - Marquise/ Terrace-Shade Opener/Shutter
 - Cistern (Water Reservoir) measuring
 - And many more specific devices + technologies (X10, ...)

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 (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?

- Split into 6-x groups (3-4 persons)
- Each group has to build a scenario
 - For Coder Lab, for Meeting room, for OpenSpace / the University, for an advanced End-User Scenario
- Each group needs to get acquainted with FHEM
- Each group has to build a setup
- Each group has to give a presentation about:
 - One protocol for home automation
 - FHEM itself (the system, front-ends, etc.)
 - Your scenario & benefits: saving in terms of CO₂ & Energy
 - Your setup
- Each group has to provide a report

What's the timing?

- Monday:
 - Get an overview of available Equipment / simulations that can be done
 - Design a Scenario
 - Select a Server-Platform and get FHEM up & running
 - Present Scenario at the Blockhouse Sauna from 16.30 onwards
- Tuesday-Wednesday
 - Work on Scenario & Description + Benefits like savings, etc.
 - Calculate Energy-savings & CO₂ + further rational for your scenario
 - Build a setup with FHEM & Devices, that shows basic elements of your scenario
- Thursday
 - Implement the setup in the appropriate room
 - Testing in open-space, meeting room, coders lab: with real integration
- Friday
 - Presentation of each group ~30 min + discussion:
 - One protocol for home automation
 - FHEM itself (the system, front-ends, etc.)
 - Your scenario
 - Your setup and guidelines how to set up
- Things to provide:
 - A full report, covering the above elements, especially also the steps to reach an implementation
 - The Slide set of the presentation
 - Source-Code + Configuration Files
 - A One-Page Poster, presenting your idea/scenraio, the benefits and ways to implement

What to do next (1)?

- Split 6-x groups (3-4 persons)
- Think about a scenario and a room
- Select your desired server platform
 - HomeManager (Debian Linux, embedded)
 - Raspberry Pi (Debian Linux, embedded)
 - TuxRadio 2/1 (Debian Linux, embedded)
 - Ubuntu with CUL/CUNO

What to do next (2)?

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

Thank you !

odroegehorn@hs-harz.de

References

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- Busware GmbH, www.busware.de
- FHEM Project, www.fhem.de
 - Wiki: www.fhemwiki.de; Google-Group,
- EnOcean Alliance, www.enocean-alliance.org
- Echelon Inc., www.echelon.com
- ELV GmbH, www.elv.de
- Conrad GmbH, Discounter, www.conrad.com (several countries)