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An economical approach for small sized automation tasks

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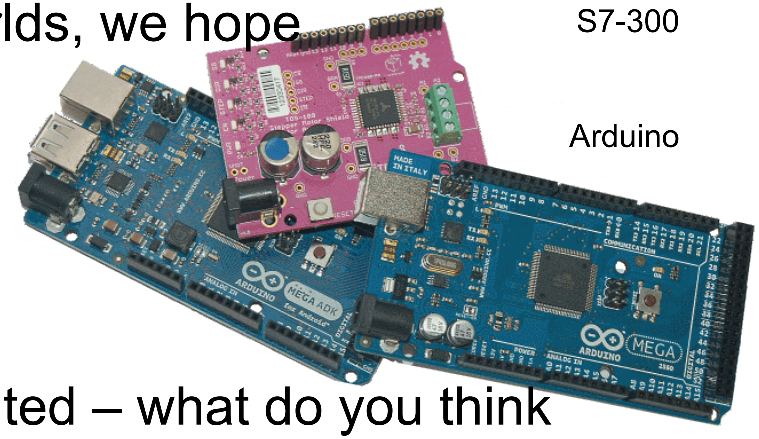
Overview

A new approch for small sized automation

- Small sized automation – where to bring into new fields and why
  - Motivating use case(s)
- Industrial automation and standard PLCs – why not to be found
- Little bare µController boards –
  why they are here and why they often should not

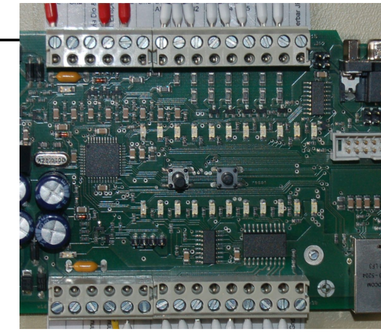
S7-300

- Specifying our approach – best of both worlds, we hope
- A module realized – the proof of concept
  - Hardware aspects
  - Software aspects
- Comparison, conclusion, use case(s) revisited – what do you think



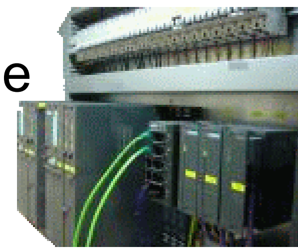
Arduino

Motivation for automation
additional, small sized, in new fields



Automation in some fields of application / markets is

- scarce to not existing or
- done by isolated proprietary / closed approaches



This is the case in small buildings and private homes, to name just one exemplary field. Nevertheless there is a need for

- introducing automation to realize small, distributed task

This will be an enabler to more functions, comfort, energy savings, growth of quality and other advantages.

Driving forces often are

- saving energy and costs as well as
- keeping or enhancing functions and comfort.

In for a hot bath ?

Motivation for automation

additional, small sized, in new fields

But in modern homes thermal insulation of walls, doors and windows is up-to-date, as are the the dish washer and other equipment.
And if 90 % of the lighting is by LEDs the only source of further savings is either a painful reduction of living comfort and quality or introducing a smart/ intelligent management of lighting, heating, ventilation, doors, shutters etc. That we can as well call small scale automation.

There is a market (a “scene”) for solutions that are

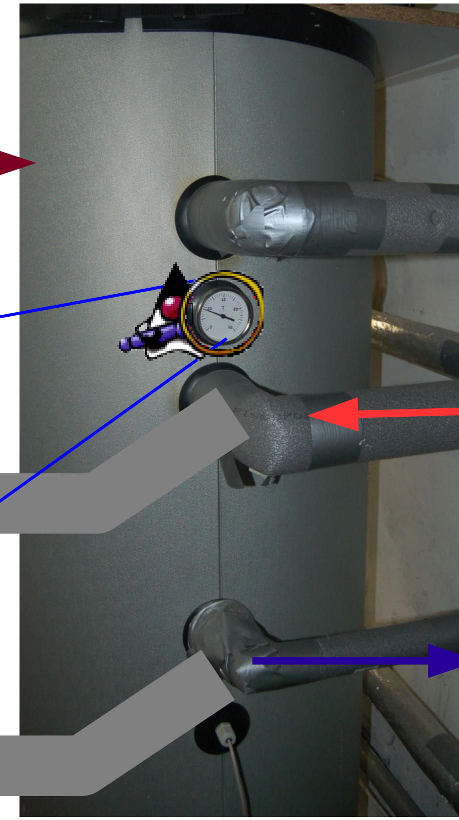
- good value for money
- adequate
- and often communicative / networked

So let's save energy and costs …
… or get more comfort.

Motivating use case
for (additional) small sized automation

Left cold after one bath and three showers in spite of

- a 600l “hot water” tank
- and plenty of thermal power by long-distance heating station



Tank loading (hot)

re-flow (cold)

Why not change the settings ?

Do ask the heating equipment manufacturer !

Motivating use case: 600l cold
Why not change the settings

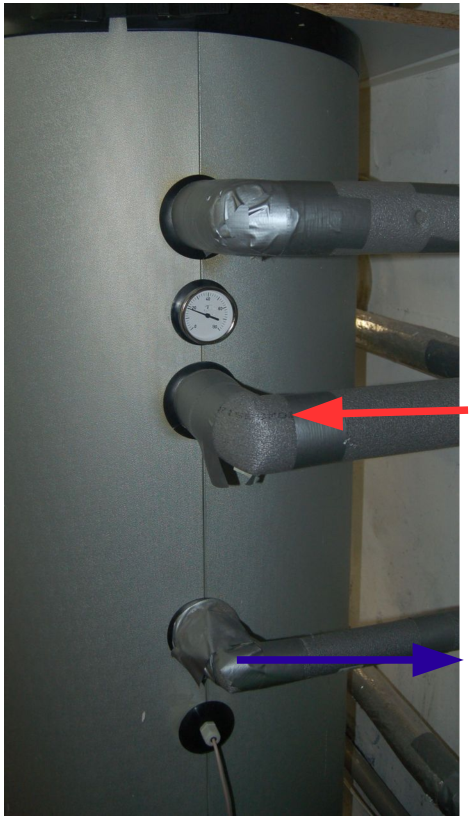
Motivating use case: 600l cold
Why not change the settings

HMI Usability : modest

Feature required here:
remove (all) tank loading
inhibits respectively delays

Setting of feature : not possible

Why not set / reprogram the heating equipment from outside?



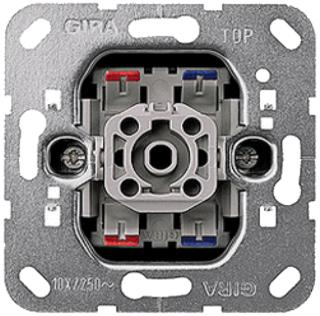
Usual answers on communication/control inter-faces:
“none we'll tell you !” … “none” … and even
(sometimes) “can you explain the question ?”

Hence, external control by an automation system, usually involves a **cheating proxy** to its sensors or actors. (Come back to this later.)

New extra small automation
Industrial systems and PLCs

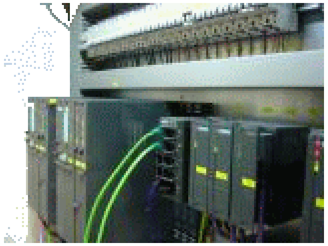
There are industrial and commercial building automation solutions

- often expensive
- intrusive (all or nothing)
- proprietary (closed, no communication or no open communication standards)


Instabus element

So they are seldom used in fields like the exemplary private home enhancement.
And why not industrial automation systems or ordinary PLCs

PLC

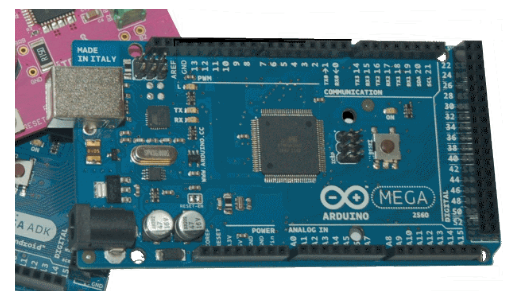


- price felt to be too high –
  often disregarding the quality and robustness
- programming tools and languages
  quite behind state of IT art

New extra small automation
bare µController boards and other DIY

Why they are here …..

- all reasons against industrial systems and PLCs – true or incorrect
- enthusiasts and early adopters – often with some IT background
- open source software, open communication standards, open tools



…. and why they often should not

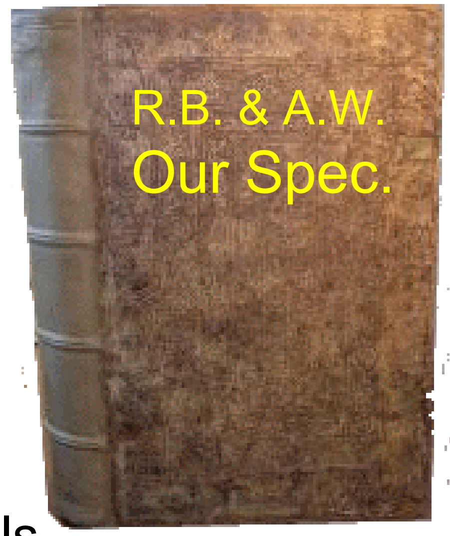
Those solutions or their deployment are often not compliant to

- any industrial, process control, process I/O standard
- electrical, interference, communication, handling rules
- electrical safety or EMC standards
  (or, regrettably, not even the most modest respective rules)

An in-depth specification
bridging the PLC µC gap – best of both worlds

Hardware oriented requirements

- supply, buffering, redundancy, low power consumption
- process signals, level, protection, safety
- communication and extension



Software oriented requirements

- multi-threading, supporting PLC-type “cylces”
- supervision, watchdog, logging
- support for I/O and multiple communication protocols
- command line interpreter
- timers and timing, date, time, zones

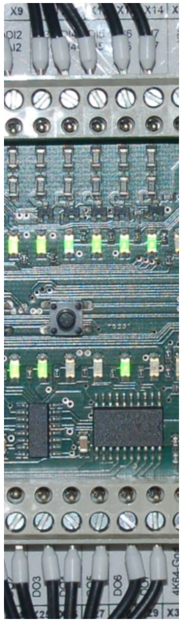
An in-depth specification
bridging the PLC µC gap – best of both worlds

Hardware oriented requirements (1)

- industry standard voltages (12 V, 24 V) for supply and process I/O ("load voltage" or LV for short)
- 9..30 V (LV), this range covering both 12V (home, facilities, small vehicles) and 24V (industrial automation, lorries, trucks) applications including all required tolerances (19 .. 27V e. g.).
- optional second redundant 9...30 V feed for the electronics, being suitable for uninterrupted battery supply or even AC (12..18 V~, alternating current)
- buffering of 20 ms supply outages without reset/re-start
- separation of PE (protecting earth) and signal/supply ground (Gnd)

An in-depth specification
bridging the PLC µC gap – best of both worlds

Hardware oriented requirements (2)



- fit for "green automation" thanks to low power consumption and by an efficient run-time software
- 8 digital output (DO) channels (LV, 100 mA, protected)
- 8 protected input channels for nominal +/-70 V input voltage (surviving 250 V_{eff}~ as absolute maximum rating)

Every one input channel (of 8) can either be configured as

- digital input
  in three threshold/hysteresis modes for different (12 V/24 V) sensors

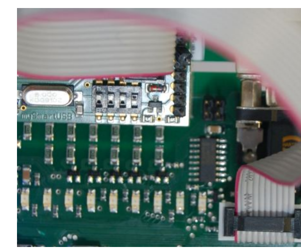
or as

- analogue input in three different single ended voltage ranges (3..50V)

An in-depth specification
bridging the PLC µC gap – best of both worlds

Hardware oriented requirements (3)

- Ethernet
  full duplex, 10 bit/s sufficient for small automation subnets
- V.24/RS232
  all usual modes, baud-rates up to 500 kBaud, optional flow control

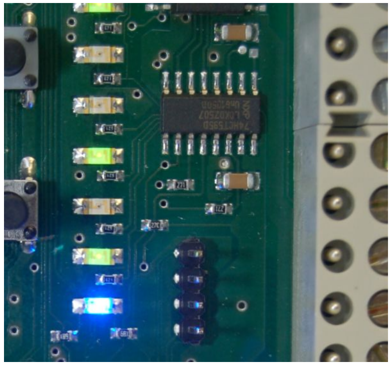


- extensibility by
  SPI (Serial Peripheral Interface Bus) and I²C (two-wire)
- widely-used micro-controller/architecture
  availability of open development / programming tool chain
- on board / in system programming (ISP)
- persistent storage
  by EEPROM and small memory cards (SMCs, slot)

An in-depth specification
bridging the PLC µC gap – best of both worlds

Hardware oriented requirements (4)

Being compact and low power (green automation) we nevertheless have to have some other typical PLC features:



- protected process I/O with error detection
  - overload, over-temperature,
  - wire breakage, short-circuit
- supervision of its supply (LV)
- status LEDs for all (16) process I/O channels (DI/AI/DO)
- status respectively error LEDs for
  - supplies
  - drivers

An in-depth specification
bridging the PLC µC gap – best of both worlds

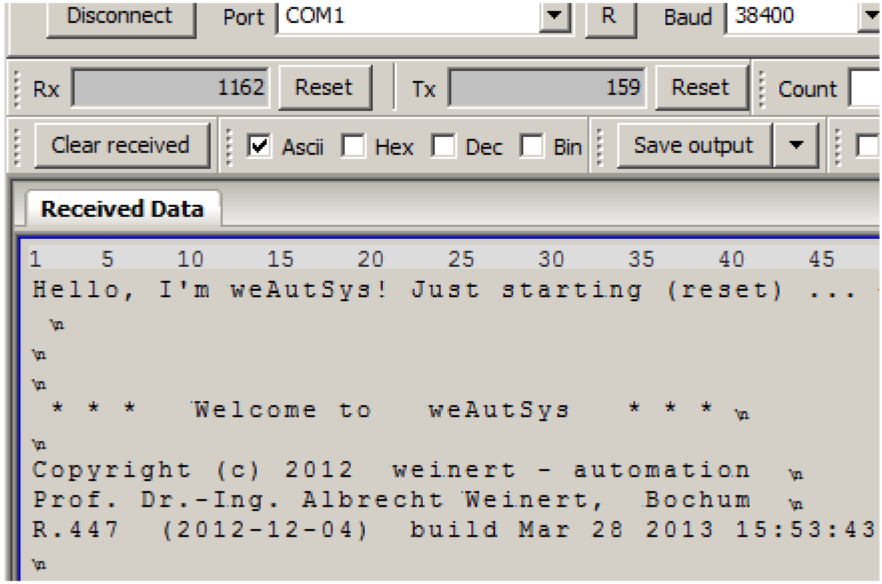
Software / run time oriented requirements (1)

- usual automation "cycles" 1 ms, 10 ms, 100 ms, 1 s
  known from most PLCs
  multi-treading
- handling of process inputs – analogue, digital, counter etc. –
  i. e. a good support for all available process I/O variants
  as well as some optional filtering
- handling and supervising of digital process outputs
  including supervision for overload over-temperature
- controlling the supervision of the load supply (LV)
- watchdog supervision of application/user software
- logging of (last) re-start cause

An in-depth specification
bridging the PLC µC gap – best of both worlds

Software / run time oriented requirements (2)

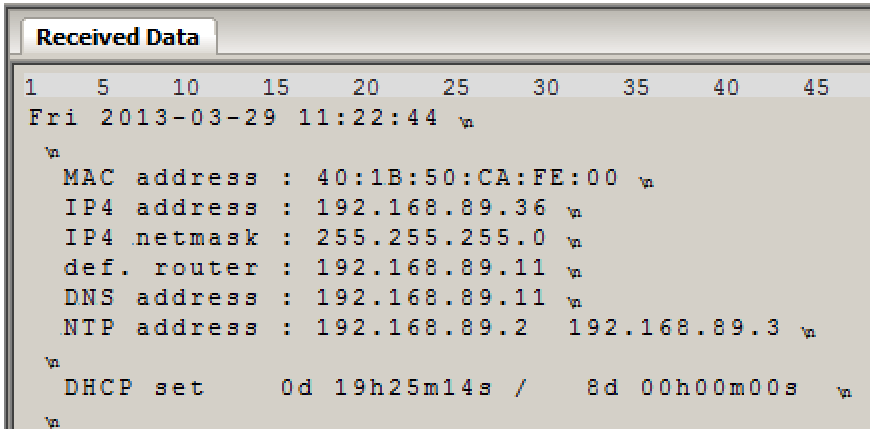
- handling of the optionally inserted small memory card providing the basic functions of the file system (FAT32)
- handling of the Ethernet communication, providing a set of protocol implementations:
    - DHCP (Dynamic Host Configuration Protocol),
    - Telnet (server),
    - Modbus (server),
    - NTP (net time protocol)



An in-depth specification
bridging the PLC µC gap – best of both worlds

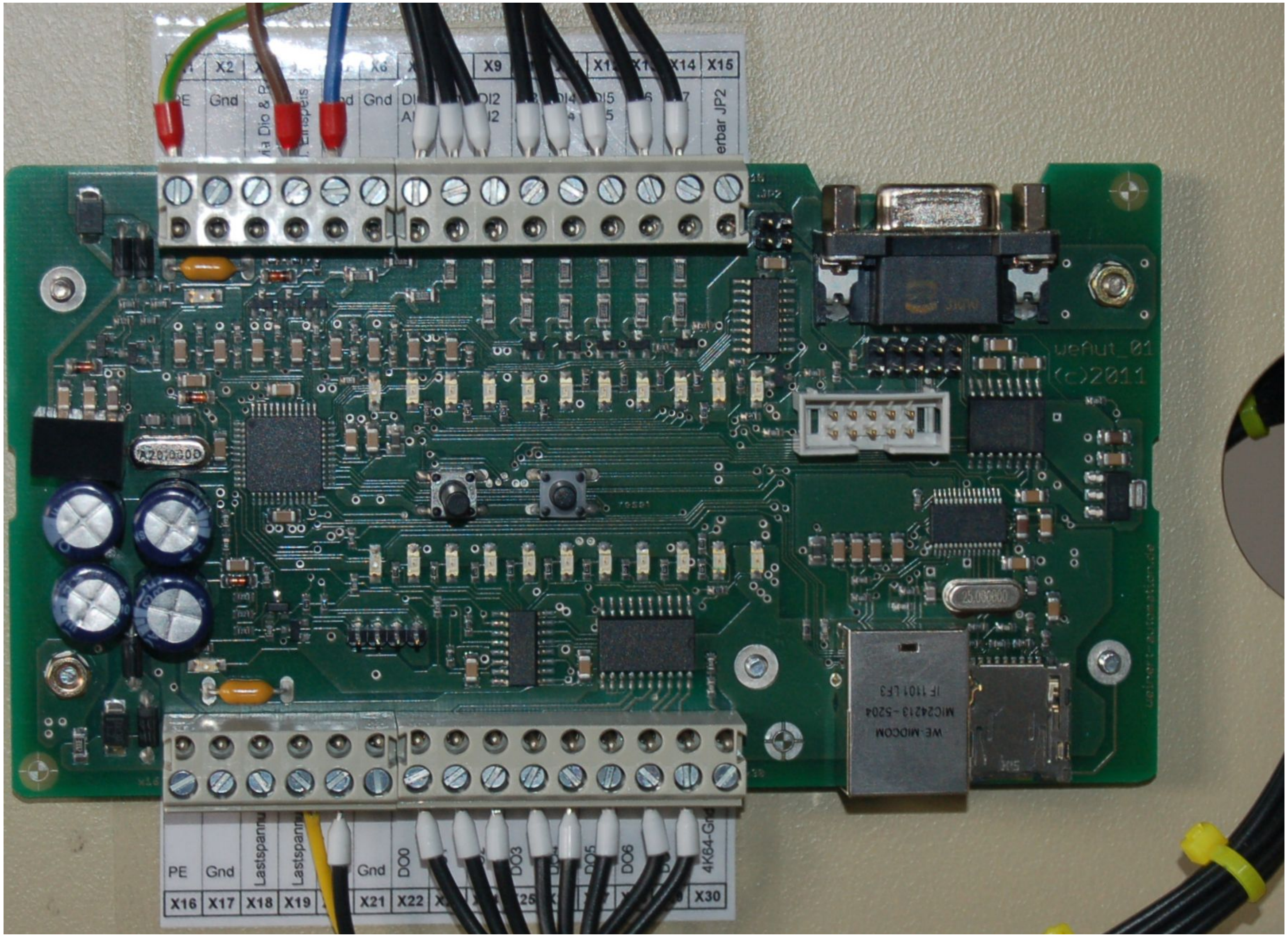
Software / run time oriented requirements (3)

- handling of communication and command line inter-faces (CLI) via serial communication (V.24, RS232) or
  by Ethernet/Telnet
- handling of date, time, zones and daylight saving, preferably by information got as DHCP or NTP client in good accuracy and 1 ms resolution
- providing both absolute (date time) and relative (duration) timers



Realized automation module

proof of concept



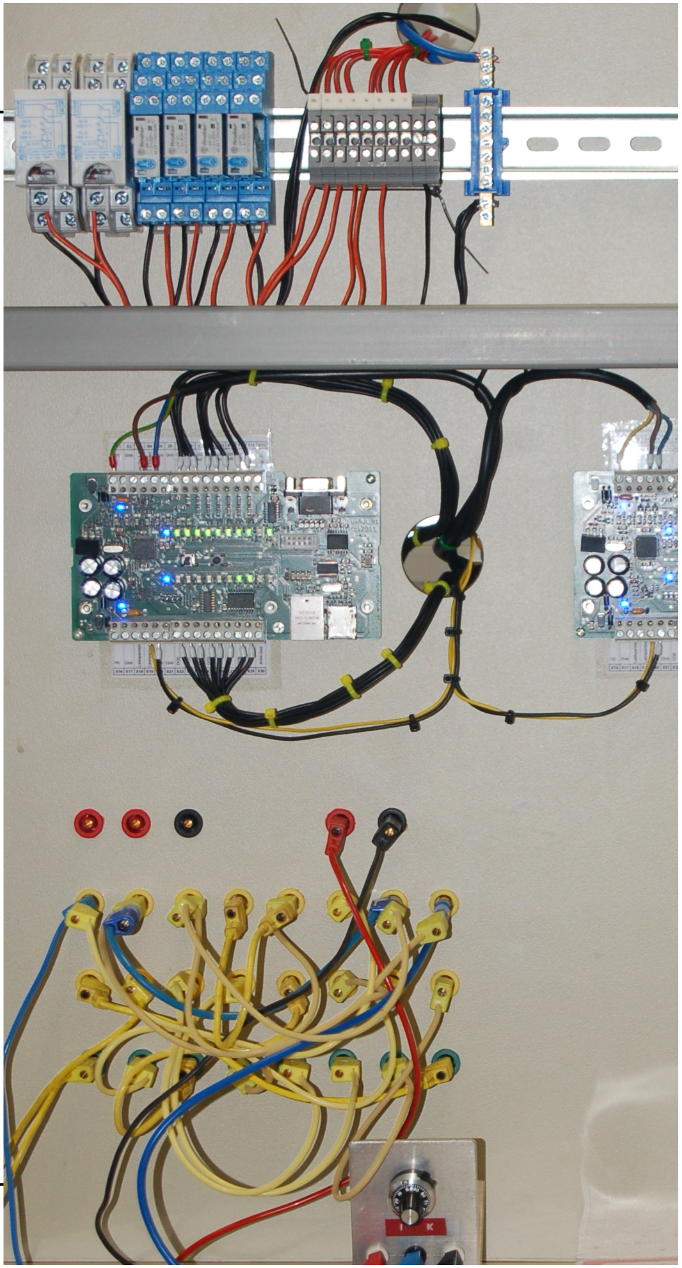
Automation module weAut_01

All HW & SW specifications fulfilled

Automation module weAut_01
demo and development board

Left cold after one bath and three showers
in spite of
- 600l “hot water” tank
- plenty of thermal power by long-distance heating

Use case revisited



Motivating use case
revisited and solved

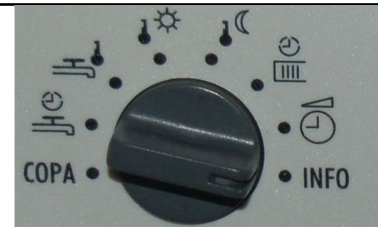
Left cold after … users and service men unable to solve the problem by setting / programming

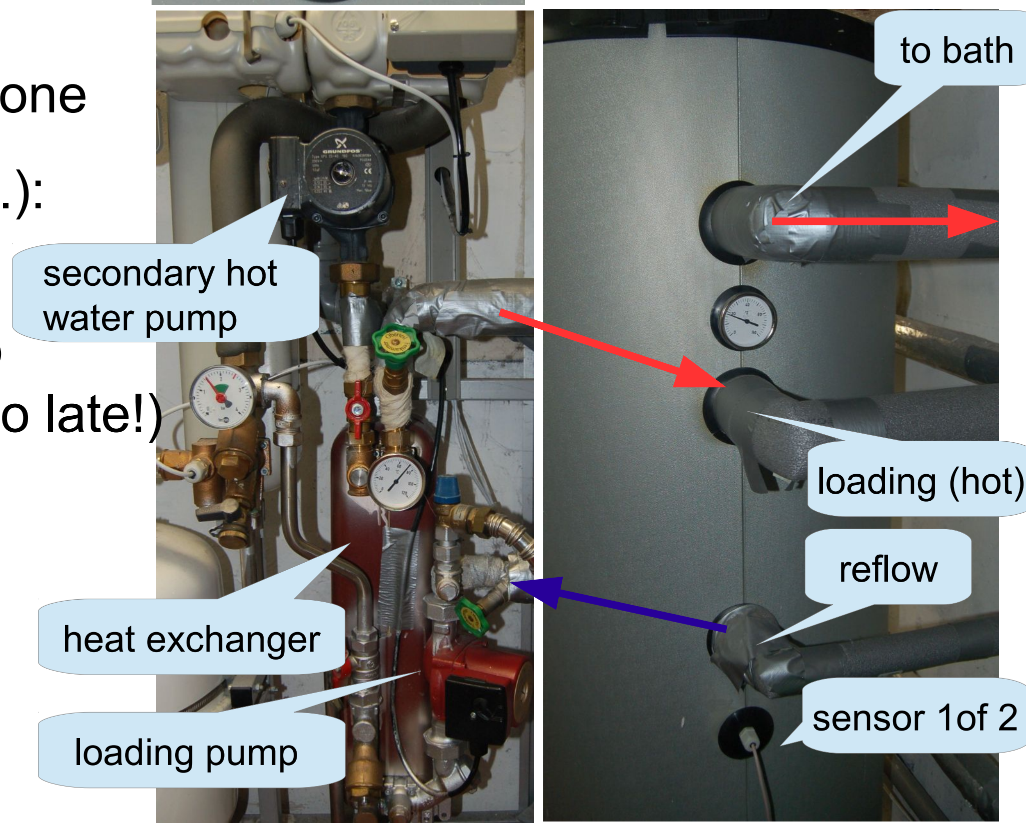
Usable / published interfaces: none

Determining the behaviour (exp.):

a) cheating both tank sensors to15ºC started secondary pump after 50..80 minutes (too low, too late!) and the loading pump 20s later.

b) forcing both pumps running on demand gave enough thermal power for at least twice the crucial demand.

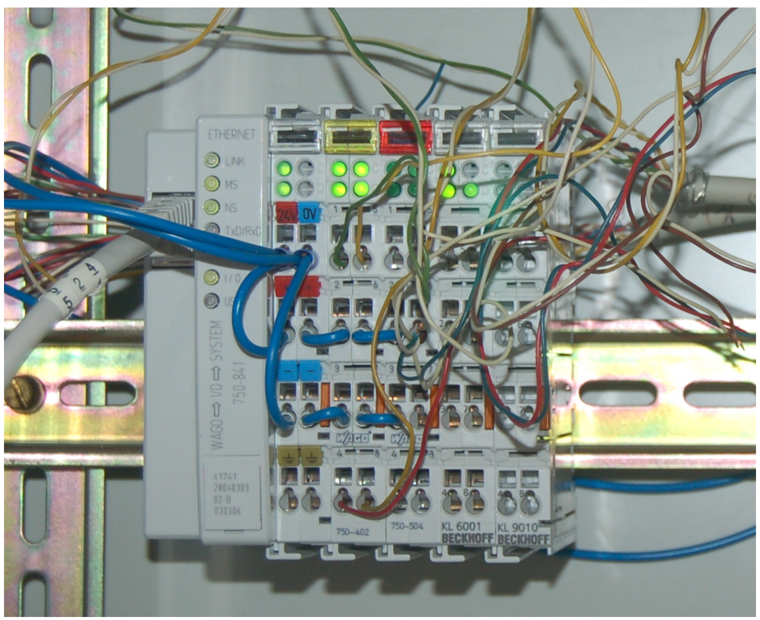


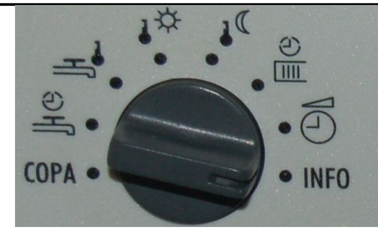


Motivating use cases
problems solved

Use case 2:

Replacement of simple 4 DO
& 4DI to Modbus I/O concentrator
for a building protection system





Use case 1:

Left cold after …
solved by cheating
proxy taking over
the loading pumps
control

Criteria:
temperature drop &
remote control

Plus: take over hot
water circulation
(comfort) pump
control

Motivating use cases
problems solved

Use case 2:

Replacement of simple 4 DO
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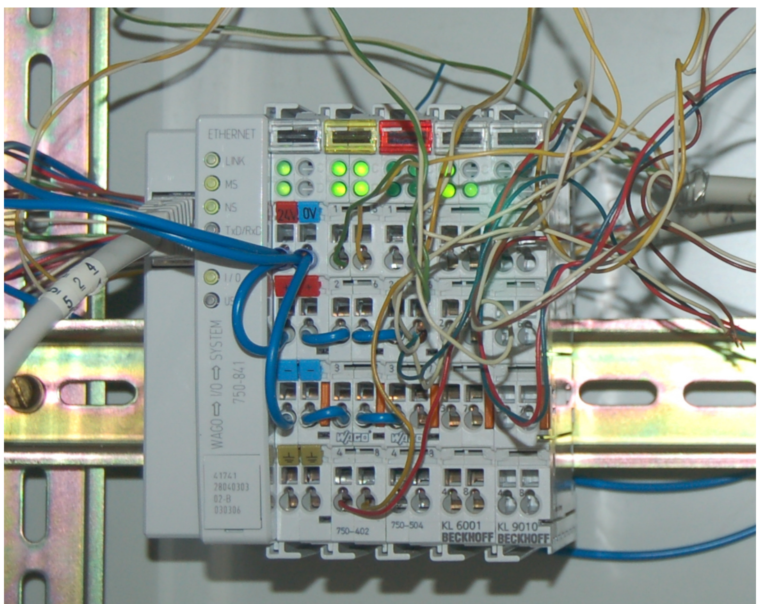
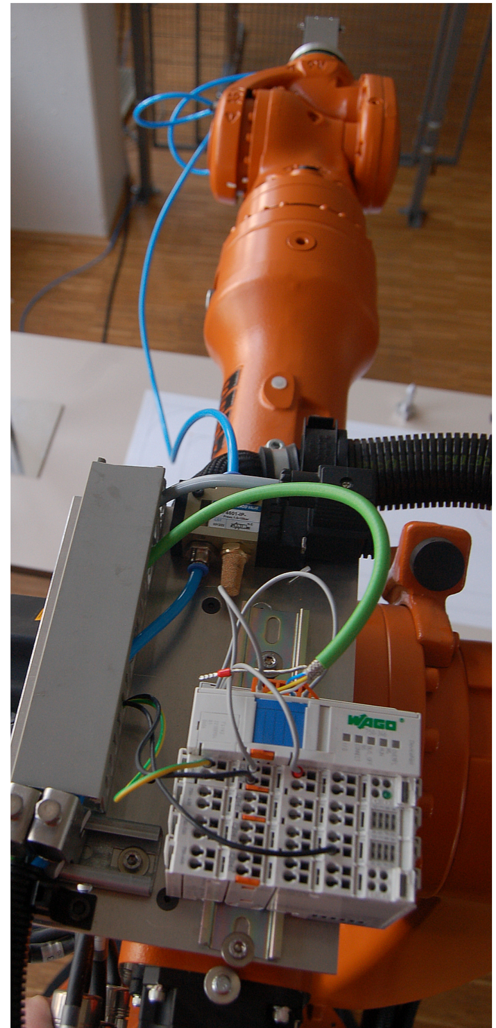




Use case 3:

Lightweight
replacement
for one extra DO
(binary output for
air vent)
riding on a Kuka
KRC2's arm

An economical approach
for small sized automation tasks

We presented a specification of an automation module combining

- industry automation proceedings, interfaces and standards with
- sparing and “green” micro-controller technique

and made a

- proof of concept evaluation board and an efficient run-time.

Compared to automation systems / PLCs:

- lower price for a board
- usability of free state of art IT software tools

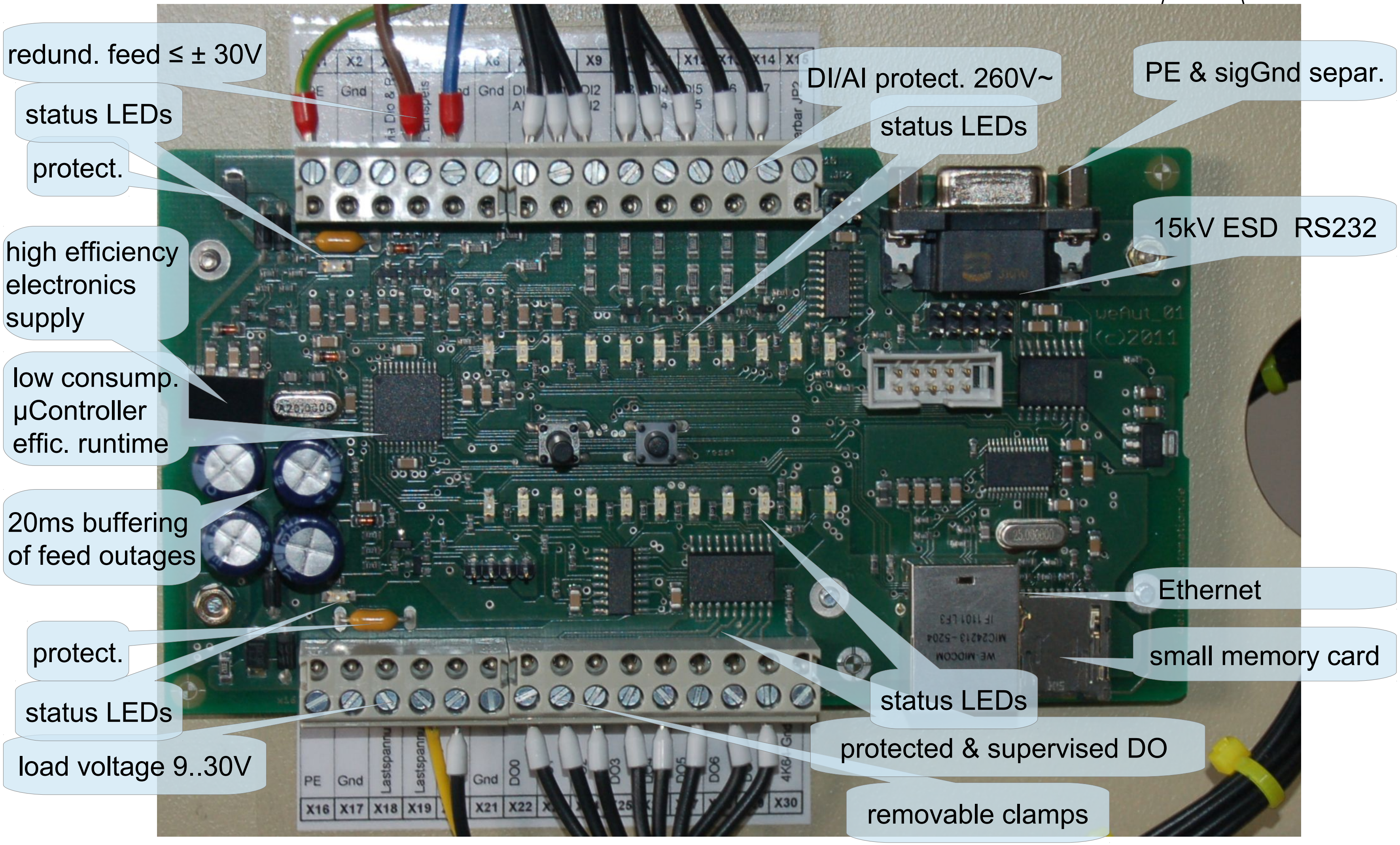
Compare to bare µPCs / µController boards:

- ~ thrice the price, area

Property	weAut_01	Raspberry Pi
Price (€)	170	50
units made & sold	100	millions
size (mm * mm)	82 * 151	86 * 54
supply voltage (V)	9..30	5
supply power (W)	1.5	3.5
memory (Byte)	144 K	512 M
CPU clock (MHz)	20	700

Proof of concept weAut_01

what footprint — and money — is spent for



Thank You

Questions ?

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