Automatization of intelligent buildings

Ondřej Nývlt

Department of Control Engineering
Czech Technical University in Prague

The Plan

1. Intelligent building
2. Building automation– categorization
   A. „Open/closed“ systems
   B. Centralization
3. Building automation– examples
   A. Xcomfort/Nikobus, Ego-n, iNels
   B. LON
   C. KNX
   D. BACnet
   E. DALI
   F. EnOcean
   G. OpenTherm
   H. DAMIC

Intelligent building (IB)

- IB – origin in USA, later in Japan (integration of computer control)
- Definition dependent on the point of view: different meaning for civil engineer and for electro-engineer

- Intelligent building ≠ passive or low-energy building

- Main tasks of automation in IB:
  - HVAC control
  - Lighting control
  - Control of electrical power system
  - Lift control
  - Security and safety system (including access control)
  - Fire alarm system
  - …

Categories of buildings

Category	Description	Examples
S	**Small and family houses**	households
M	**Middle-sized buildings**	hospitals, schools, hotels, office houses, retirements homes
L	**Large buildings and complex of buildings**	large office complexes, universities, airports

- **Every category has different priorities and needs:**
  - **S:** 1. Safety (fire alarm, intruder alarm, water leakage…)
    2. Comfort
    3. Cost-effective usage of energy sources
  - **M:** 1. Low operating and repair costs
    2. Cost-effective usage of energy sources
    3. Flexible room
    4. Comfort and safety
    - most common usage of automation
  - **L:** 1. Low operating and repair costs; investment return

Ecology – „Green“ buildings

Home automation

- Emphasis on comfort
- Intelligent household today:
  - High user comfort – lighting control; dimming; intelligent shutters; HVAC based on meteo-data; control of electronic devices; remote controllers; voice control…
  - Remote control and visualizations PC/PDA/mobile phone
  - Security and safety – fire, intruder and broken window alarm; simulation of presence; GSM alarms
  - Effective management of power sources and energy -> low-energy building
  - Interconnection with audiovisual system
  - Flexibility
  - Less complicated wiring (bus)

Basic categorization

- **„Open/closed“ systems:**
  1. Open standard (KNX, LON, DALI…)
  2. Closed system - one manufacturer (Ego-n, iNels, Xcomfort)
- **Centralization:**
  1. Centralized (Ego-n)
  2. Decentralized (KNX, LON, Xcomfort…)
  3. Hybrid (Nikobus)
- **Complexity:**
  1. Complex building control system (KNX,LON,Xcomfort, Ego-n)
  2. Specialized system/protocol for one task (DALI, OpenTherm)
- **Transmission medium (physical layer):**
  1. Twisted-pair/RS-485
  2. Powerline 230V
  3. RF/infra-red
  4. Ethernet

„Open/closed“ systems

- „Open“ systems:
  - Specification of the protocol is public – standards: IEC, ANSI, ISO, EN
  - Advantages and disadvantages:

    + competition and big variety -> flexibility

    + academic research

    - price for small projects
  - Examples: KNX - EN 50090, ISO/IEC 14543, Lon - ANSI/CEA 709.1, BACnet – ASHRAE/ANSI 135 ISO 16484-5

- „Closed“ systems:
  - Specification of the protocol is private in company
  - Advantages and disadvantages:

    + easy installation and programming

    + price

    - dependency on one manufacturer

    - very limited variability
  - Examples: ABB Ego-n, Moeller Xcomfort

Centralization

- **Centralized system** (topology/control)
  - Entire system controlled by one (or few) central unit
  - Earlier: direct connection of I/O; today: bus for connection

  + no need of „intelligent“ sensors

  - case without bus: length, price and disorganization of wiring
  - sensitivity on failure of the central unit

  - Examples: Ego-n (8 central units), some systems with PLC

- **Distributed system**:
  - Control algorithms divided in more subprograms
  - Intelligent units (containing subprograms) all over building

  + distributed intelligence – robust solution
  + always use bus

  - Examples: LON, KNX

- **Hybrid system** – Moeller Nikobus
  - quasicentral units

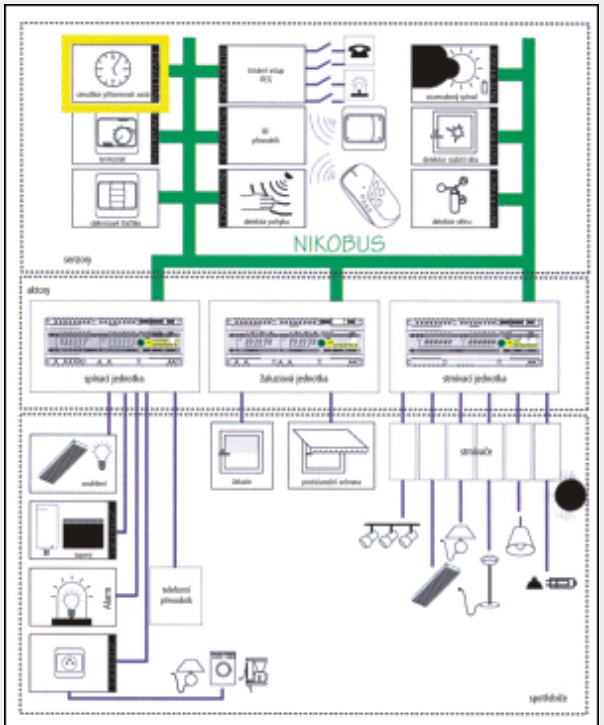
„Closed“ systems

Xcomfort Moeller

- Fully decentralized wireless (868.3 MHz) system
- Suitable for reconstructions
- All basic task of home automation
- Can be controlled through GSM, PC/PDA
- Actors and sensors are able to rout
- Configuration with or without PC

Nikobus Moeller

- Hybrid system – „wired version of Xcomfort“
- Inputs (sensors) connected through bus
- Outputs (actors) connected with quasicentral unit using star topology
- Presence simulation; connection with security and fire-alarm systems

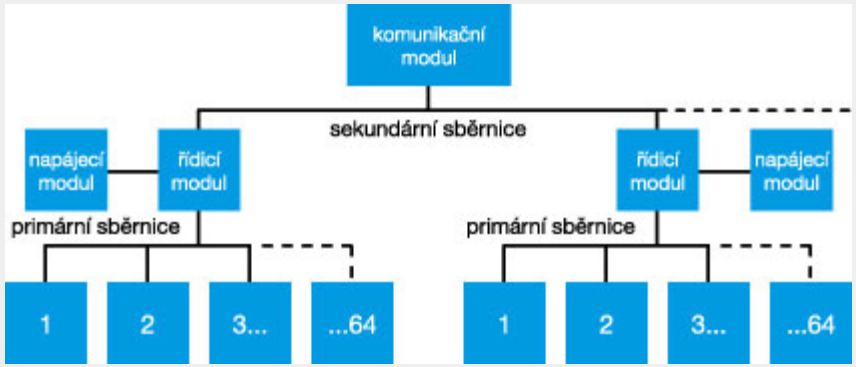


Obr. 1. Topologie systému Nikobus

„Closed“ systems

Ego-n ABB

- Centralized bus system (4-cores cable) originally from Czech
- Configuration with or without PC
- Primary bus (max 700m) – max 64 units (sensors and actors)
- Secondary bus (max 2000m) – control modules (max 8); TCP/IP module; GSM module; module of logical functions …
- Lighting and shutter control, HVAC, motion detector, visualization on PDA/PC/mobile phone, presence simulation, care about pool and lawn…

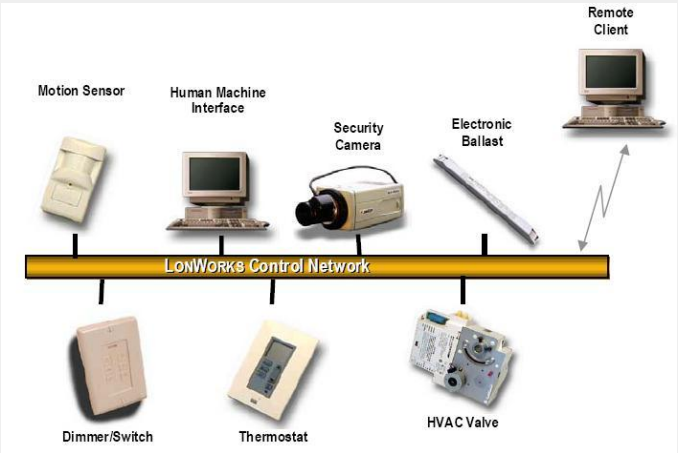


iNels

- Czech centralized bus (CIB) system
- Connection with PLC Foxtrot Tecomat
- Classical portfolio of „closed“ home automation systems (+ voice control)
- Possibility to connect with LON, MODBUS …

LonWorks

- **Very universal and general standardized distributed system**
- **Originally designed for automobile applications (90er)**
- **Today main usage in buildings**
- **More popular in USA than in EU (in EU mainly Schneider Electric)**
- **Based on the net of Neuron chips**
- **6 physical layers – TP, Powerline 230V, optic fibre, RF, IR, coaxial cable**
- **Covers almost every possible demand in building automation – including security system, CCTV, fire-fighting system and so on**
- **Disadvantages** – price for small houses; universality
- **Companies (>500): ABB, Honeywell, Loytec, WAGO, Thermokon, Schneider, Somfy…**
- **Czech companies – ZPA, ATD**
- **Usage:**
  - train and subway control; building automation; industrial production; public lighting systems, gas stations…



Konnexbus

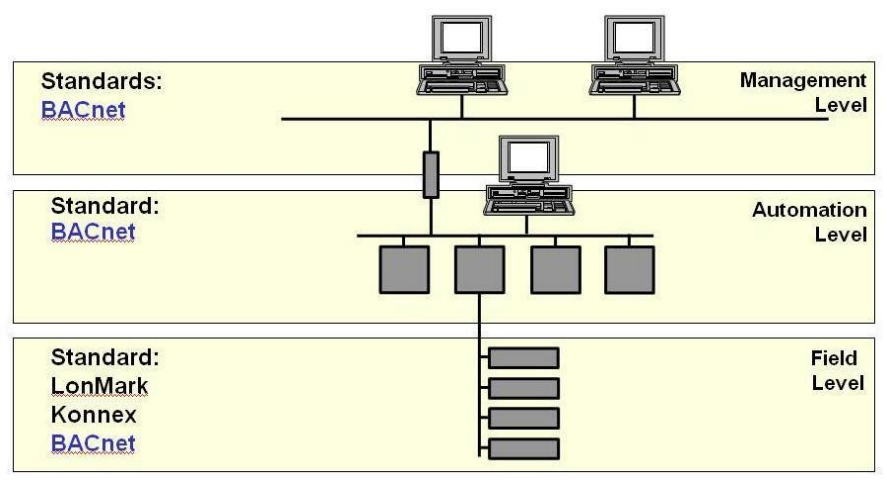
- Most important protocol in Europe (80% of market) – competitor to LON
- Standards – ISO/IEX, CEN EN, CENELEC EN, GB/Z (China)
- Academic development – 50 universities (TU Wien)
- Gateways for almost every system/protocol
- Covers all demands for building control (from office to family houses) including effective energy usage and so on
- 5 physical layers – Twisted-Pair, Powerline 230V, Infra-red, RF, Ethernet
- Disadvantage: price for small home automation -> larger projects
- Configuration by SW *ETS 3.0*

- Companies (>100) – ABB, GIRA, Siemens, Hager, WAGO, Buderus, Viessmann…
- Over 7000 products

- Applications:
  - Public Lighting System in Salzburg; Heathrow Terminal 5; cruise ship MS Bele de l'Adriatique; hotels …

BACnet

- **Developed by ASHRAE and ANSI in USA for building automation (1995)**
- **Focused on higher levels of automation (not on process automation)**
- **Protocol based on objects – terms: objects, properties, service**
- **Independent on physical layer: LonTalk, RS-485, ARCNET, Ethernet, RS-232, KNX-TP**
- **Independent on specialized chips**
- **Usage:** HVAC and lighting control, CCTV, Fire Alarm Systems, Security systems
- **Many companies; gateways to KNX, DALI…**



DALI

- **Specialized protocol and bus for lighting control**
- **Replacing dimming control 1-10V**
- **Features:**
    1. Master-slave (mono/multimaster)
    2. Free topology, two-wires bus, 1200 b/s, one line max 300m
    3. One line max 64 devices, max 16 groups and 16 scenes
- **Advantages**: feedback from devices, bus, free topology
- **Disadvantages**: only for slow dimming, price
- **Aplications:**
    - „Madrid Calle 30“ – lighting control of the inner ring (73.000 light sources)
    - „Terminal Heatrow 5“ – 120.000 light sources controlled by DALI/KNX
    - „Kölner dom“ – cathedral in Köln
    - Lighting control in theaters

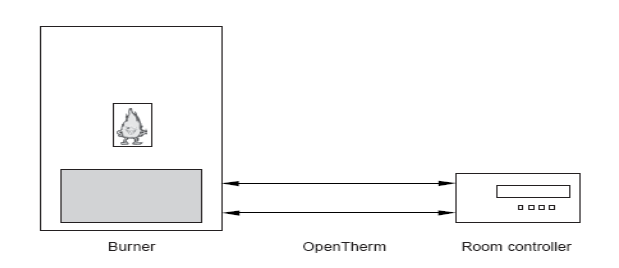
- **Gateway–KNX, BACnet, LON, Xcomfort, Nikobus, DMX512, Modbus, PLC**
- **Companied (>40) – ABB, WAGO, Philips, Tridonic, Zumbotel…**

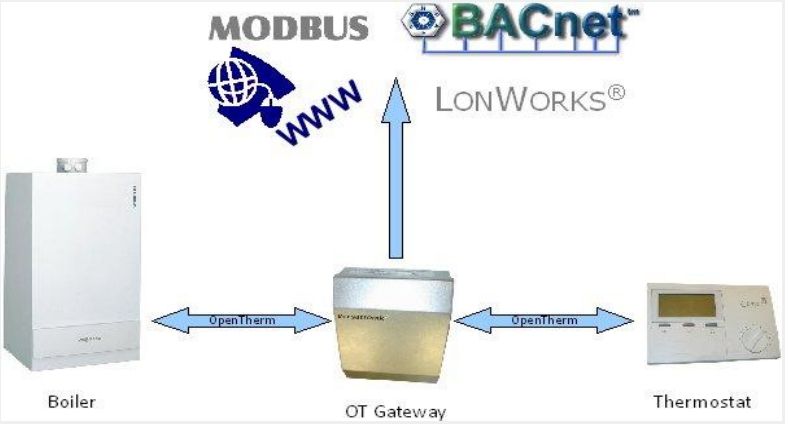
EnOcean

- **Wireless bus - 868.3 MHz, range 30m – 300m**
- **Distributed control system / distributed IO**
- **Most of units are batteryless and maintenance-free**
- **Energy harvesting:**
  a) Battery/line-power supply (gateways, repeaters)
  b) Energy from a pressure – deformation of piezoelectric crystal
  c) Solar energy
  d) Energy from a temperature change (Peltier)
  e) Energy from vibrations and rotational motion
- **Usage:**
  a) HVAC and lighting control
  b) Presence sensors…
  c) Automobiles and industry (vibrations and rotational motion = energy)
  d) Voting systems
- **Companies (>100) – Siemens** (author 2001)**, WAGO, Osram, Thermokon, VIPA…**

OpenTherm

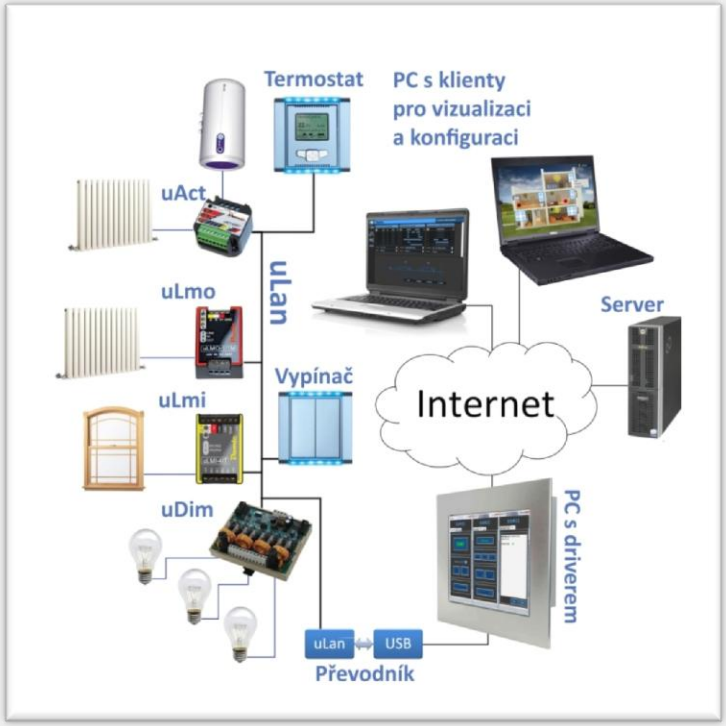
- **Specialized open protocol for heating control (e.g. boilers)**
- **PTP connection of a thermostat with a boiler (master-slave)**
- **MPTP – more controllers operates 1 boiler (multimaster-slave)**
- **Master units are powered over communication lines from a slave unit**
- **Physical layer:** polarity-free untwisted pair, max 50m
- **Two versions of the protocol: OT/- a OT/+**
- **Gateways to: BACnet, Lon, Modbus, WWW, KNX RF**
- **Companies (>40) – Honeywell** (author 1996), **Viessmann, Hager, Siemens…**





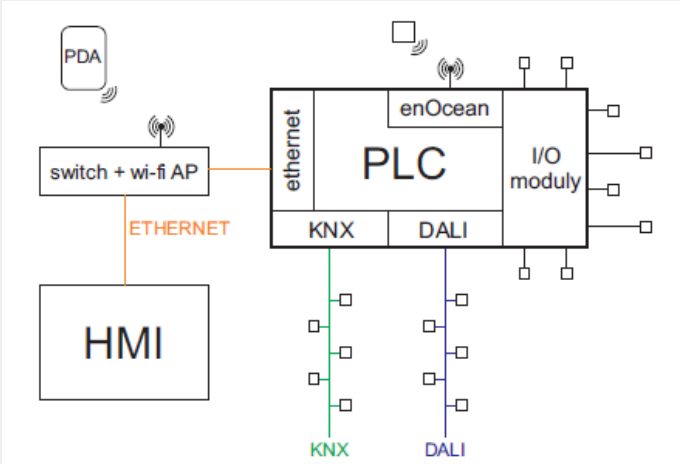
Damic

- Project of the DCE under development: **DAMIC**
- **Distributed system based on open-source bus protocol uLan**
- **Lighting and heating control; detection of opened windows…**
- **Web-based remote control and visualization**



Demonstration model for home automation

- Project of the DCE placed in room KN:E-s109
- KNX, DALI, EnOcean …
- Lighting and heating control; detection of opened windows; intruder alarm; energy consumption measure; color mixing; shutter control …
- Web-based visualization (WiFi, HMI)
- WAGO PLC and HMI panel



Thank you for your attention!