KNX Association

History of Bus Systems
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1 History of Bus Systems

The history of bus systems began in the 60’s with the development of the first usable computer. Bus systems were invented in order to connect the internal components of the computers with each other for information technology. This trend continued with advances in miniaturisation. With the introduction of the departmental computer, external bus systems were used in addition for the first time, enabling the individual departmental computers to be linked to each other. The bus systems that had been used until then were manufacturer-specific and were not made open to all, not least for marketing reasons. With the introduction of the PC in the 80’s, proprietary bus systems were no longer in line with market requirements as customers were demanding open systems.

The task of bus systems was at that time connecting systems with each other. Now, it’s not the bus system which connects installation components, but the bus system itself is the installation. This is e.g. the case with KNX. There is no central unit, in which a program is running, but the “program” is divided all over the installation in many countless intelligent network nodes, of which the interaction between them determines the complete installation function.
2 Areas of Application for Bus Systems

With the further development of bus systems in the field of computers, the area of application of bus systems became more widespread. In a first development stage, bus and microcomputer systems were also used in production and building automation. Initially, the functions available were only very limited and the systems were seldom compatible with each other.

Nowadays there are many different bus systems on the market, where each bus system shows its main area of use. Bus systems, which have the support of a united group of manufacturers and can thus gain a significant market position, such as e.g. KNX, are the systems that are gaining ground.

As these systems are however often too large for basic applications (which can be seen in the costs), simple, good value and even proprietary systems have also gained a certain share of the market.

In these past few years, RF bus systems have been introduced next to “wired” bus systems. These RF bus systems are gaining an increased significance in building services engineering due to the fact that they can be used for fast changing applications as well as in the renovation industry.
3 Hierarchy Model for Automation

Each bus system can be categorised in the model represented above, in which many bus systems also cover several levels. The KNX bus is categorised in the area of the field buses. The following statements can be made:

- Data volumes, requirements for fault tolerance and system costs are increasing.
- Demands on reaction time to specific events are decreasing whereby these requirements are also dependent on the area of application of the bus system.
- Not every application requires all the levels of this model e.g. the KNX can already be used sufficiently as a field bus.

For a complex application, such as the administration and management of distributed properties, a mixture of different bus systems is frequently used nowadays. Different KNX systems are interconnected for example via Ethernet or linked with an existing intranet or the entire Internet world.

4 Overview of Current Bus Systems in Building Systems Engineering

As it has meanwhile become almost impossible to keep track of the number of different bus systems in the field of building systems engineering, only a small segment of these can be examined here. In the following section, some bus systems are selected arbitrarily by way of example and described in more detail. A significant number of additional systems are then presented in a table to provide an overview however we cannot guarantee that the list is complete.
4.1 LCN

- LCN stands for “Local Control Network”
- Manufacturer: Issendorff GmbH, Retten
- Physical medium: one free strand of the 230 V wiring (4-wire)
- Topology: as required
- Bus cable length: 1000 m per segment for NYM 1.5 mm² / 2.5 mm², less for different cable types (e.g. 500 m for 0.75 mm²)
- Number of bus devices: 250 per segment, extension via segment coupler (max. 120 segments)
- Transmission rate: 9,600 bit/s (base band)
- Functions without a control centre, multi-master operation
- Each module has its own microcomputer with its own power supply (230 V AC)
- Addressing: via installation software, download via RS 232 into the module
- Protocol: proprietary, not open, bus arbitration?
- Two basic modules: flush-mounted module, DIN rail mounted module
  - Each module has inputs for 6 or 10 conventional push buttons via separate adapter, impulse input and two Triac outputs for switching/dimming up to 300 VA (DIN rail mounted variant available with 500 VA), greater capacity via additional relay
- Application modules:
  - Functions essentially via conventional switching devices (no LEDs), separate temperature sensor, etc. – no complex application modules such as room temperature sensors, information display, timers etc. An KNX retaining ring with 10-pole connectors can be supplied as an accessory for the flush-mounted module, support for standard KNX 4-fold switch sensors from Berker, Gira, Jung and Busch-Jaeger
  - Applications: core building functions (switching, shutter control, dimming, time delays, AND/OR functions, individual room temperature control, security functions) as well as visualisation, RS 232 coupler module, …
  - Special installation regulations when using RCCBs, as the current flowing via the data conductor and neutral conductor is considerable.

Notes:
The advertising material of the LCN is pitted almost directly against the KNX. Products since 1994. Proprietary system – only one supplier, training is offered by the manufacturer. Telegram structure is specific to the function i.e. functional information is also transmitted in telegrams, each input (conventional pushbutton) has three functions (short/long pushbutton action and release). Until 1996 the actuators operated the neutral conductor (since then current-sourcing actuators are also available). Basic modules have a comprehensive design.
4.2 PHC

PHC stands for “PEHA House Control System”
Successor of the IHC system manufactured by LK (Denmark) and has been distributed since 1994 in Germany by PEHA under the name “PHC” and its own label. PHC is not compatible with IHC.
PHC was developed by PEHA themselves and was launched onto the market around February 1997
Functions with a control centre (such as PLC). 4 control centres can be interconnected
Input and output modules as DIN rail mounted, to which conventional installation devices are connected
64 modules per control centre
Physical medium: four-wire cable JY(St)Y 2x2x0.8
Addressing: addressing to the devices via DIP switch. The assignment between inputs and outputs is implemented by means of a PC and special software
Number of devices: limited by the number of inputs and outputs and module connection possibilities to the control centre
Bus cable length: max. 100 m per data line
Topology: in the switchboard: line
Devices: DIN rail mounted power supply unit, DIN rail mounted control module, DIN rail mounted input module, DIN rail mounted output module, DIN rail mounted dimmer module, DIN rail mounted analogue module, telecontrol, RF modules
Applications: switching, dimming, roller blind/shutter control, simple heating and ventilation control, time/clock functions, alarm functions, telemonitoring via a modem, visualisation

Notes:
The IHC/PHC system is more of a central controller than a bus system. The system is similar to a programmable controller whereby distributed modules are connected to the control unit via a twisted twin-core cable. The functional scope is relatively broad, very suitable for smaller installations. Modules are available. Both the input circuits and the controlled circuits (output circuits) are connected to the modules.
4.3 LonWorks®

LonWorks® stands for “Local Operating Network”, LonWorks® denotes LON hardware and software technology as a whole.

Manufacturer: many, world-wide
Distribution: direct from the manufacturer, no retailer
Technology provider: Echelon (Palo Alto, USA), development of the neuron chip, transceivers, protocol and development tools
Functions without a control centre, multi-master operation
Intelligent modes, equipped with a neuron chip
Communication principle:
Nodes exchange data via network variables. Network variables are linked together using a network management tool (PC program). The sensor node then sends value changes of its output variable to the linked input variables of the actuator node(s)
Physical medium: various
typical: Twisted Pair in “Free Topology”, “Link Power” as a Twisted Pair variant with superimposed direct voltage (42 V DC) for supplying the nodes via the bus cable, bus cable must be terminated (EOL resistors)

Further media: Powerline (CENELEC C band for consumer use, CENELEC A band for EVU), radio frequency, fibre optic, infrared, coaxial, implemented by fitting the devices with various transceiver modules (Neuron® link module - medium)

Number of bus devices: dependent on the selected medium and the transmission rate (transceiver type), typically: 64 nodes per cable segment

Protocol: LonTalk®, at first only implemented in the neuron chip, was laid open in 1998 for transportation to more powerful processor systems, protocol in accordance with ISO/OSI 7 layer model.

Transmission speed: varies depending on the medium and topology, determined by the transceiver type used, typ. 78 Kbit/s for TP in free topology, max. 1.25 Mbit/s for line topology (backbone). The neuron chip however does not make full use of this bandwidth.

Bus access: variant of the CSMA/CD procedure, collisions lead to retransmission according to random delay, acknowledgements often only possible in succession, group addressing therefore is often “unacknowledged” or “unacknowledged repeated”.

Node addressing in protocol: various
typical: Individual node addressing using logical node address, several nodes via group addressing, otherwise subnet and broadcast addressing. Each neuron chip has its own 48 bit serial number (neuron ID) as a physical address for commissioning

Bus cable length: dependent on the medium, transmission rate and the type of 2-core wire, typically (for JY(ST)Y 2x2x0.8): max. distance of 320m between nodes of a segment, 500m total cable length, boundaries are crossed using a repeater or router

Topology: dependent on the medium and the transmission rate, typically: free topology (incl. ring), alternative line bus structure with short spurs (3 m) for greater cable lengths (up to 2.5 km)

Commissioning software:

Various available from a variety of manufacturers, also available with a German operator interface. Distinction can be made for text- or graph-based tools (Viso). Most
of the tools are based on the unified Echelon database platform (LNS). Universal additional programs (plug-in) enable the parameterisation via Windows dialogs.

Flush-mounted LON bus coupling units with KNX PEI are available, mechanically and electrically compatible with KNX, push button applications for switching/dimming/shutter control and single room control enable the use of several KNX application modules.

Notes:
The LonWorks® technology (neuron chips, LonTalk® protocol, neuron C compiler and transceiver) was developed by Echelon and launched onto the market at about the same time as KNX. Manufacturers use this technology primarily as a platform for proprietary systems e.g. cashier systems, filling station systems etc. Only later were requirements added by the LONMARK organisation for interoperability of the applications (comparable to DPT). The conversion of this guideline was put into operation, supported by the German user organisation (LND). Device certification according to the LONMARK is currently not universal.
The system should find worldwide distribution in industry and in buildings, there is great deal of marketing activity (large stands at exhibitions and conferences), product variety is increasing, products are becoming more professional. It is however a considerably more complex system than KNX that requires more extensive knowledge.
4.4 Field Buses of Industrial Automation Technology as Building Buses

Field buses from industrial automation technology such as the Profibus or the industrial Ethernet are used by many manufacturers and users as building buses. These bus systems have not been developed as building buses in terms of their concept and their implementation therefore has some unusual qualities. The available bus devices generally have a considerable data width so that installations with these bus systems can be set up as a partially centralised system.

In general, conventional switchgear is used which is led to a distribution board in the conventional manner. Only then does the bus technology begin. The signals are then combined in the distribution board or in a more central location e.g. in a PLC. We are therefore dealing essentially with a central controller and not with distributed intelligence as in KNX.

However, since PLC or PC solutions are frequently used in large buildings for building management tasks particularly in the area of heating, ventilation and air conditioning, suppliers of this technology like to use this solution. Various gateways to these types of bus systems (KNX/Profibus, KNX/Ethernet) are meanwhile also available so that the starting point is not a competitive situation but an addition to the various bus systems.

4.5 Table with an Overview of Different Building Bus Systems

The following table provides an overview of the bus systems used in building management systems. The table has two sections:

1. Bus systems across different companies
2. Company-specific bus systems
### Bus systems across different companies

<table>
<thead>
<tr>
<th>Control concept</th>
<th>Number of bus devices</th>
<th>Expansion</th>
<th>Transmission medium</th>
<th>Topology</th>
<th>Applications</th>
<th>Internet addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KNX</strong>&lt;br&gt;Distributed bus system with random bus access</td>
<td>58384 addressable devices, whereby many devices have realised several input/output points</td>
<td>700 metres per galvanic unit, possible to extend complete system by many kilometres</td>
<td>Twisted twin core cable, Powerline, radio, individual sections of optical fibre</td>
<td>With twisted twin core cable: Free tree structure</td>
<td>Lighting, blind control, heating, ventilation, access control, monitoring, visualisation and load management</td>
<td><a href="http://www.knx.org">www.knx.org</a>&lt;br&gt;www.knx.de&lt;br&gt;www.knx-professionals.de</td>
</tr>
<tr>
<td><strong>LON</strong>&lt;br&gt;Local Operating Network</td>
<td>32385 devices per domain. Several input/output points are often implemented in a device</td>
<td>Very varied, depending on the selected transmission type and transmission speed. In general, similar expansions to the KNX system can be achieved</td>
<td>Various types with twisted twin core cable, coaxial cable, Powerline, radio, infrared, fibre glass</td>
<td>Very varied depending on the selected transmission type</td>
<td>Complete applications for lighting, blind control, heating, ventilation, monitoring, load management and visualisation</td>
<td><a href="http://www.echelon.com">www.echelon.com</a>&lt;br&gt;www.lonmark.org&lt;br&gt;www.lno.de</td>
</tr>
</tbody>
</table>
## Company-specific bus systems

<table>
<thead>
<tr>
<th>Company</th>
<th>Control concept</th>
<th>Number of bus devices</th>
<th>Expansion</th>
<th>Transmission medium</th>
<th>Topology</th>
<th>Applications</th>
<th>Internet addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dupline</strong>&lt;br&gt;<strong>Dupline®</strong></td>
<td>Bus system with central channel generator which is also aware of central control tasks</td>
<td>128</td>
<td>approx. 10km</td>
<td>Twin core cable without special requirements. Shielded TP cables to improve the interference response</td>
<td>Line, star, ring in any combination</td>
<td>Lighting, blind control functions, monitoring and reporting, visualisation</td>
<td><a href="http://www.doepke.de">www.doepke.de</a></td>
</tr>
<tr>
<td><strong>LCN</strong>&lt;br&gt;Local Control Network</td>
<td>Distributed control</td>
<td>Max. 250 modules in 120 buses = 30000 modules in total, whereby each module can contain several inputs and outputs</td>
<td>1km per bus</td>
<td>Free cores in 230V system</td>
<td>free</td>
<td>Lighting, blind control, logic functions, heating, visualisation, recording of measured values</td>
<td><a href="http://www.lcn.de">www.lcn.de</a></td>
</tr>
<tr>
<td><strong>Nikobus</strong></td>
<td>Mixture of central and distributed control</td>
<td>approx. 5000</td>
<td>Maximum installed cable 1000m, distance between actuator and sensor 350m</td>
<td>Twin core cable</td>
<td>Star, tree</td>
<td>Lighting, blind control, heating</td>
<td><a href="http://www.niko.be">www.niko.be</a></td>
</tr>
<tr>
<td><strong>PEHA PHC</strong></td>
<td>Mixture of central and distributed control</td>
<td>64 per central controller&lt;br&gt;Max. 4 central controllers</td>
<td>1000m between two modules</td>
<td>Twin core cable between the modules</td>
<td>Line</td>
<td>Lighting control, blind control, logical functions, heating, visualisation</td>
<td><a href="http://www.peha.de">www.peha.de</a></td>
</tr>
</tbody>
</table>
### RF bus systems

<table>
<thead>
<tr>
<th></th>
<th>Used frequency</th>
<th>RF range</th>
<th>Number of bus devices</th>
<th>Internet Address</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Z-Wave</strong></td>
<td>868 MHz</td>
<td>30 – 200 m</td>
<td>232 devices</td>
<td><a href="http://www.z-wave.com">www.z-wave.com</a> <a href="http://www.z-wavealliance.org">www.z-wavealliance.org</a></td>
</tr>
<tr>
<td><strong>ZigBee</strong></td>
<td>868 MHz and 2400 MHz</td>
<td>10 -100 m</td>
<td>A device can operate up to 240 other devices</td>
<td><a href="http://www.zigbee.org">www.zigbee.org</a></td>
</tr>
<tr>
<td><strong>EnOcean</strong></td>
<td>868 MHz and 315 MHz</td>
<td>30 – 300 m</td>
<td></td>
<td><a href="http://www.enocean.com">www.enocean.com</a></td>
</tr>
<tr>
<td><strong>Moeller RF bus</strong></td>
<td>868 MHz</td>
<td>30 – 50 m direct,</td>
<td>Max. 200 components</td>
<td><a href="http://www.moeller.net">www.moeller.net</a></td>
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