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KNX & IP

Weinzierl Engineering GmbH

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Agenda

- Introduction
- IP Network Basics
- KNXnet/IP Tunneling
- KNXnet/IP Routing
- KNXnet/IP as Medium
- KNXnet/IP Security

About us

Founded in 2001

Management

- Dr.-Ing. Th. Weinzierl, CEO

20+ Employees

- 10+ Developers

Quality management

- ISO9001

Products and Solutions

- KNX Development
- KNX Stack and Modules
- KNX Devices

Where to find us

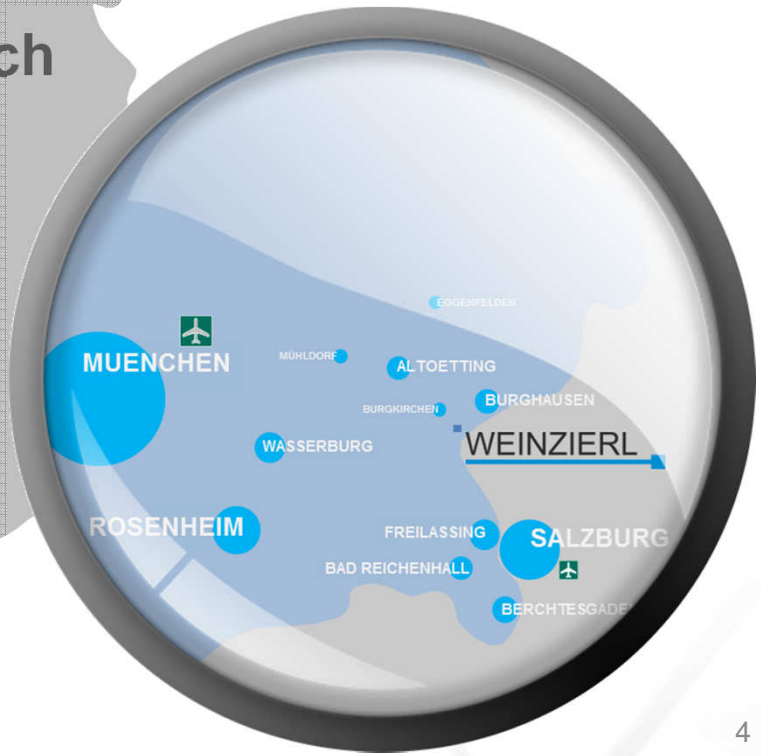
Local community Burgkirchen an der Alz

District Altötting in Southeast Bavaria

Approx. 50 km Northern of Salzburg

Approx. 110 km Southeast of Munich

Own office building



Our Focus: KNX

15+ years of experience

Shareholder in KNX Association cvbl

Active in the KNX System Group

Complete support of the KNX Standard

- Technology
- Solutions
- Products
- Accredited KNX Test Lab

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KNX Development

Development Services

- Hardware
- Software

KNX BAOS Modules

- Certified KNX Stack
- Transceiver

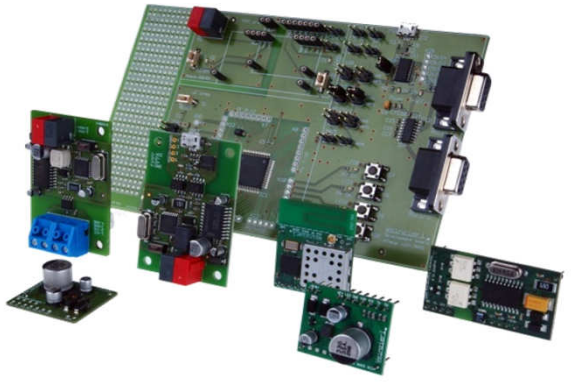
KNX Stack NGS

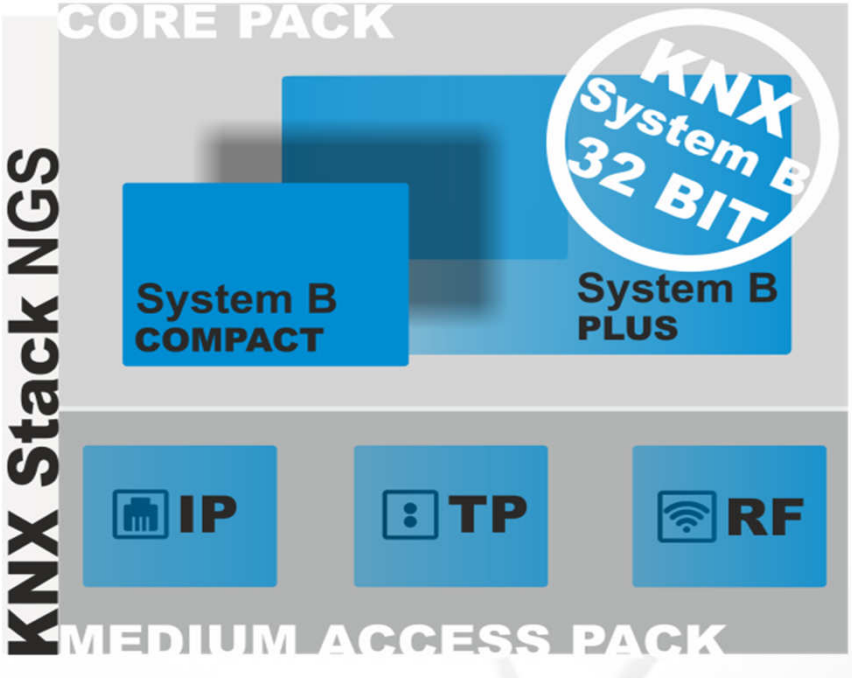
- Full integration

Development Tools

Testing & Certification

- Own KNX Test Lab





IP for Home and Building Control

IP: Internet Protocol

- Widespread basis for communication applications
  - Data Exchange
  - Email
  - Telephone (VoIP)

Media Ethernet commonly available in buildings

- Reduction of the installation effort

Connection to the Internet

- Available almost everywhere

KNX & IP

Usage as Interface

- Access from every point in the network possible
- Access is also possible via the internet
- Alternative for RS232 / USB interface

-> KNXnet/IP ***Tunneling***

Usage as fast backbone

- Replacement of line-/area coupler through IP Router

-> KNXnet/IP ***Routing***

Usage as KNX medium

- Like TP, IP, RF

-> KNX IP only devices

KNXnet/IP Requirements

Finding and discovering of KNXnet/IP-Devices

- Core services

Configuration of KNXnet/IP-Devices

- Device management

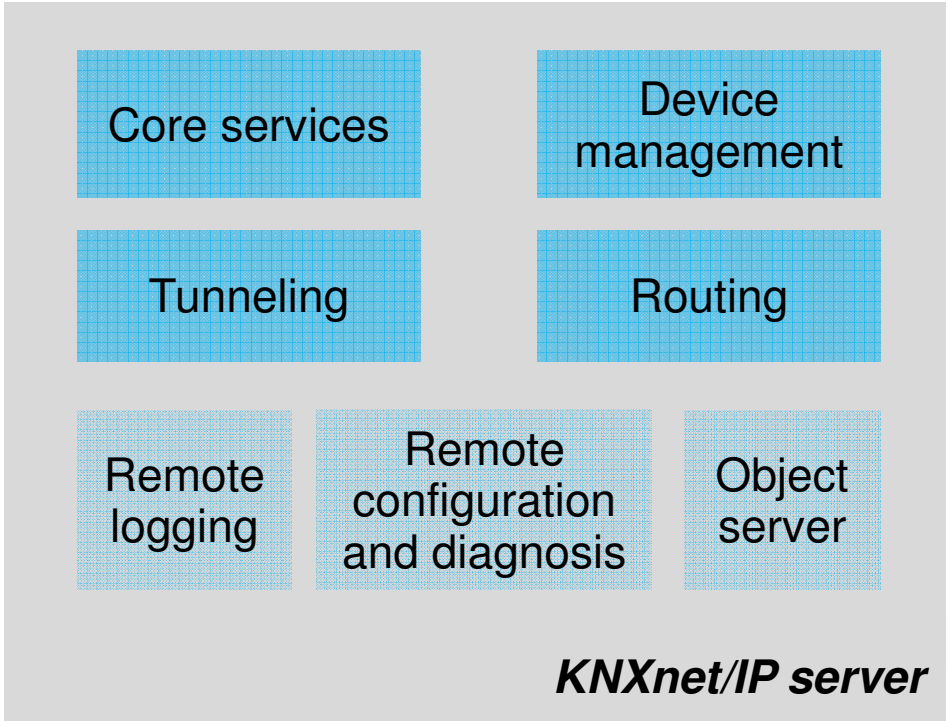
Bus access (ETS)

- Tunneling

Line / Area Coupling

- Routing

➔ **Part of the KNX Standard**



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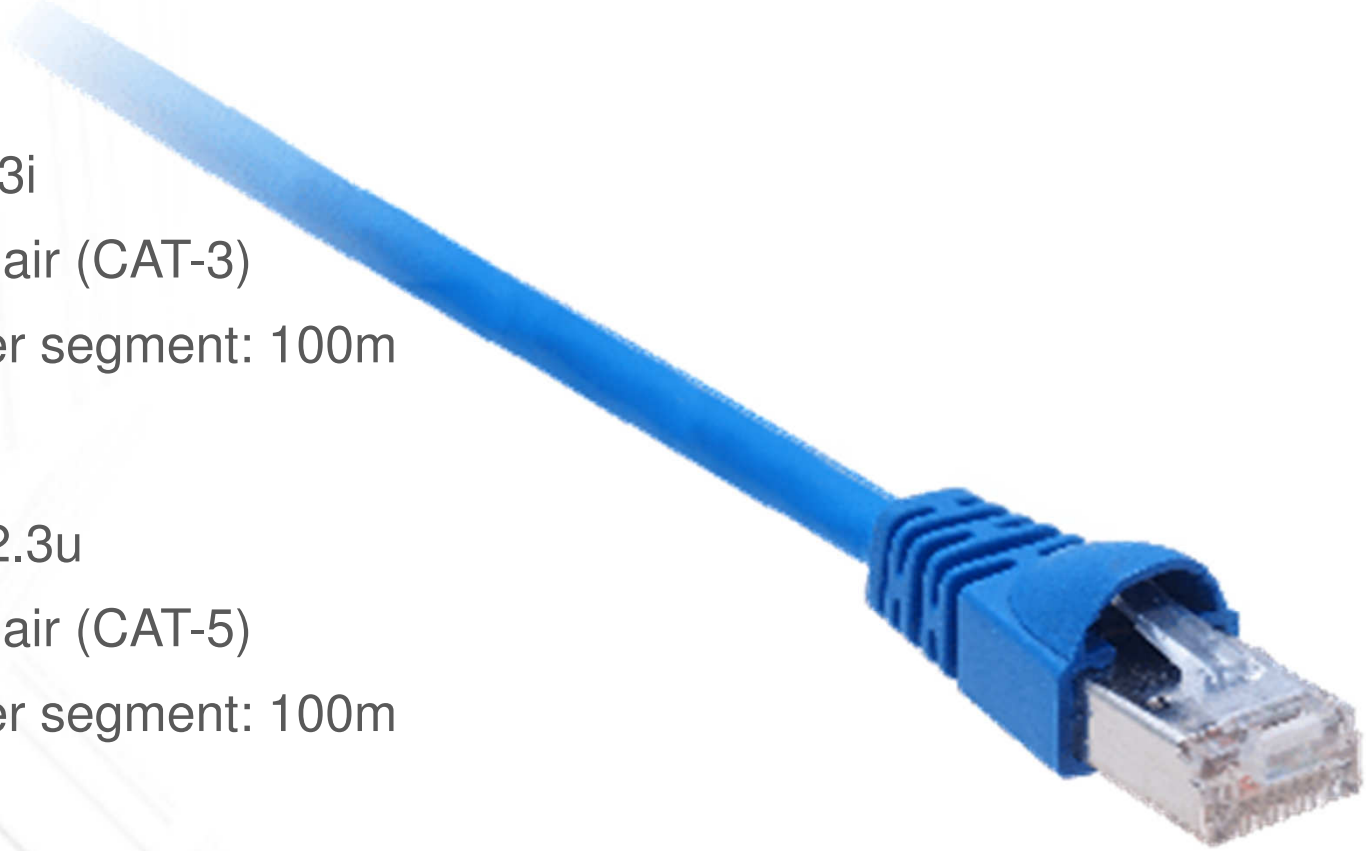
Network Basics: Media

10Base-T

- IEEE802.3i
- Twisted Pair (CAT-3)
- Length per segment: 100m

100Base-TX

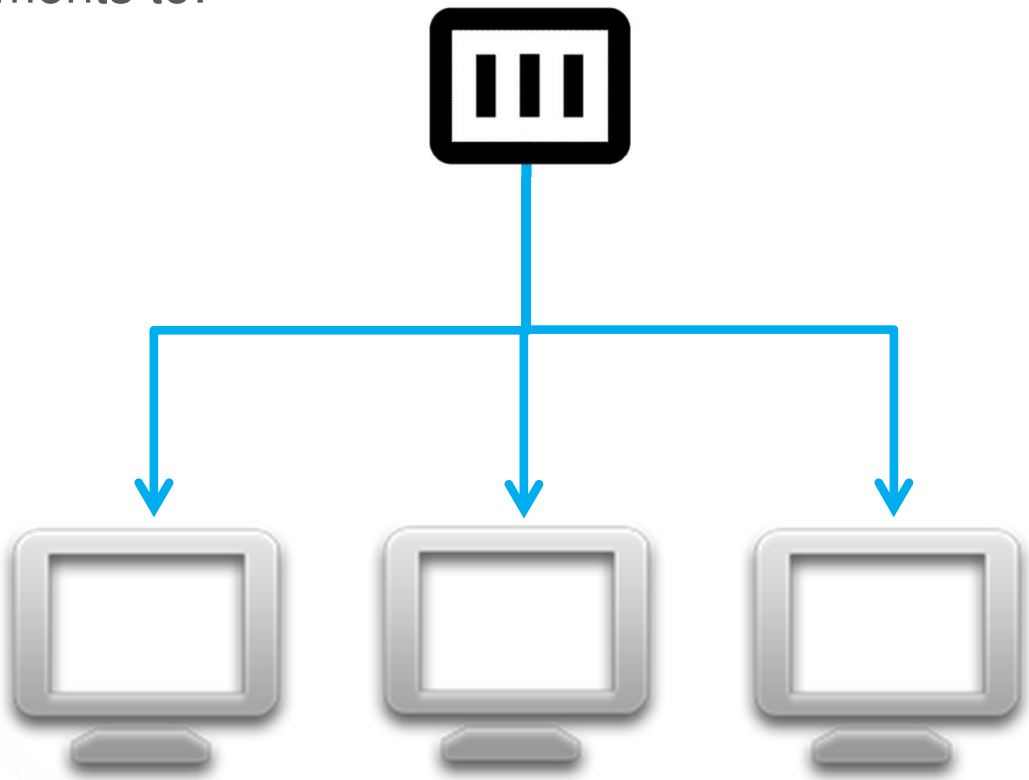
- IEEE8002.3u
- Twisted Pair (CAT-5)
- Length per segment: 100m



Network Basics: Topology

Star

- Connection of the segments to:
  - Hub
  - Switch



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Network Basics

Addressing of a Device in the Network

- MAC-Address (Media Access Control)
  - Unique in the World
  - Unchangeable (fixed to the Hardware)
  - Length 6 Bytes
  - Syntax: 00-50-C2-55-40-00

IP-Address (Internet Protocol)

- Awarded by the Administrator
- Length 4 Bytes (IPv4)
- Syntax: 192.168.1.1
- Subnetworks

Network Basics

IP-Addressing

Splitting to Subnetworks

Splitting of the IP-Address to

- Net-ID
- Host-ID

```
Example:
Subnet-Mask:                255.255.255.0
11111111.11111111.11111111.00000000
Net-ID:                     192.168.1.0
First IP-Address:           192.168.1.1
Last IP-Address:            192.168.1.254
Broadcast:                  192.168.1.255

IP-Address:                 192.168.1.25
Host-ID:                    0.0.0.25
```

Network Basics

Subnetworks

- Usage of personal IP-Addresses
  - Are not used in public
  - Class B: 172.16.0.0 to 172.31.255.255
  - Class C: 192.168.0.0 to 192.168.255.255

Gateway-IP-Address

- When a user is beyond the Subnetwork, it's necessary to have a gateway

➔ **Remote access**

Network Basics

Multicast-Addressing

- One transmitter – multiple receivers
- IP-Address area:
  - 224.0.0.0 to 239.255.255.255
- Reserved for KNXnet/IP:
  - 224.0.23.12

Multicast MAC

- 23 Bits of the IP-Address are mapped on 01-00-5E-00-00-00
- Example: 224.0.23.12
  - MAC: 01-00-5E-00-17-0C

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Network Basics: Ports

Address element (Transport Layer)

Assignment to corresponding Service (in Application Layer)

Length 2 Bytes

Reserved Ports

- 21 FTP Data Transferring
- 80 HTTP Webserver
- 110 POP3 Access to Email-Server
- 3671 KNXnet/IP Building Information

Dynamic Ports

- Variable usable
- Not fixed to an application
- Interval from 49152 to 65535

Network Basics: DHCP

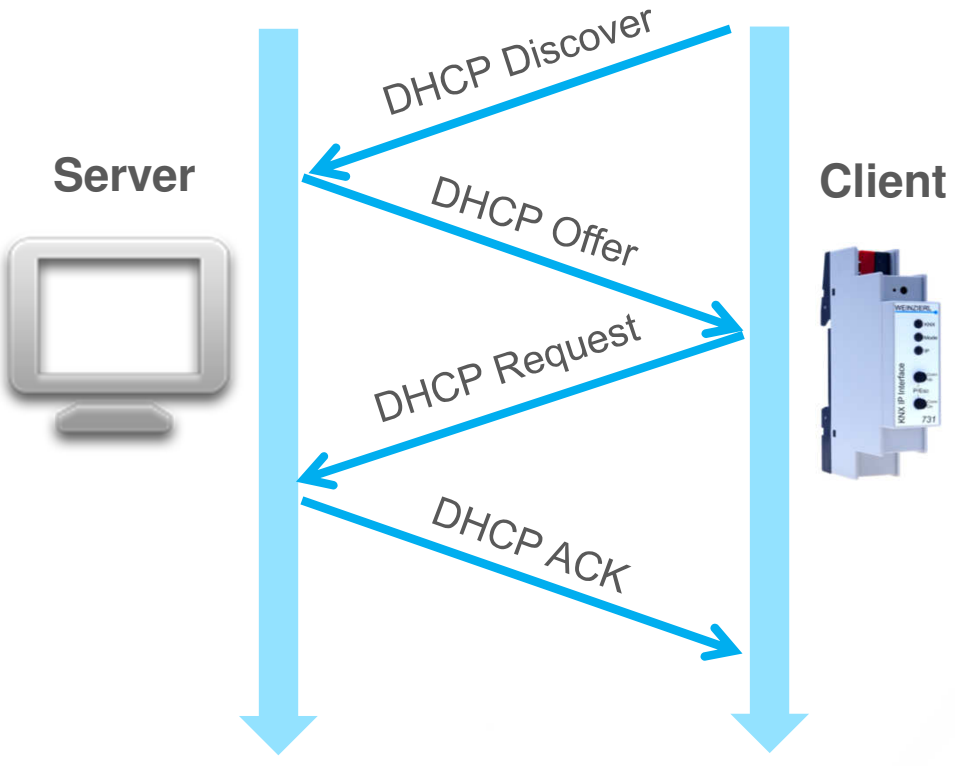
Dynamic Host Configuration Protocol

Central placing of

- IP-Address
- Sub-Network
- Gateway-IP-Address

DHCP-Server necessary

- Contained in common DSL-Routers



Network Basics: Layers

Application Layer (AL)

- KNXnet/IP

Transport Layer (TL)

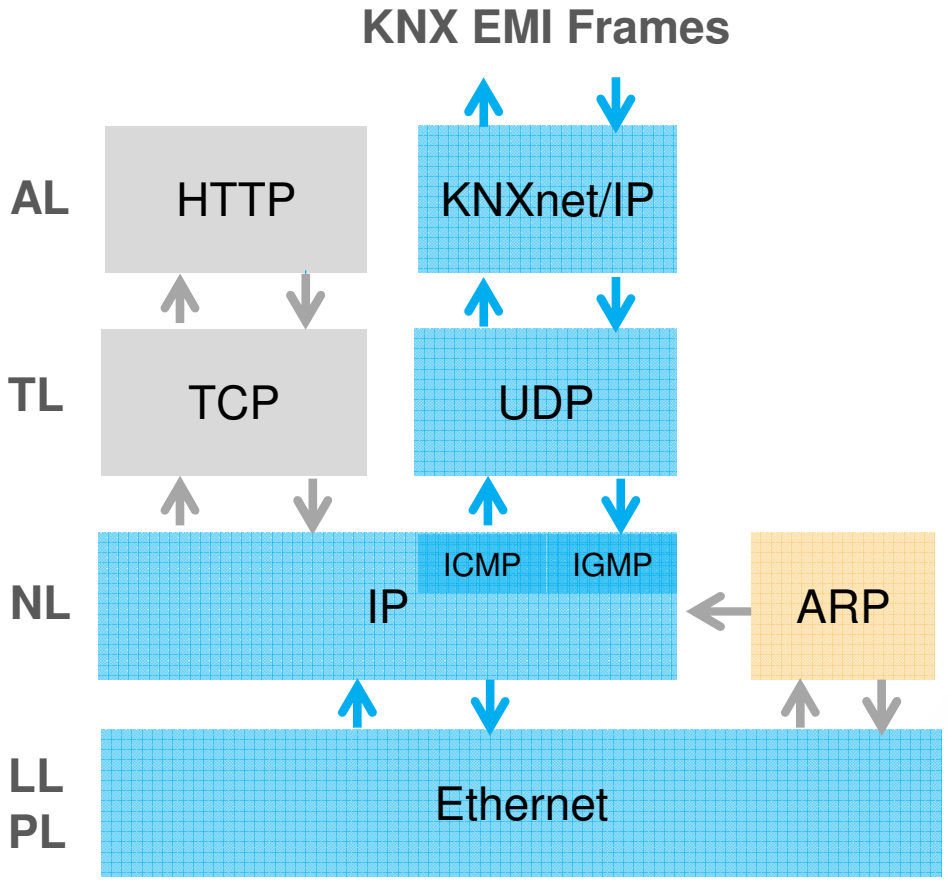
- User Datagram Protocol

Network Layer (NL)

- Internet Protocol
- Address Resolution Protocol

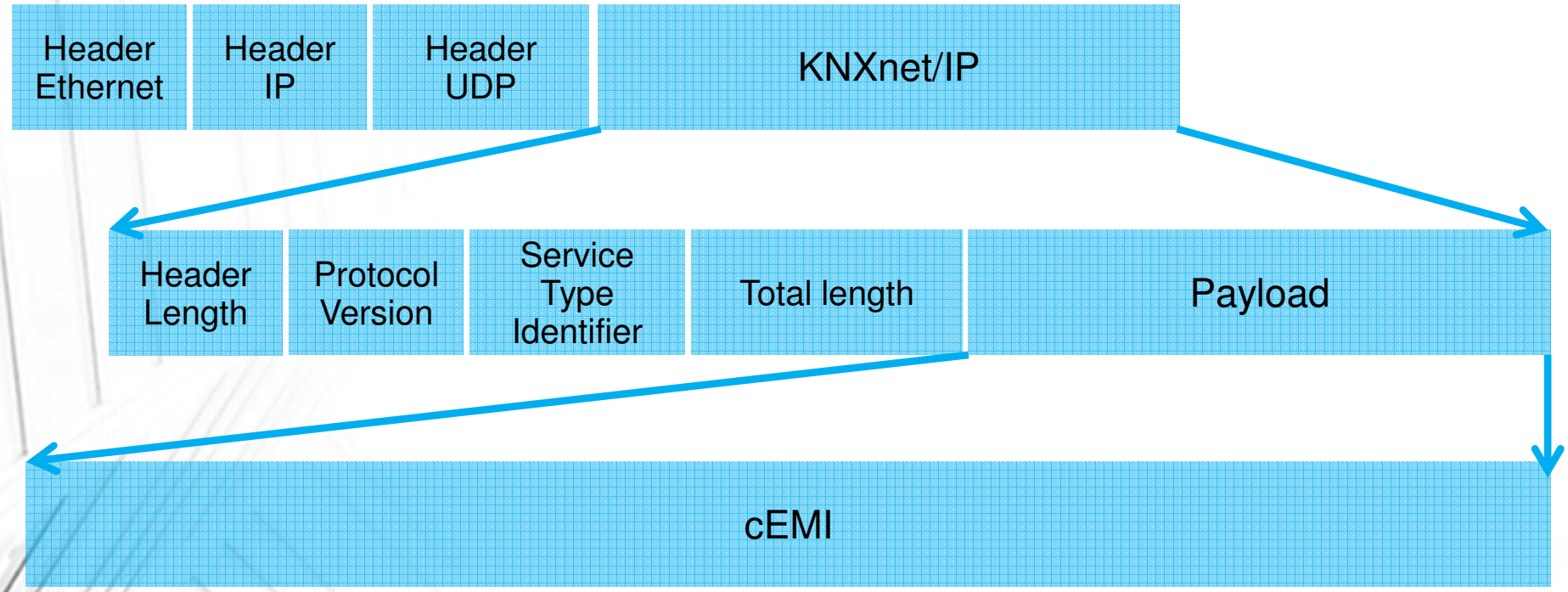
Physical Layer (PL)/ Link Layer (LL)

- Ethernet



KNXnet/IP: Protocol

KNXnet/IP Telegram based on UDP



KNX coded in cEMI (Common EMI)

- Example: Group telegram (Routing)

```
TP1:                          BC    11 04 00 01 E1 00 80 CS
IP : 06 10 05 30 00 11 29 00 BC D0 11 04 00 01 01 00 80
```

Network Requirements

TP-Cable (at least CAT-3) with RJ-45-connector

Free Bandwidth

- Hardly ever critical

Multicast

- Routing of Multicast-Telegrams
- Multicast-IP-Address
  - 224.0.23.12
  - Probably more

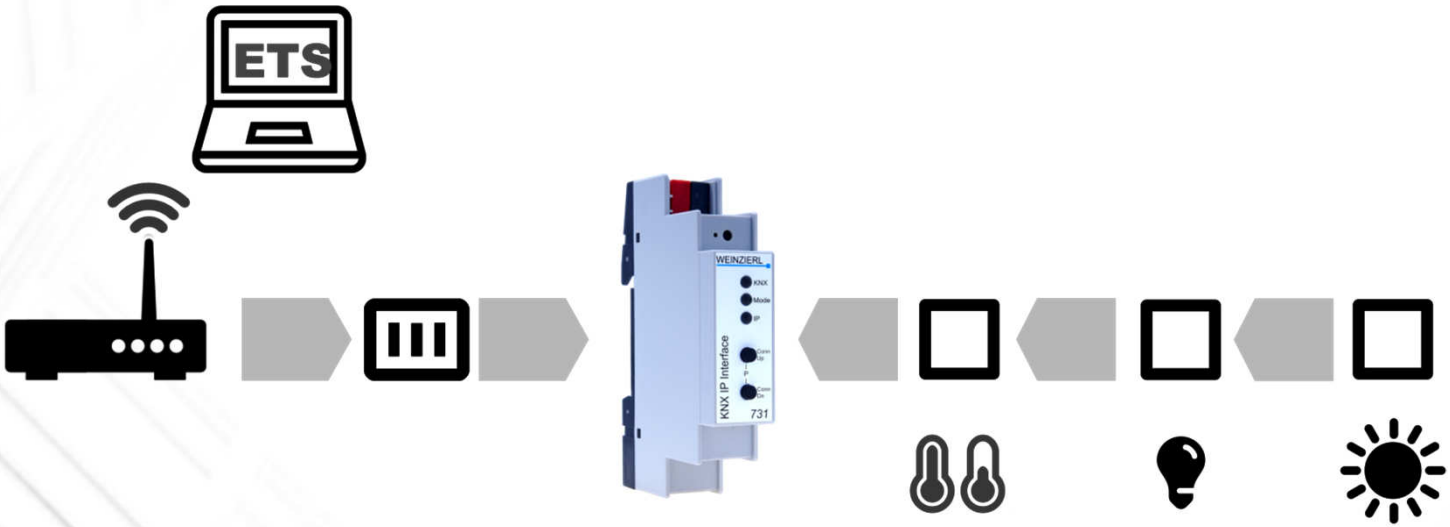
Port

- 3671

KNX IP Interface: Tunneling

Interface to one KNX Line via IP

e.g. for the ETS



KNX IP Interface 731

KNX IP Interface 731

- First KNX IP Interface with 18mm width (1 module)
- Functionality like the market proven model 730
- Powered by the KNX bus
- Up to 5 simultaneous KNXnet/IP Tunneling connections
- Display of tunneling connections on the device

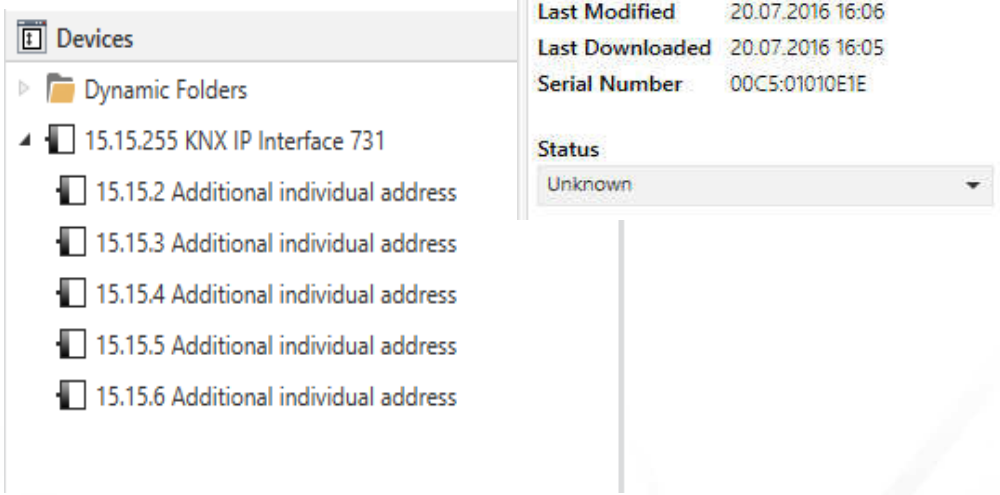
KNX IP 731: Individual Address

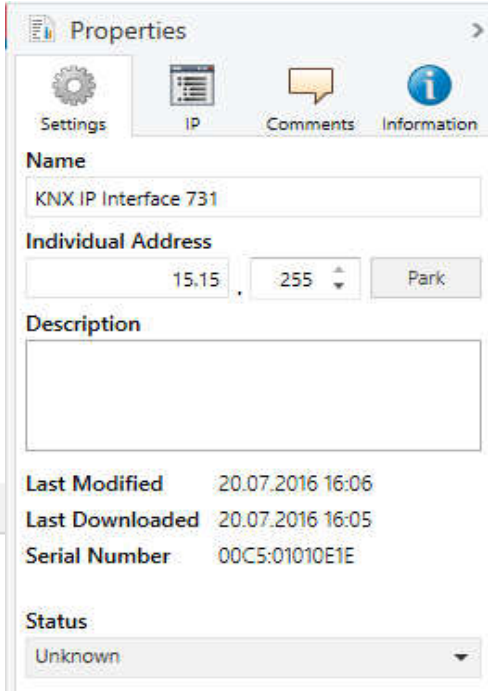
Device Address

- As for all KNX devices

Additional individual addresses

- One for each IP tunnel
- Must be unique
- Since ETS5:
  Visible in device tree





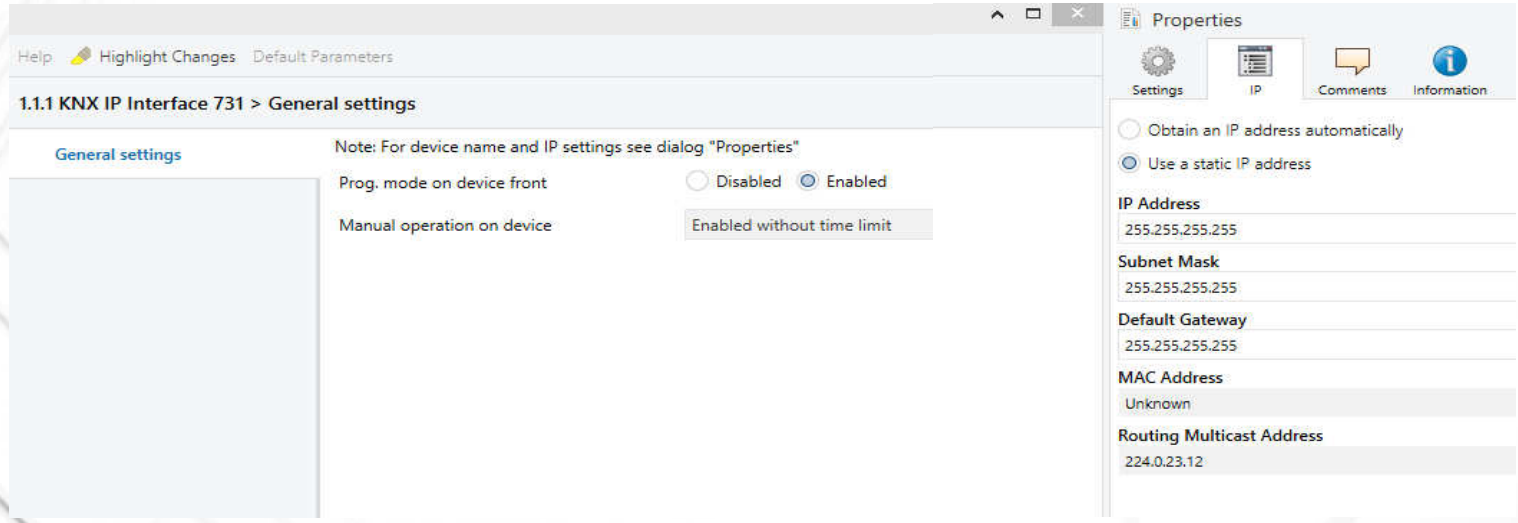
KNX IP 731: Parameter - General

Programming Mode on device front

- Disable/Enable

Manual operation on device

- Disable
- Enable with and without time out



KNX IP 731: Parameter - IP Settings

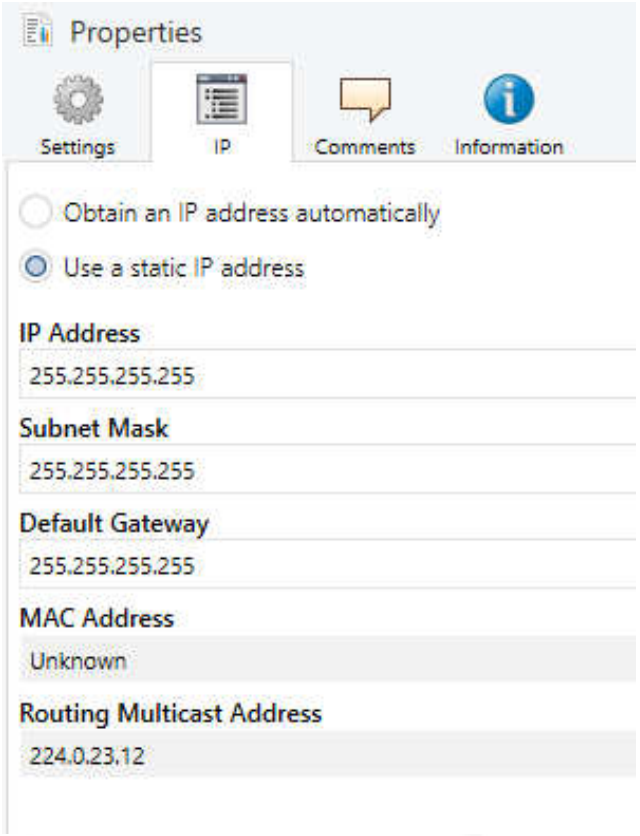
In ETS Property side bar

Device Name

- Identification of the KNX/IP-Interface
- e.g. „first floor“

IP-Address assignment

- manual
- automated (DHCP)



KNX IP 731: Parameter - IP Settings

IP-Address

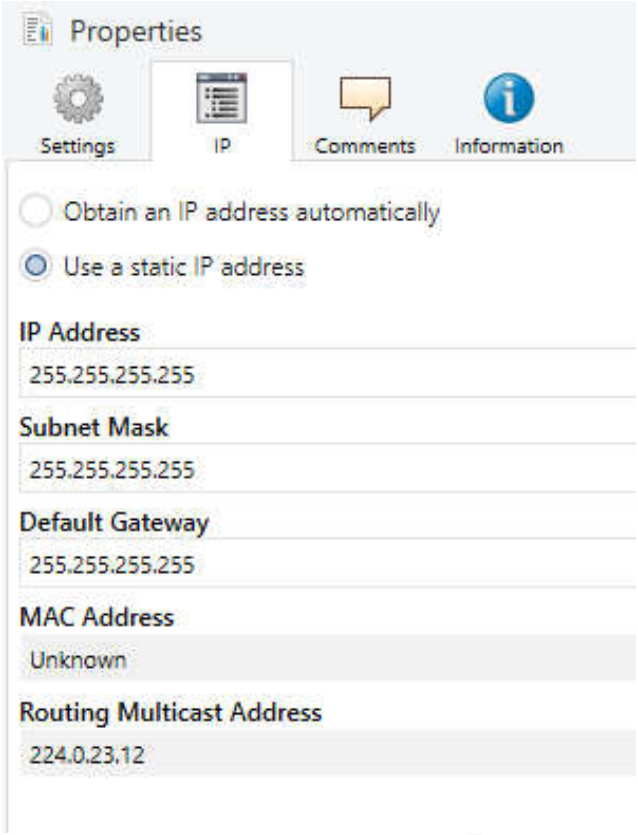
- IP-Address of the KNX/IP-Interface

IP-Subnetwork

- For decisions about Destination Address
  - Communication Partner
  - Gateway

IP-Gateway-Address

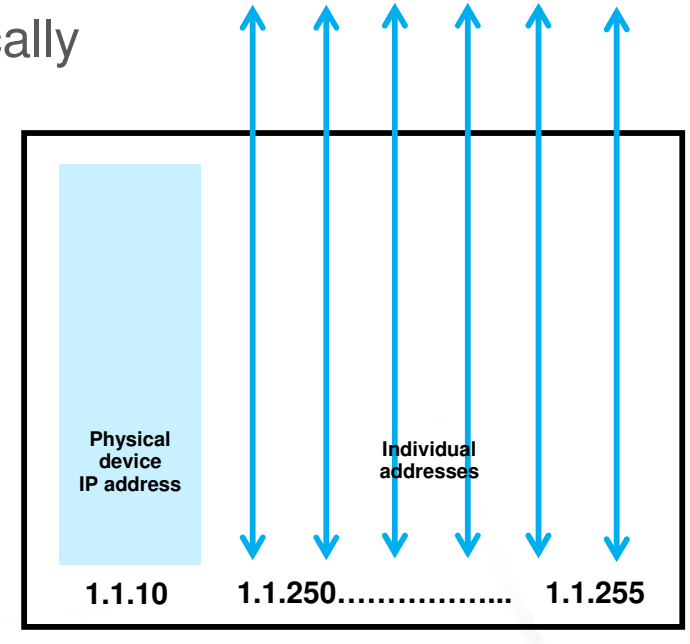
- For external communication



KNX IP 731: Usage as Interface (ETS)

Choice of individual addresses (up to 5)

- Used for bus connection
- Has to be configured manually
- Saved in the device
- Must not already be in use
- Has to fit topologically



KNX IP 731: Connection in ETS

Usage of Tunneling (KNXnet/IP)

Point-to-point-Connection

Accessible by every PC in the network

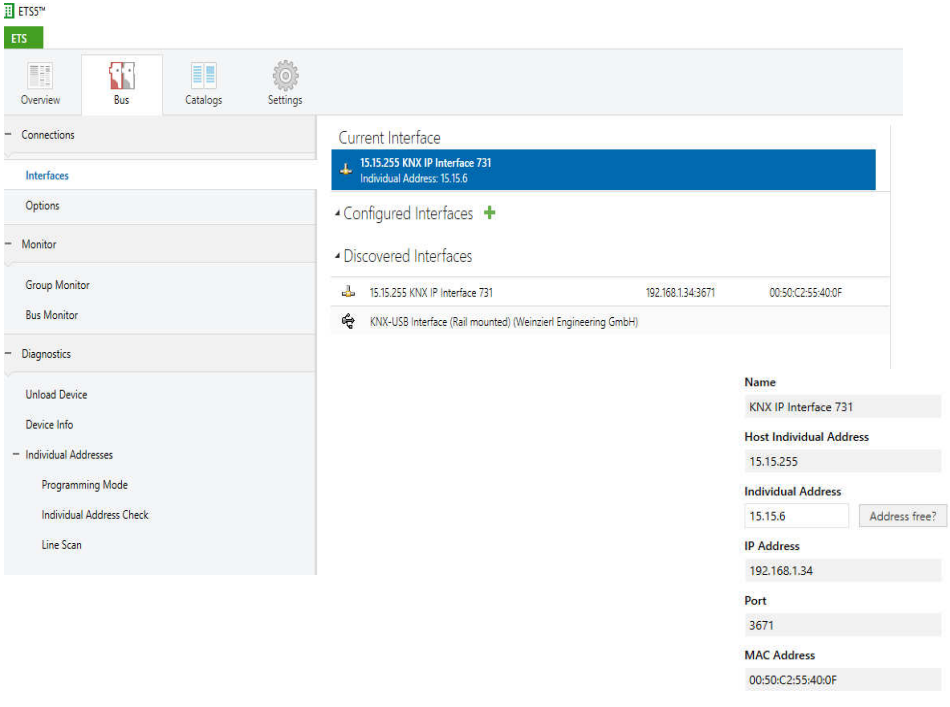
Minimum ETS 3.0c required

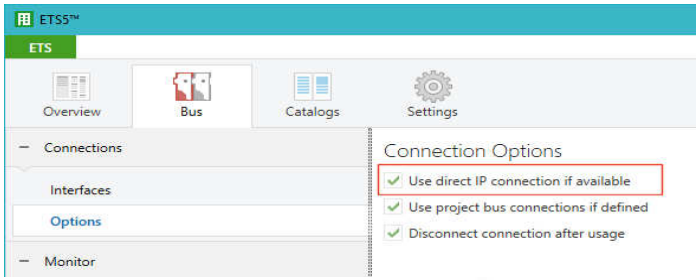
Settings: Communication

- Automatic search of all available interfaces
- Choose the desired interface (Settings -> Communication)

Direct connection possible

Group monitor / Bus monitor





KNX IP Interface 740 *wireless*

- Interface to KNX (Tunneling), e.g. for the ETS
- Wi-Fi (integrated Wi-Fi access point)

KNX IP Interface 740 wireless

KNX IP 740 *wireless* - Benefits

Supported by ETS

Usage of common network components

- Notebooks already equipped with Wi-Fi

Initial start up possible by one Person

- Installer can move around the building almost freely

Encryption possible (WPA2)

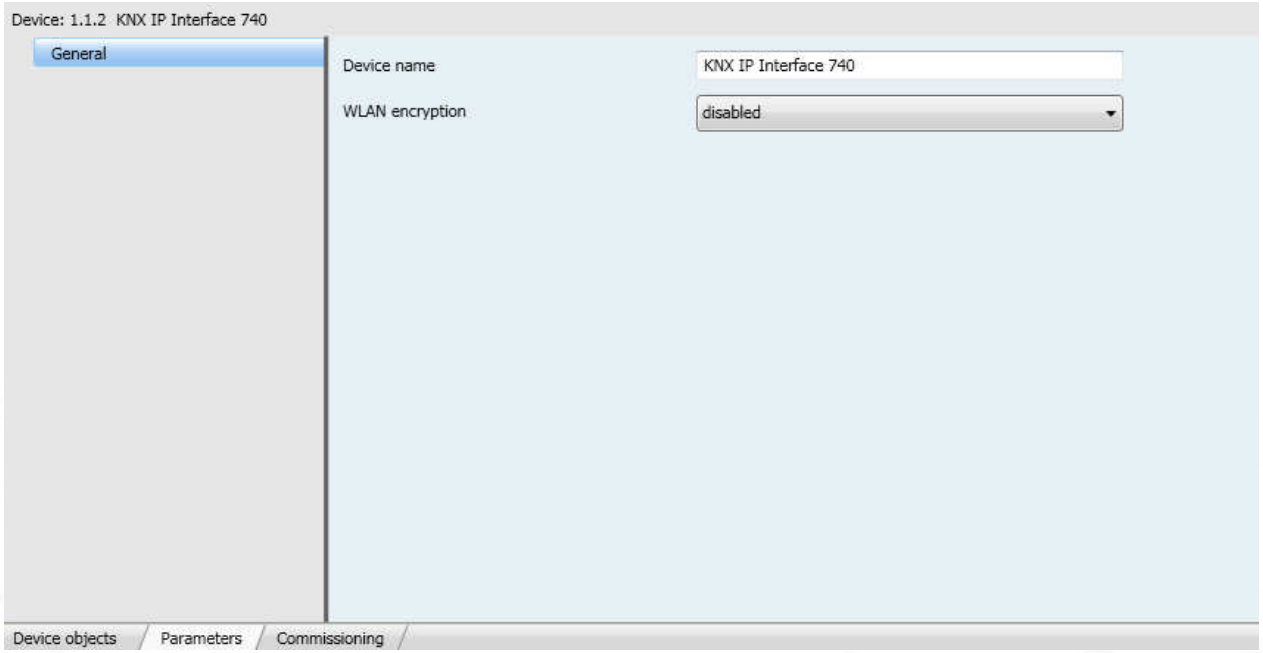
KNX IP 740 Parameters - General

Device Name

- Identification of the KNX/IP-Interface
- SSID (WLAN)

WLAN encryption

- Disabled
- Enabled



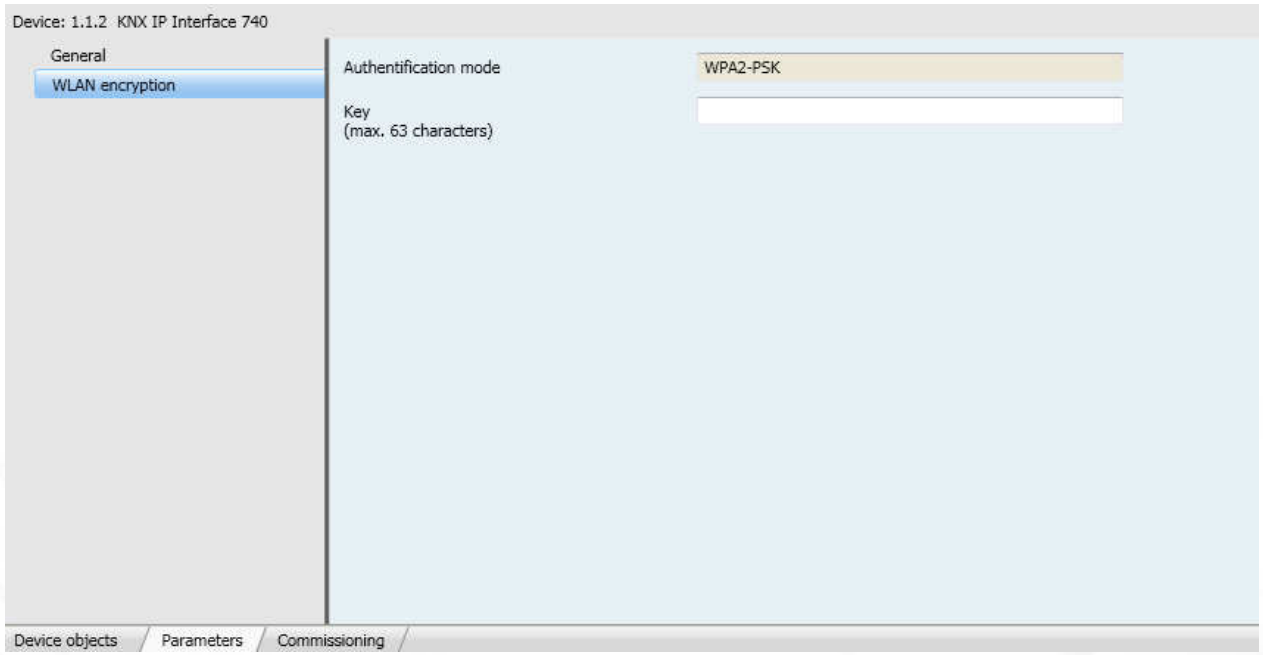
KNX IP 740 Parameters - WLAN

Authentification mode

- WPA2-PSK (Wi-Fi Protected Access 2, PreShared Key)

Key

- 63 characters available



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KNX IP 740 – What's in the box

- KNX IP 740
- Plastic suitcase
- Wall power supply
- Antenna
- Screwing terminal
- Documentation

Classical KNX Topology

KNX TP only

Usage of

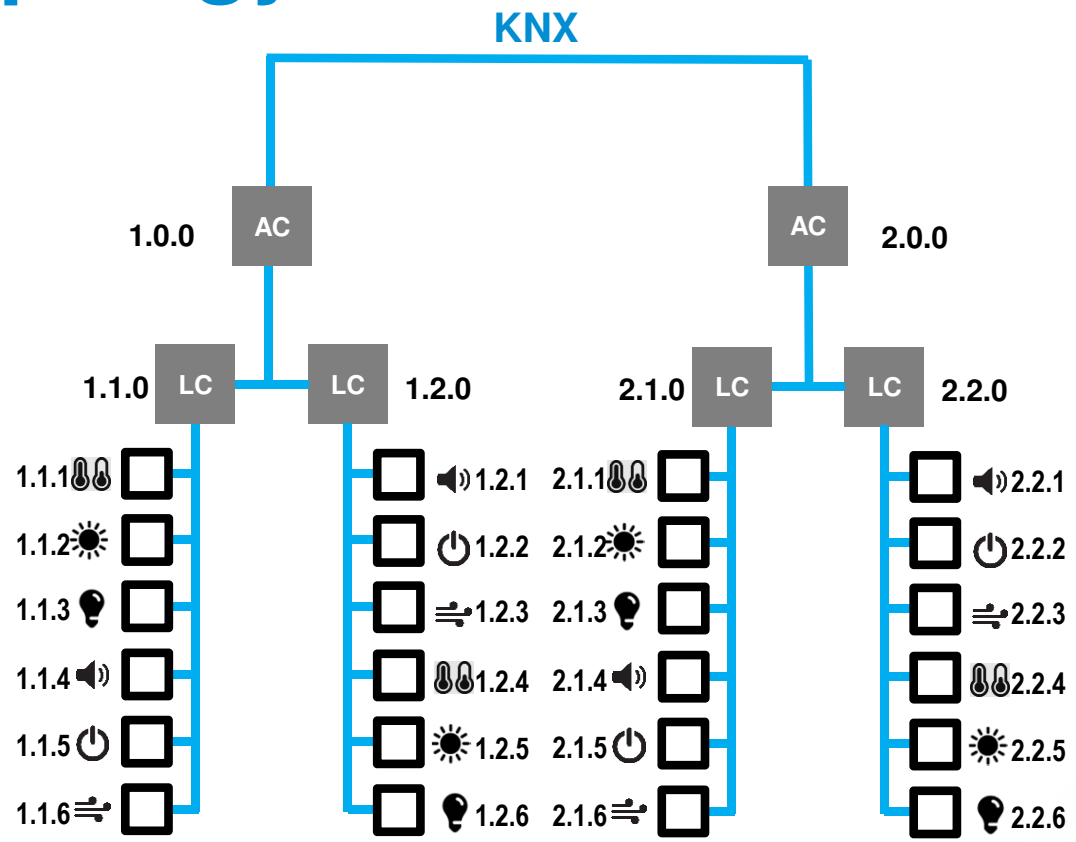
- Line Couplers (LC)
- Area Couplers (AC)

Problem: Backbone

- Routing for Visualization
- Central function
- Slow
- Telegram loss possible

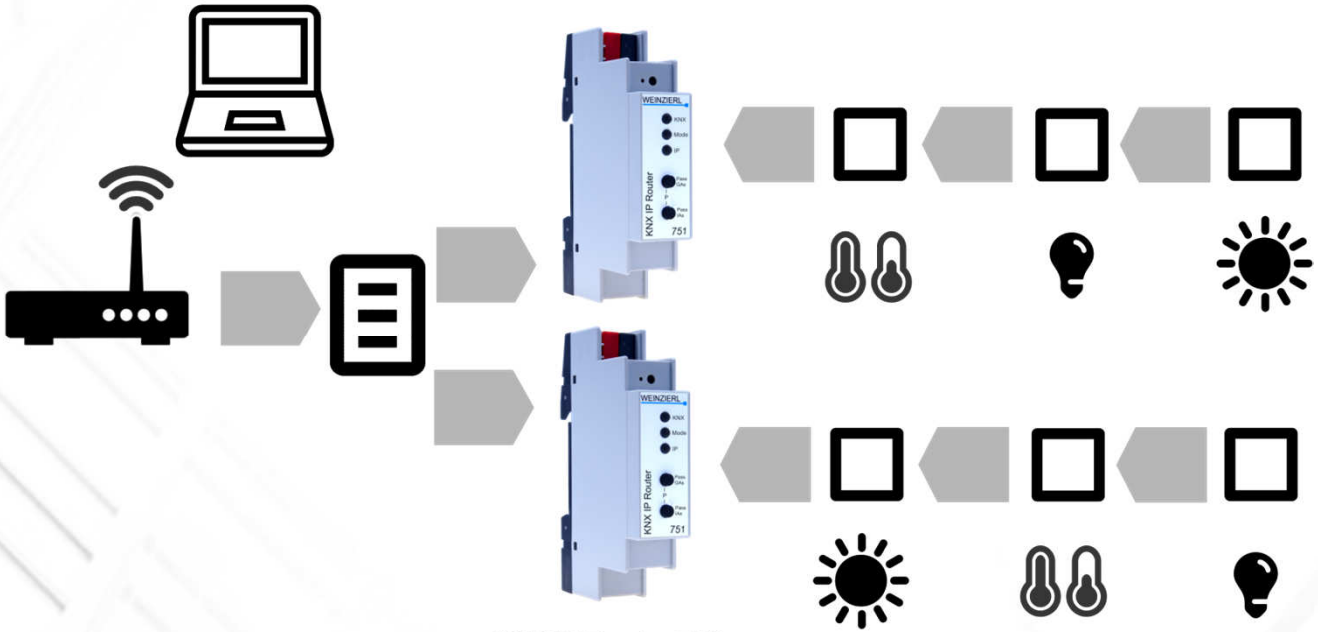
Closed system

➔ **Solution: KNX/IP-Router**



KNX IP Router

- Interface to KNX (Tunneling), e.g. for the ETS
- Line coupler functionality (Routing)

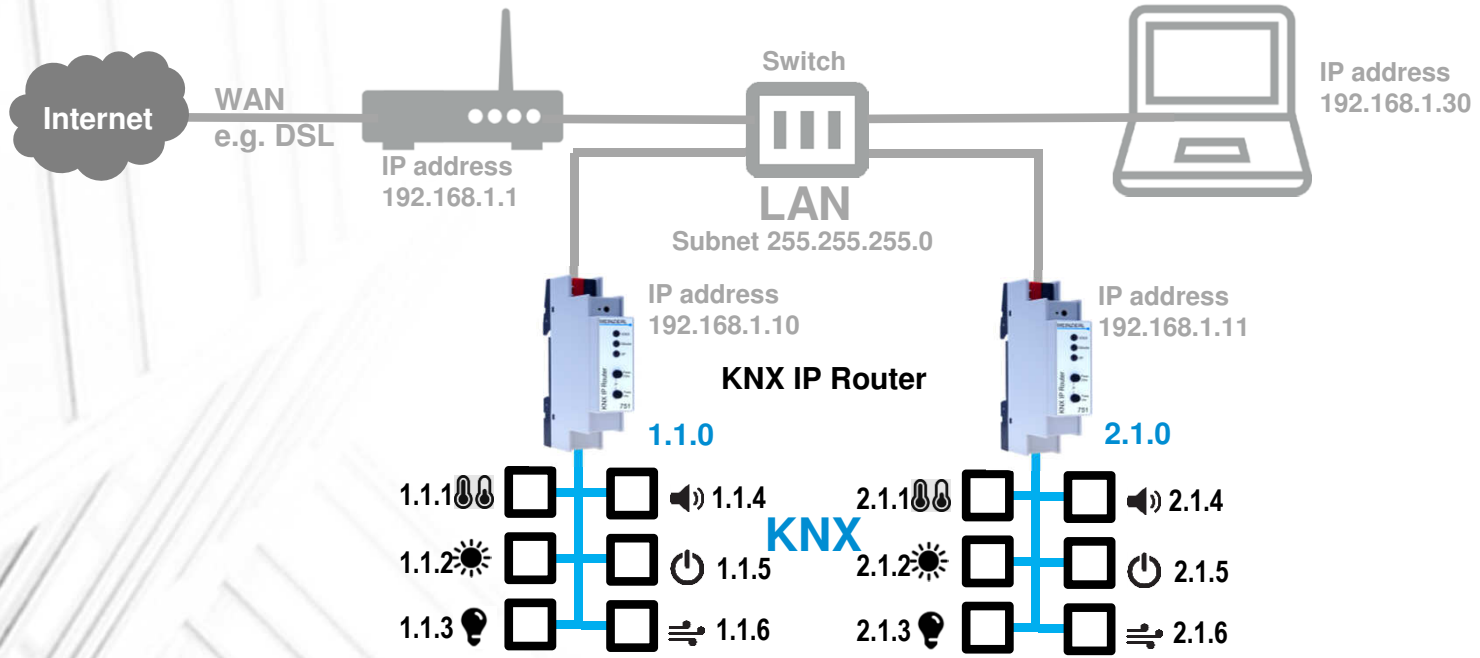


KNX IP Router 751

KNX IP Router 751

- First KNX IP Router with 18mm width
- Functionality like the market proven model 750
- Powered by the KNX bus
- Up to 5 simultaneous KNXnet/IP Tunneling connections
- Diagnosis functions via buttons
- Display of communication errors

KNX IP Router: Installation



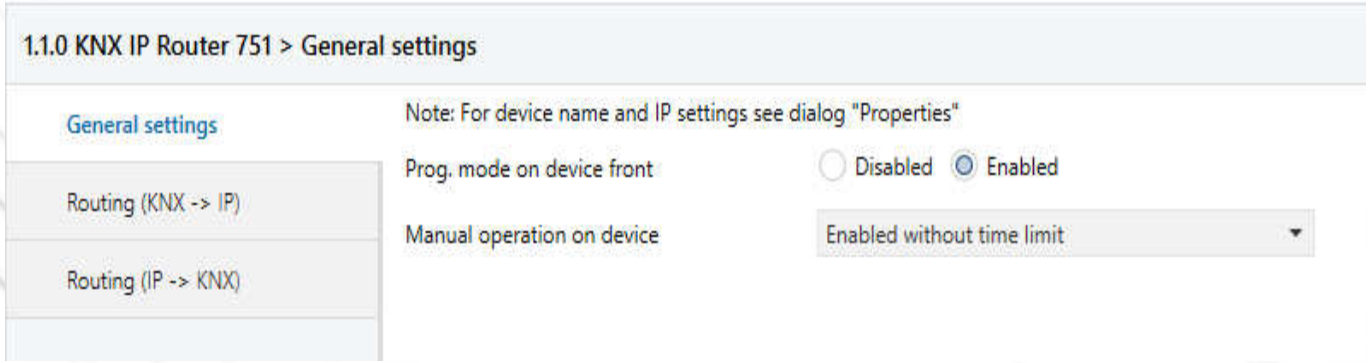
KNX IP 751: Parameter - General

Programming Mode on device front

- Disable/Enable

Manual operation on device

- Disable
- Enable with and without time out



KNX IP 751: Parameter - IP Settings

In ETS Property side bar

Device Name

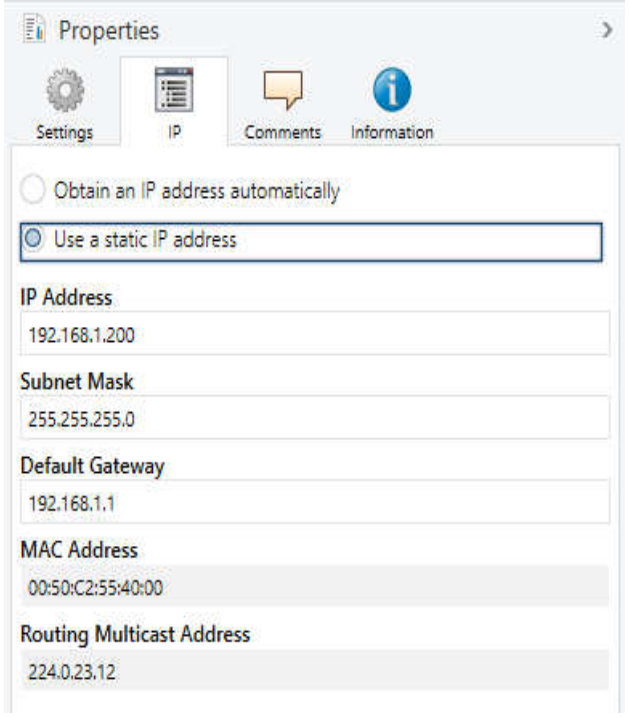
IP-Address assignment

IP-Address

IP-Subnetwork

Default Gateway

IP Routing Multicast Address



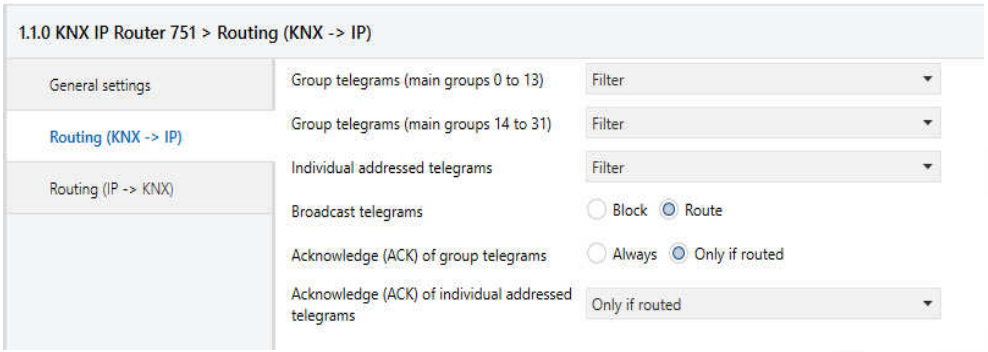
KNX IP 751: Parameter – Routing

Group telegrams (main groups 0 to 13)

- Block
- Route
- Filter

Group telegrams (main groups 14 to 31)

- Block
- Route



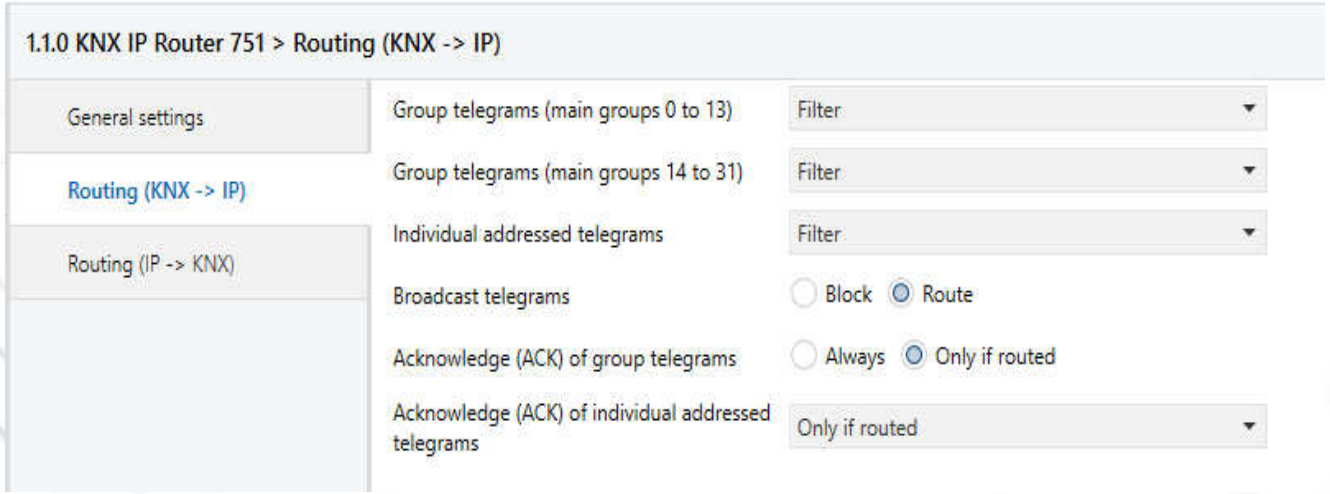
KNX IP 751: Parameter – Routing

Individual addressed Telegrams

- Block
- Route
- Filter

Broadcast Telegrams

- Block
- Route



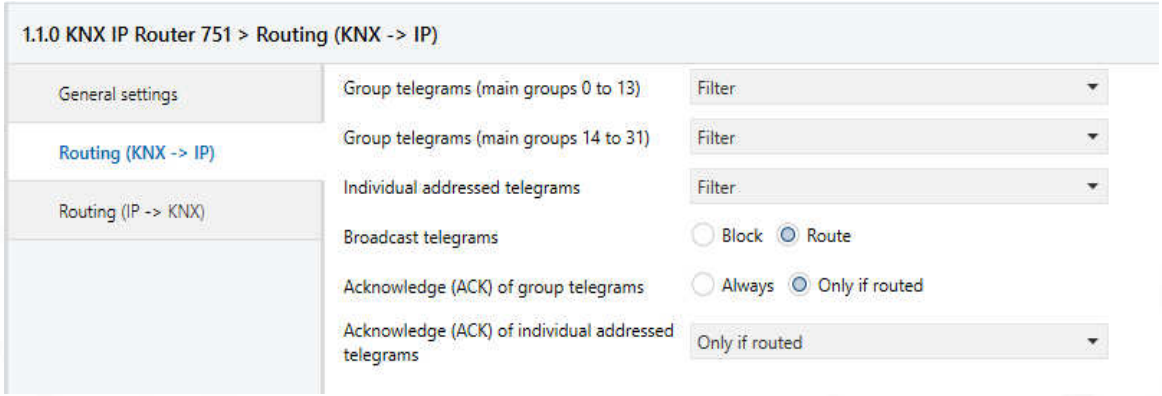
KNX IP 751: Parameter – Routing

Acknowledge of group telegrams

- Always
- Only if routed

Acknowledge of individual addressed telegrams

- Only if routed
- Always
- Answer using NACK



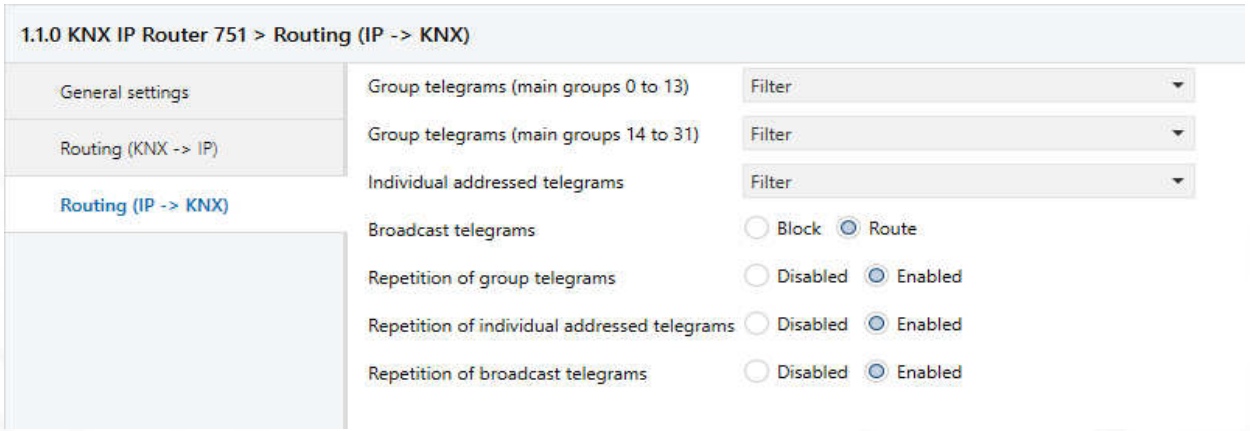
KNX IP 751: Parameter – Routing

Group telegrams (main groups 0 to 13)

- Block
- Route
- Filter

Group telegrams (main groups 14 to 31)

- Block
- Route



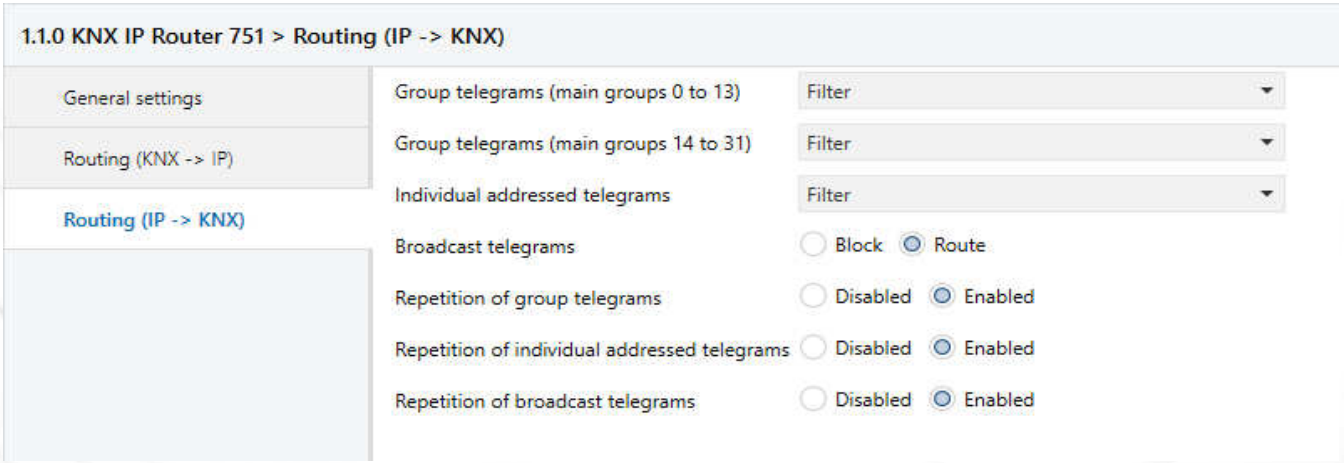
KNX IP 751: Parameter – Routing

Individual addressed telegrams

- Block
- Route
- Filter

Broadcast telegrams

- Block
- Route



KNX IP 751: Parameter – Routing

Repetition of group telegrams

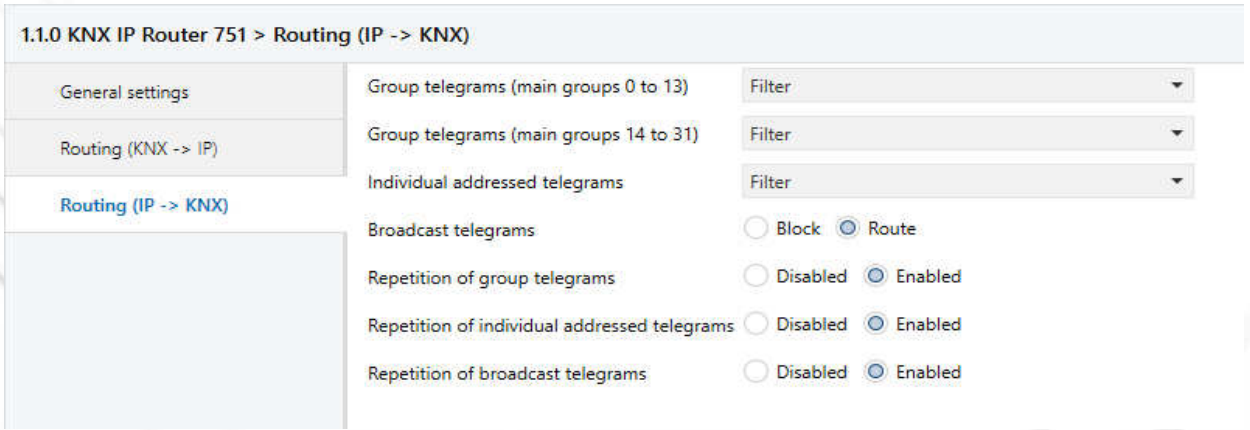
- Block
- Enable

Repetition of individual addressed telegrams

- Block
- Enable

Repetition of broadcast telegrams

- Block
- Enable



ETS – Filter Table

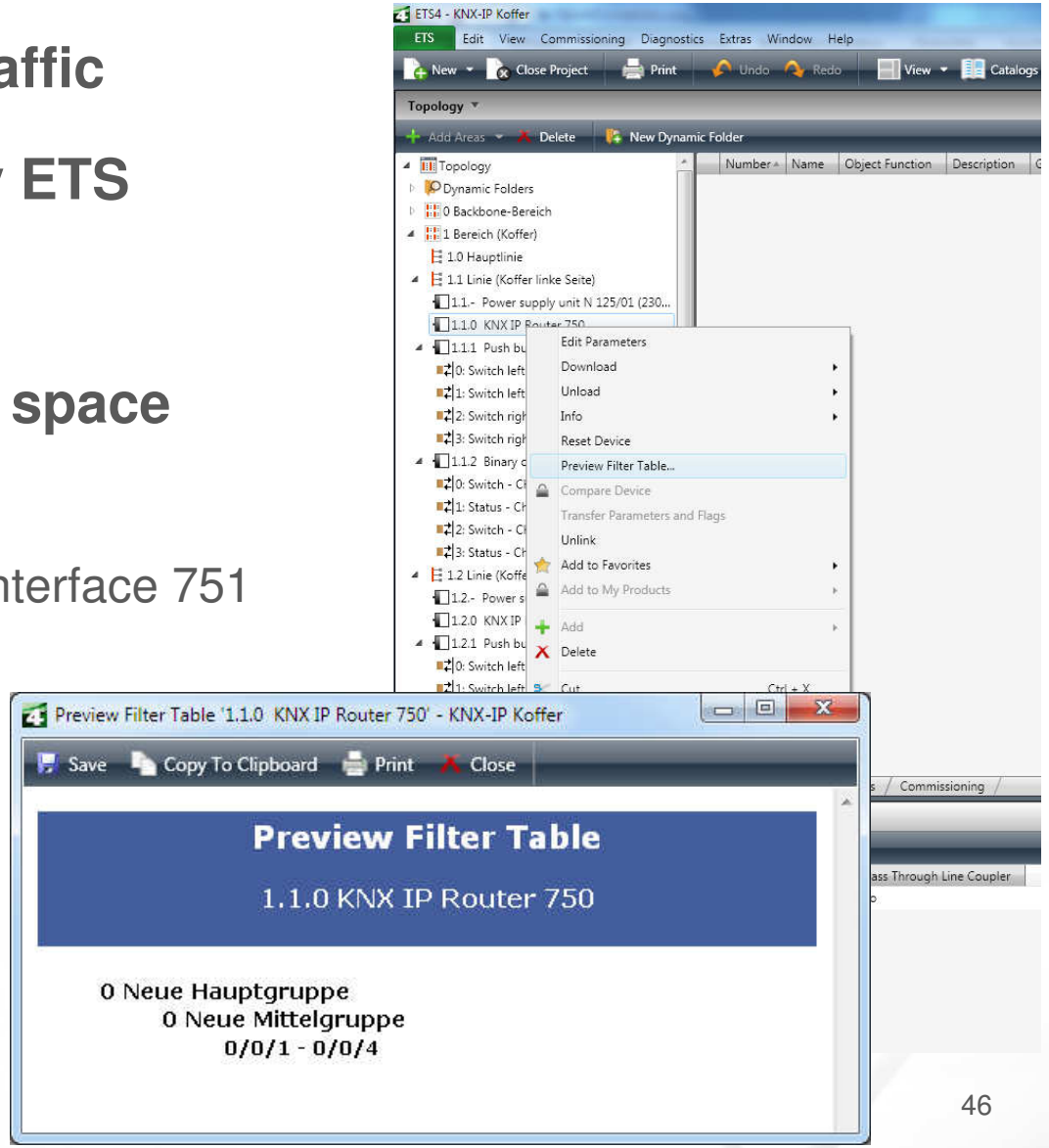
Reduction of telegram traffic

Automatically created by ETS

Preview function

New: Full group address space

- Since ETS4
- Implemented in KNX IP Interface 751



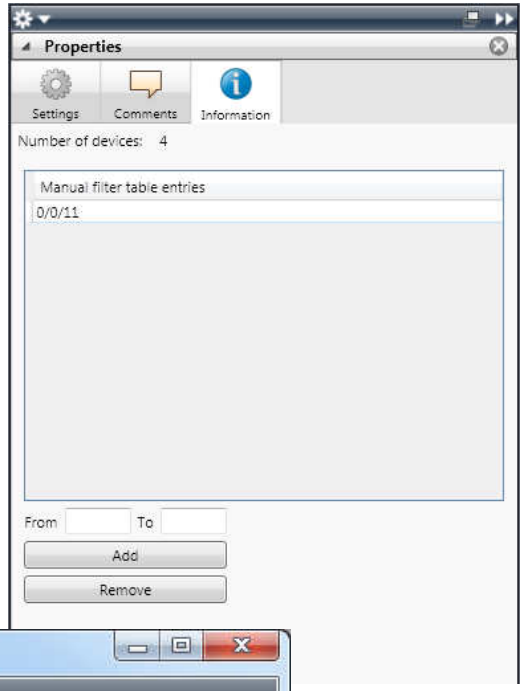
ETS – Filter Table

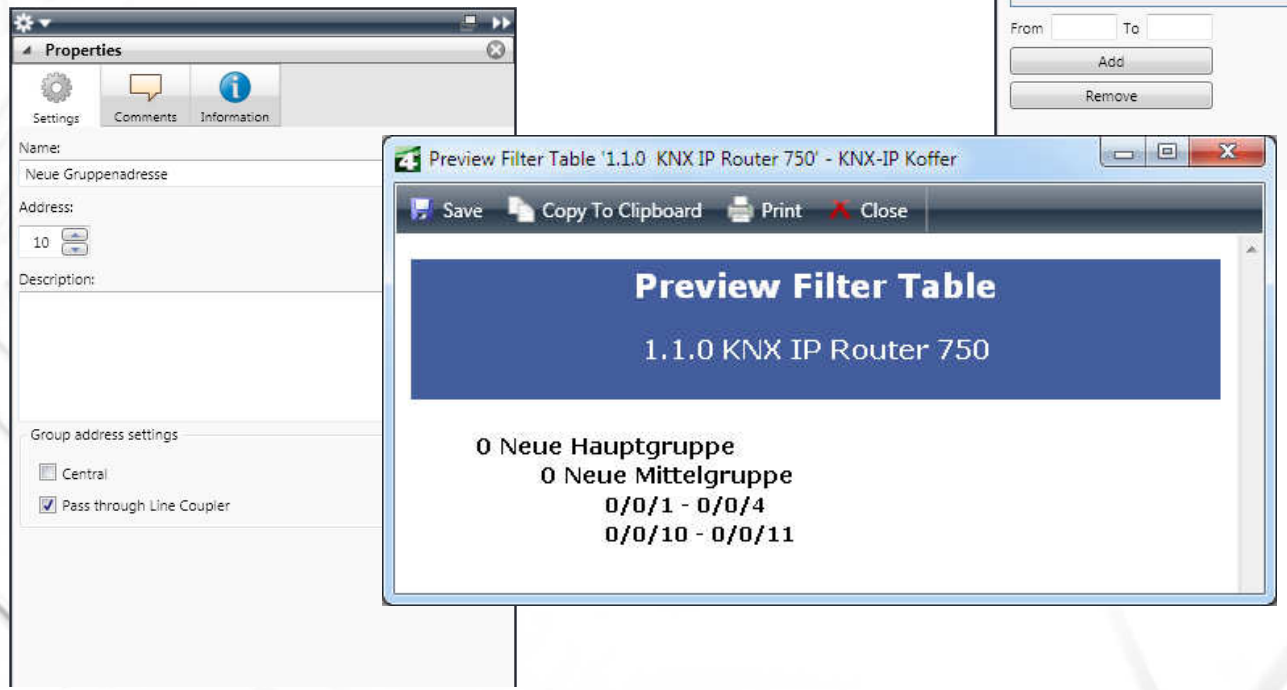
Manual assignment of Group addresses

- Drag & Drop

Drag it to the corresponding line

- Activation of the routing-flag





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Why use a Filter Table?

Routing IP -> KNX (TP)

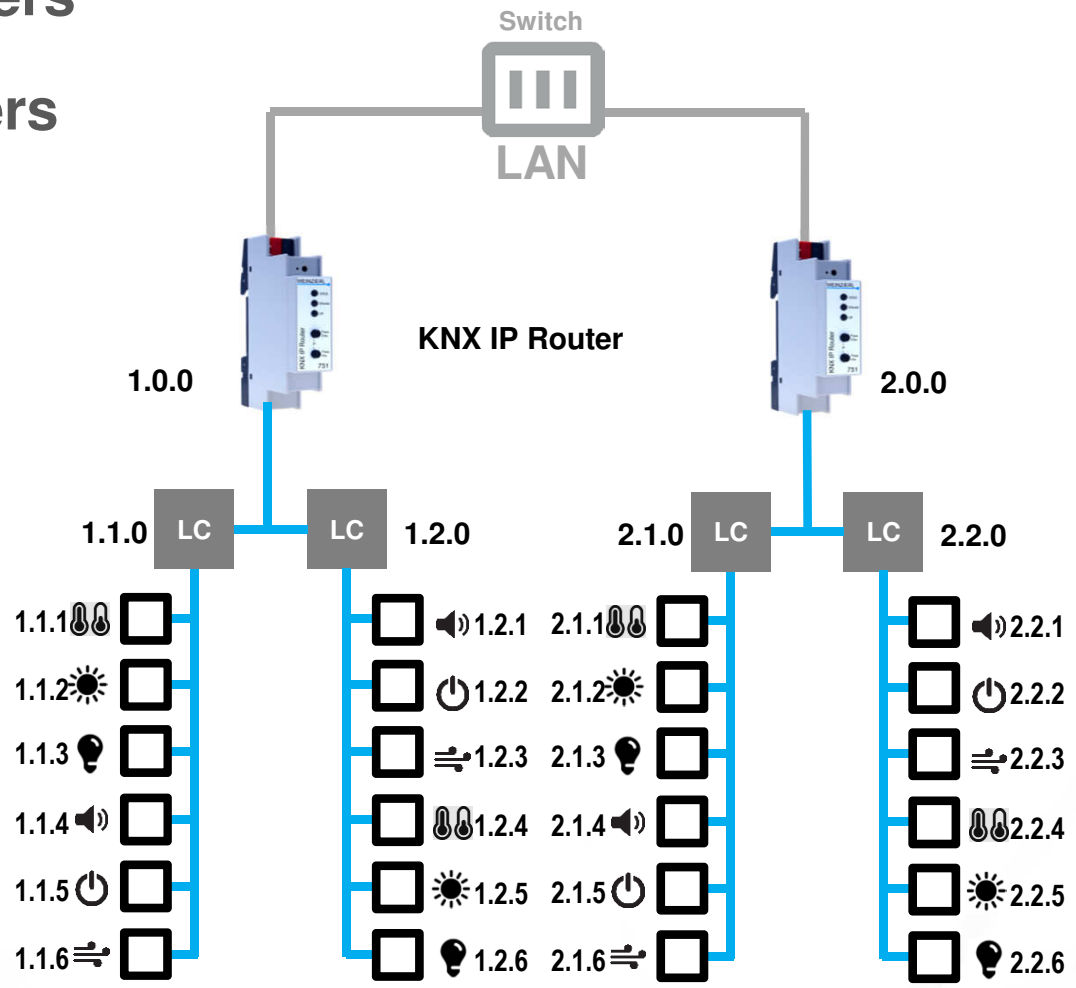
- From a faster network to a slower network
  - KNX TP: 50 Tel. per sec.
  - KNX IP: 10 000 Tel. per sec. (10MBit/s)
- Filter table essential
- Buffering of telegram bursts
  - KNX IP-Router 751: 150 buffers (FIFO)
  - Approx. 3 seconds buffer
- Routing Lost Message

KNX IP Router 751 as Area Coupler

- Replacement of Area Couplers
- Preservation of Line Couplers
- Addressing:
  - x.0.0 (x: 1..15)

Warning:

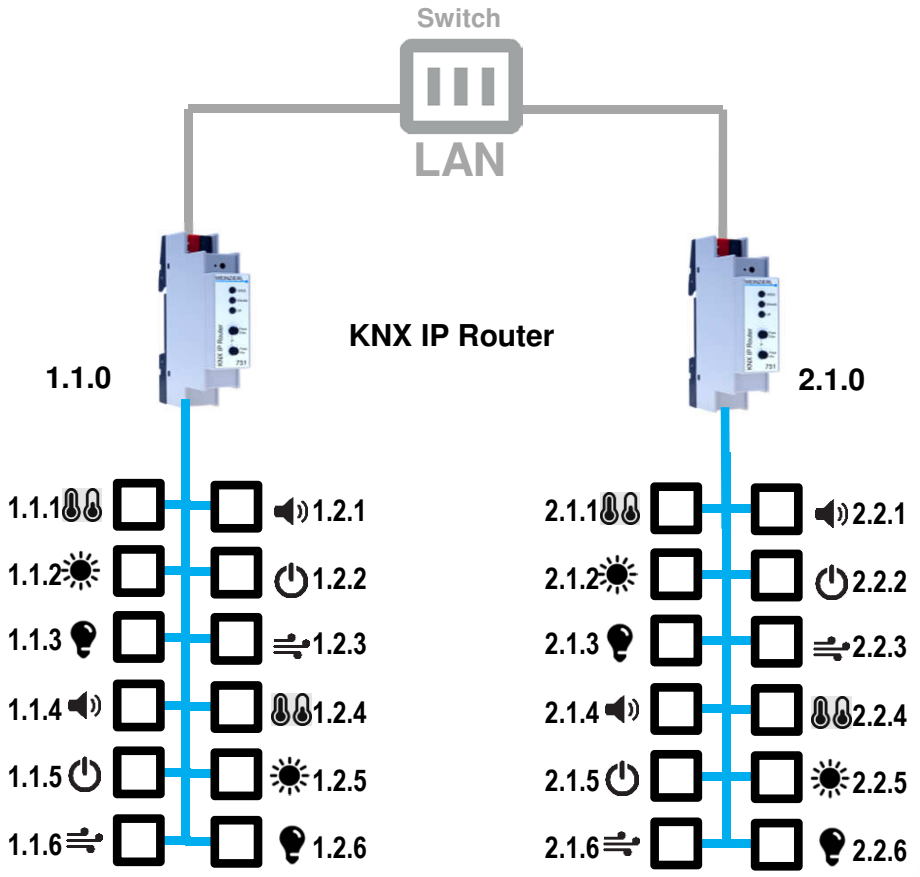
KNX/IP Router addresses must not conflict!



KNX IP Router 751 as Line Coupler

- Replacement of Line Couplers
- No Area Couplers essential
- Addressing:
  - x.y.0 (x, y: 1..15)
  - 225 Lines

Warning:
KNX/IP Router addresses must not conflict!

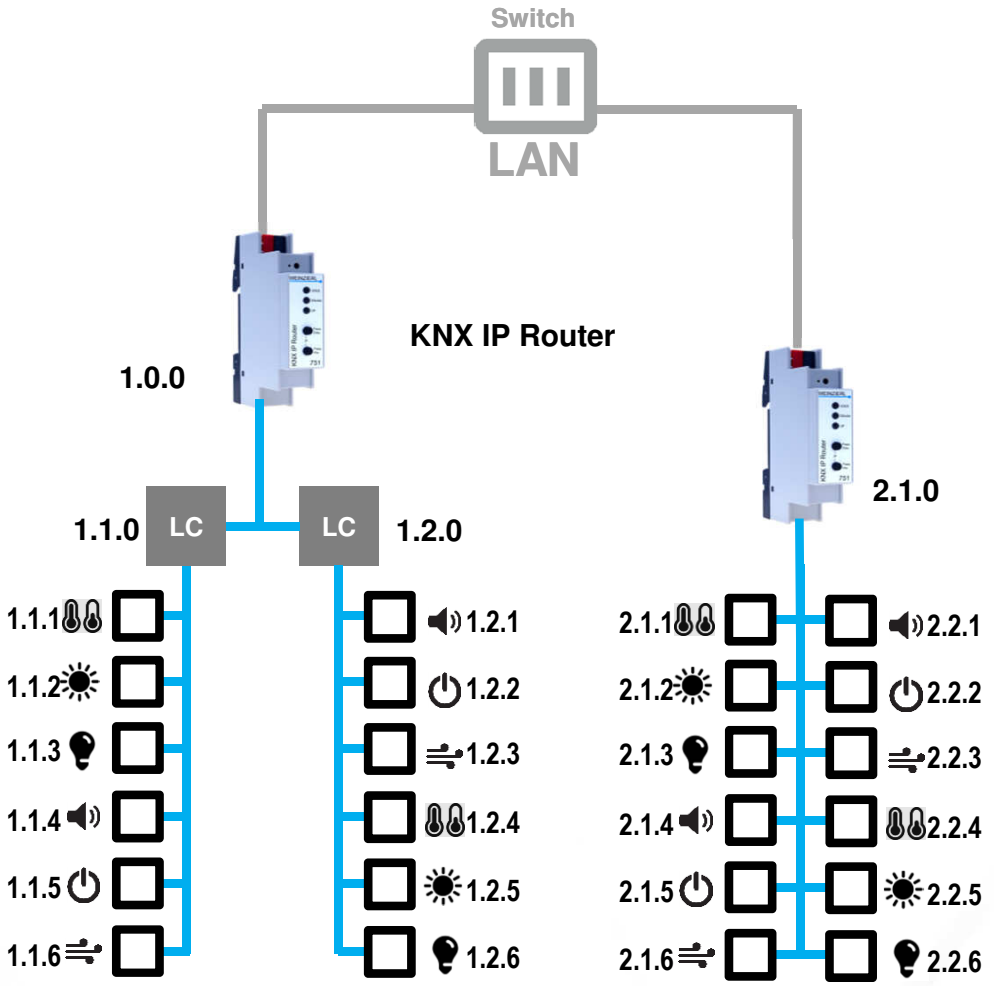


KNX IP Router 751 - Mixed Installation

Usage of KNX/IP-Routers as

- Line Couplers
- Area Couplers

Extension of existing installations



KNX IP 751: Connection in ETS

Integrated Interface

- Usage of Tunneling (KNXnet/IP)

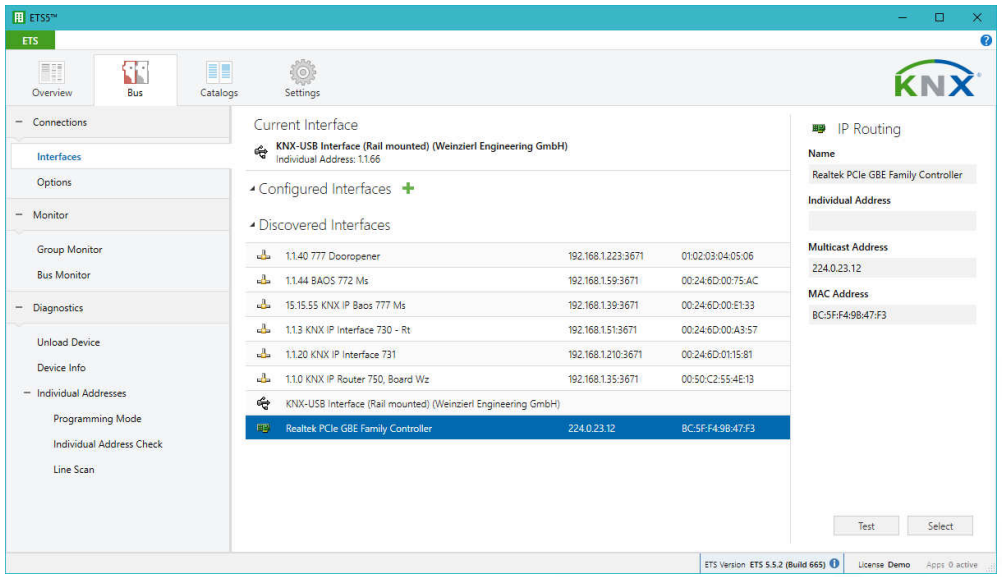
Routing Port

- Usage of Routing (KNXnet/IP)
- Multicast
- No flow control
- Limited speed

Group monitor

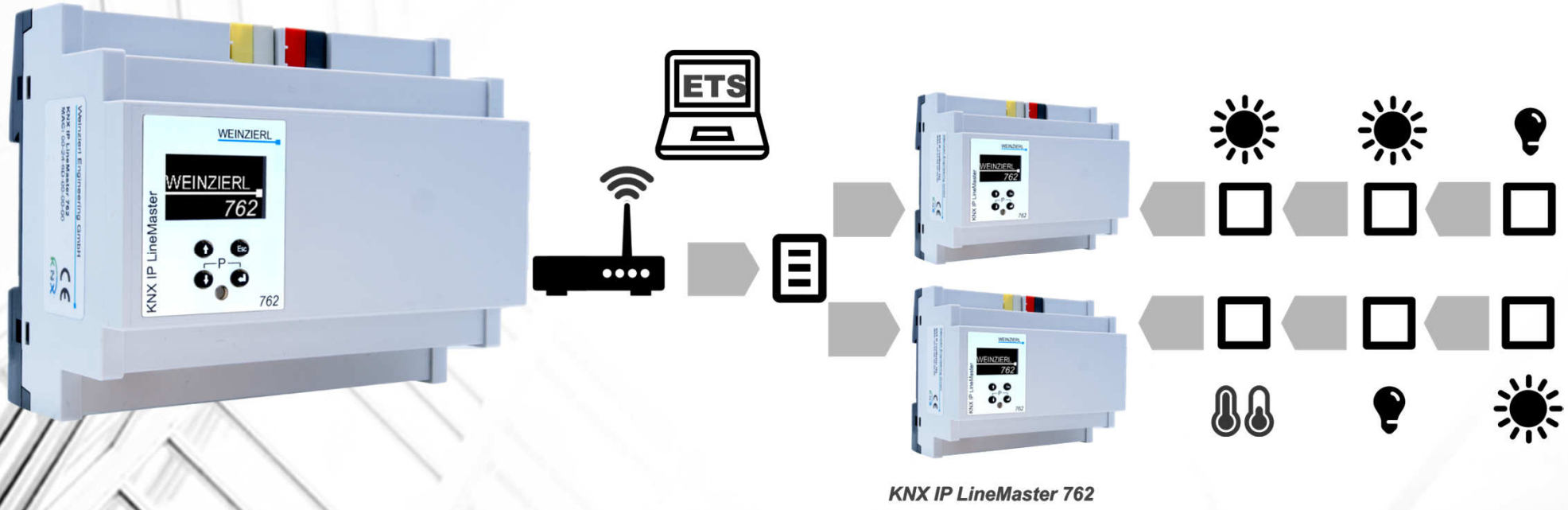
No Bus monitor

- No allowed
- Would conflict with routing



KNX IP LineMaster 762

- Power supply (640 mA) including choke
- IP Interface to KNX (Tunneling), e.g. for the ETS
- IP Line coupler functionality (Routing)



KNX IP LineMaster 762

KNX IP LineMaster 760 - Features

KNX Power Supply with KNX IP Router

- Width of 6 units (108 mm)
- Integrated Choke
- Auxiliary output
- 640 mA

IP Router

- Extended Filter table (Main groups 0..31)
- IP Interface function (6 Connections)

Diagnosis via display

- Power
- Communication

KNX IP BAOS

What is BAOS?

Bus Access and Object Server

Bus Access

- Telegram level
- Programing interface for ETS

Object Server

- Group object level
- Universal IP Gateways
  for home and building control
- Residential Gateway
- For an easy access to KNX networks
  for non-KNX applications

BAOS: Applications

Typical application areas

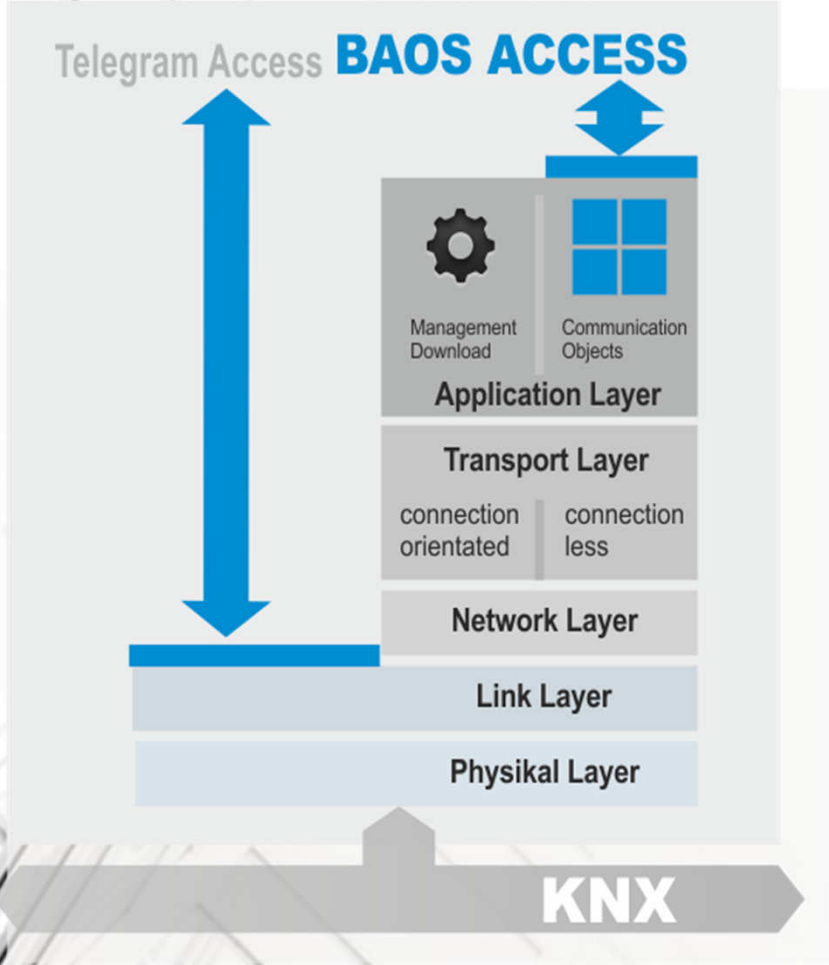
- Visualization without additional Editors
- KNX Gateways for
  - Heating
  - Air Conditioning
  - Audio
  - …

Applications just use BAOS protocol

- No need to handle KNX telegrams
- No need to know group addresses

KNX IP BAOS 773

BAOS Communication



Group Objects: Application Layer

Telegrams: Link Layer

BAOS allows access to data points

OSI/ISO Reference Model

- Separation between application and communication

Object server stores data point values

- Active even if no client connected
- Short latency without Group-Value-Read

KNX IP BAOS 773 / 774

- First KNX IP BAOS with 18mm width
- Functionality like the market proven model 771/772
- Support of 250/1000 data points
- Powered by the KNX bus
- Up to 5 simultaneous KNXnet/IP Tunneling connections
- Diagnosis functions via buttons
- Display of communication errors

KNX IP BAOS 773 / 774

BAOS Binary Protocol V2 on UDP/IP or TCP/IP

Web Service Protocol JSON (Java Script Object Notation)

- For browser integration

SDK / Tools available

- Windows
- Linux

Connect to BAOS - Binary Services

Native written applications

Link a already built-in Ethernet device to KNX

- E.g. Audio actuator
- PLC (Programmable Logic Control)

Usage together with BAOS SDK (Software Development Kit)

Easy start (no client-side implementation of the KNX BAOS Binary protocol necessary)

C++, C#, VisualBasic.net

Connect to BAOS – Web Services

To be used within web applications

Based on JSON (Java Script Object Notation)

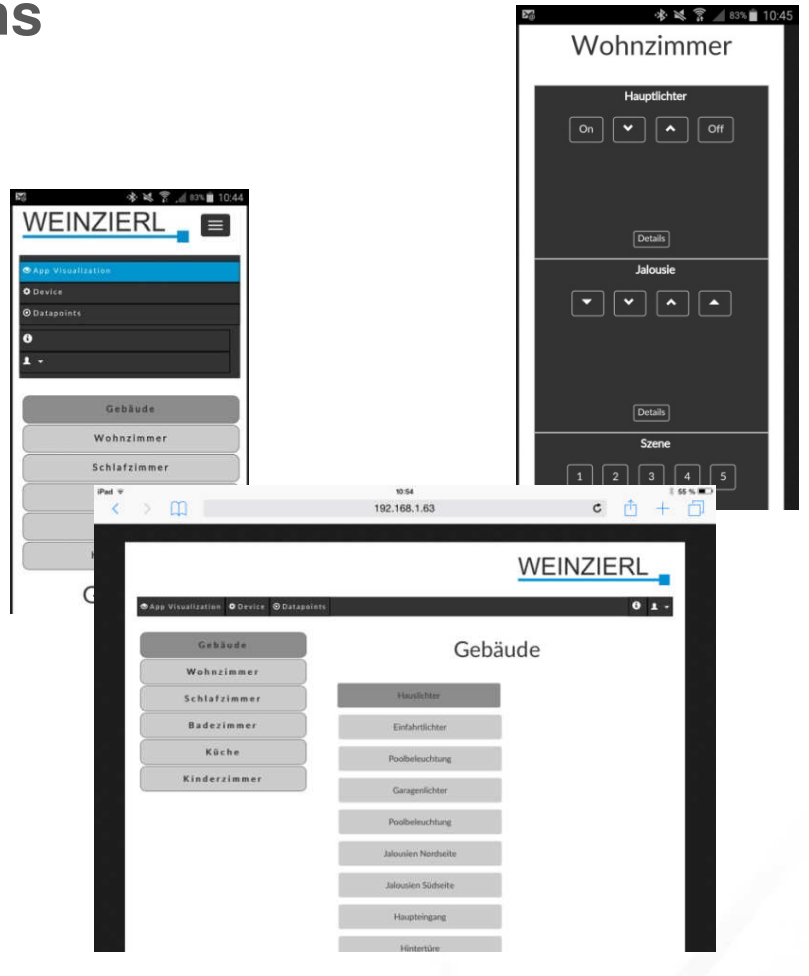
Perfect for web programmers

Applicable on mobile devices

- iOS (iPhone, iPad)
- Android based mobile phones

API (Application Program Interface) available

Demo incl. usage of API available



KNX IP BAOS Parameter - General

Programming mode on device front

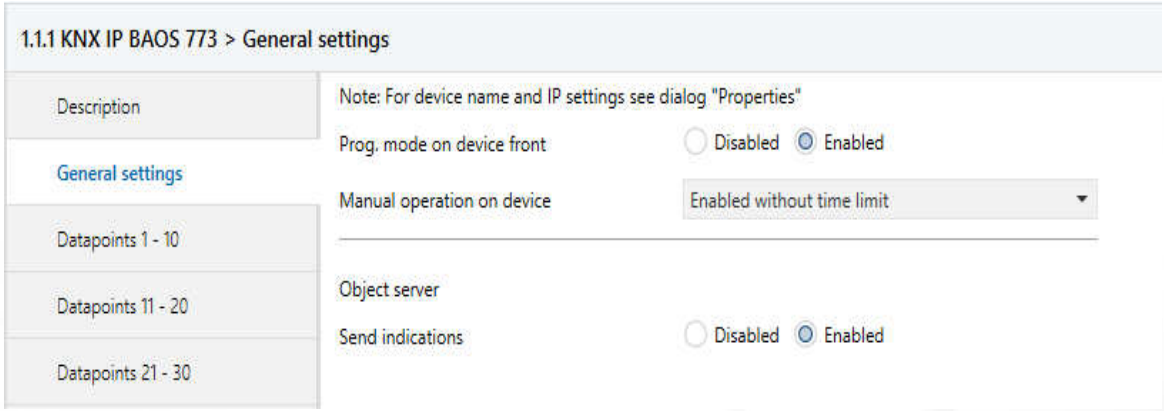
- Disabled
- Enabled

Manual operation on device

- Disabled
- Enabled with timeout
- Enabled without timeout

Sending of indications

- Disabled
- Enabled



BAOS Parameters – IP Configuration

In ETS Property side bar

Device Name

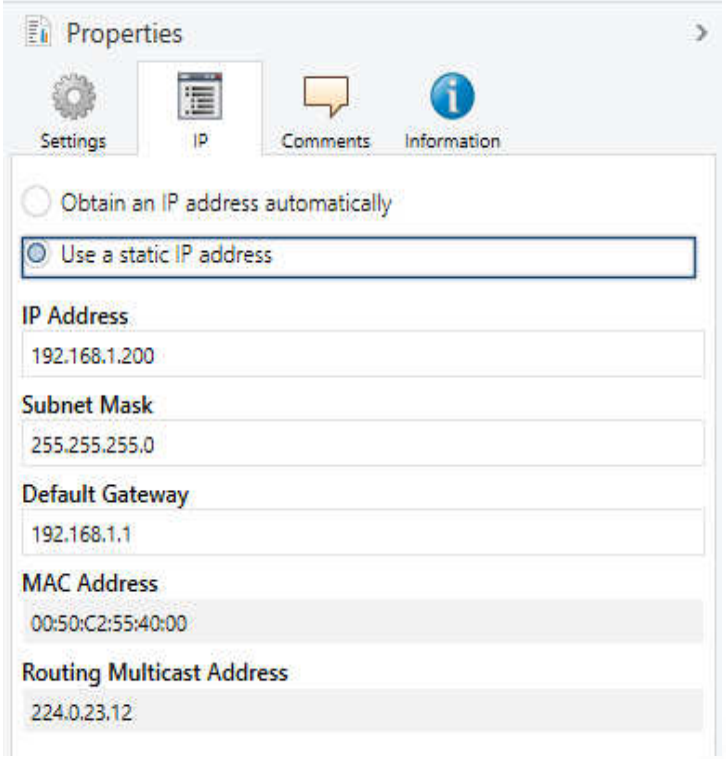
IP-Address assignment

IP-Address

IP-Subnetwork

Default Gateway

IP Routing Multicast Address



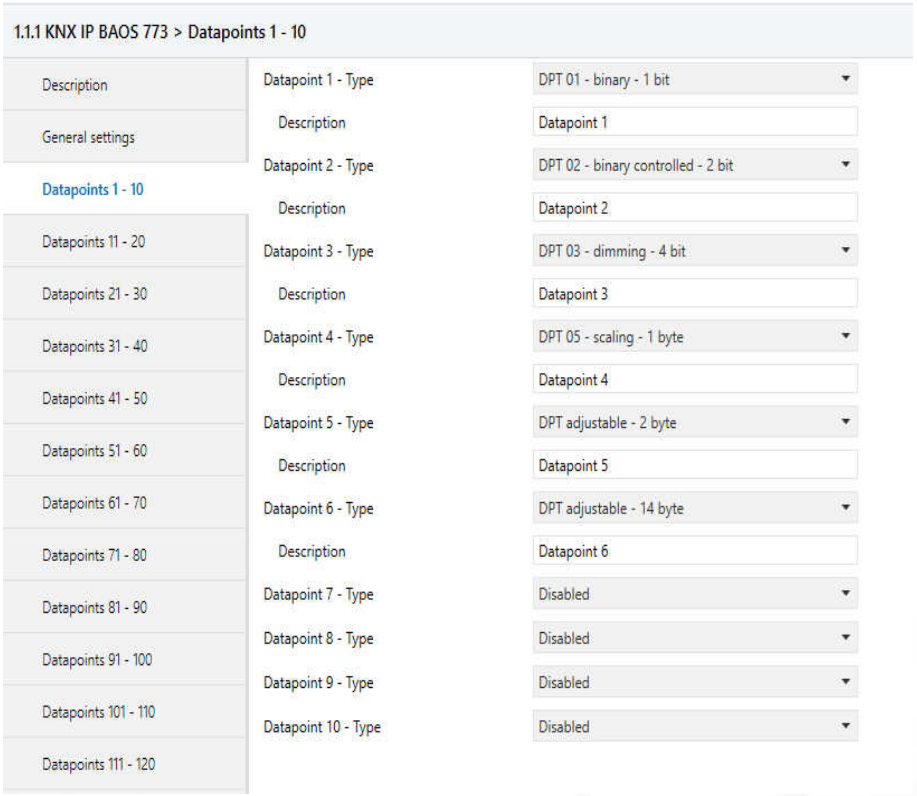
BAOS Parameters – Data points

Type of data point

- Select data point type (DPT)

Description of data point

- String to identify data point, e.g. „Light Living Room“
- Used in group object view



KNX IP BAOS 777

- Universal KNX IP Gateway
- KNX IP Interface
- Object Server
- Web Server

KNX IP BAOS 777: System Integration

KNX Telegrams

Configuration
Structure & Links

Structure &
Values

KNX IP BAOS 777: Configuration

On Device (menu + keys)

- IP Configuration: DHCP / Static

Web Browser

- IP Configuration
- Individual Address
- System time
- KNX Programming Mode
- Services enable / disable

ETS

- Complete configuration

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KNX IP BAOS 777: Product entry

With building structure

- Rooms
- Functions
  - Set of related group objects
  - E.g. dimming control with state
- Generation of semantic information
- E.g. for Visualizations
- Meta data available via RESTful web services

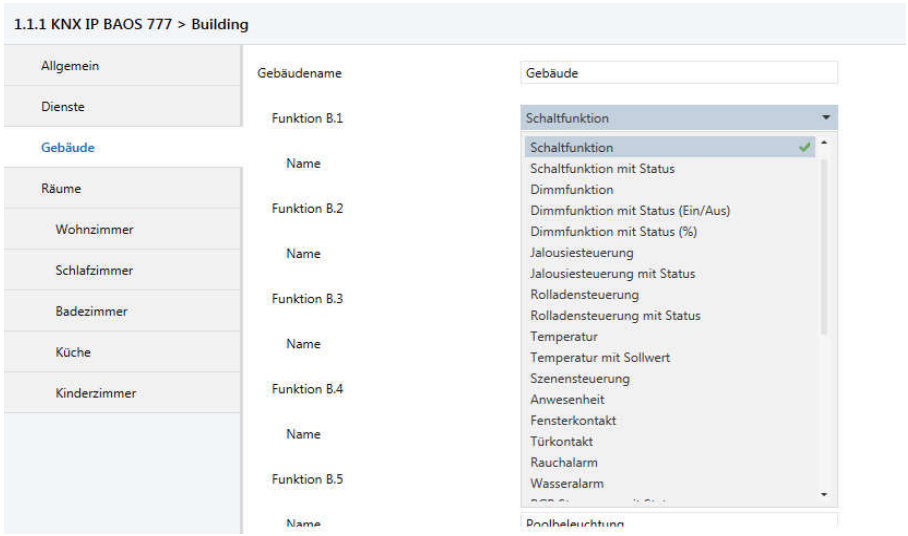
Generic

- Flat list of data points
- Mainly for development

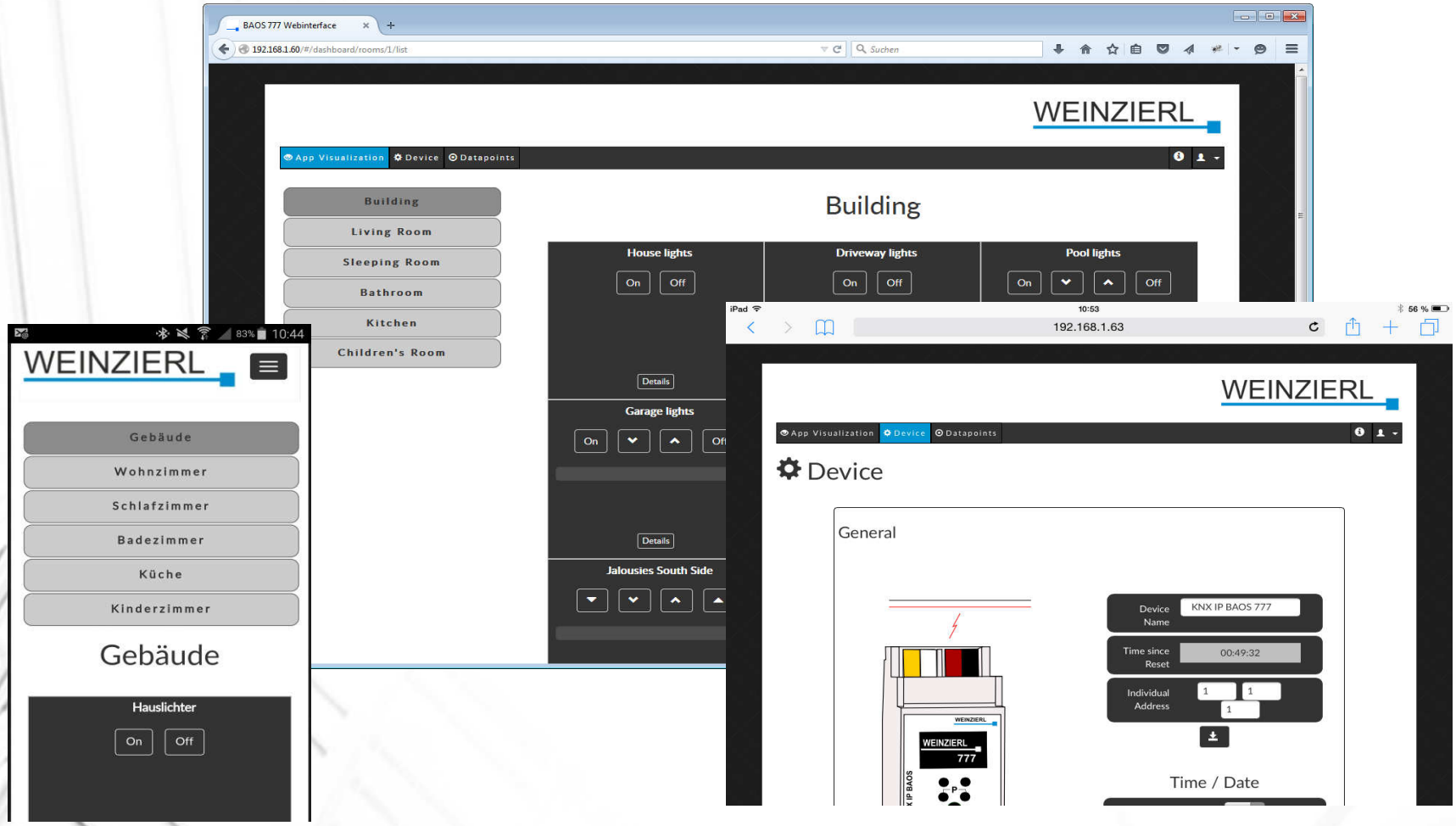
KNX IP BAOS 777: Structured ETS

Functions

- Switching
- Switching with state
- Dimming
- Dimming with state
- Temperature with set point
- RGB Control
- …



KNX IP BAOS 777: Web Visualization



KNX IP BAOS 777 - Features

Timers

- One time (Date / Time)
- Interval timer
- Stored and running in BAOS device, active even without client

History

- For each data point available
- Up to 1 mio. events

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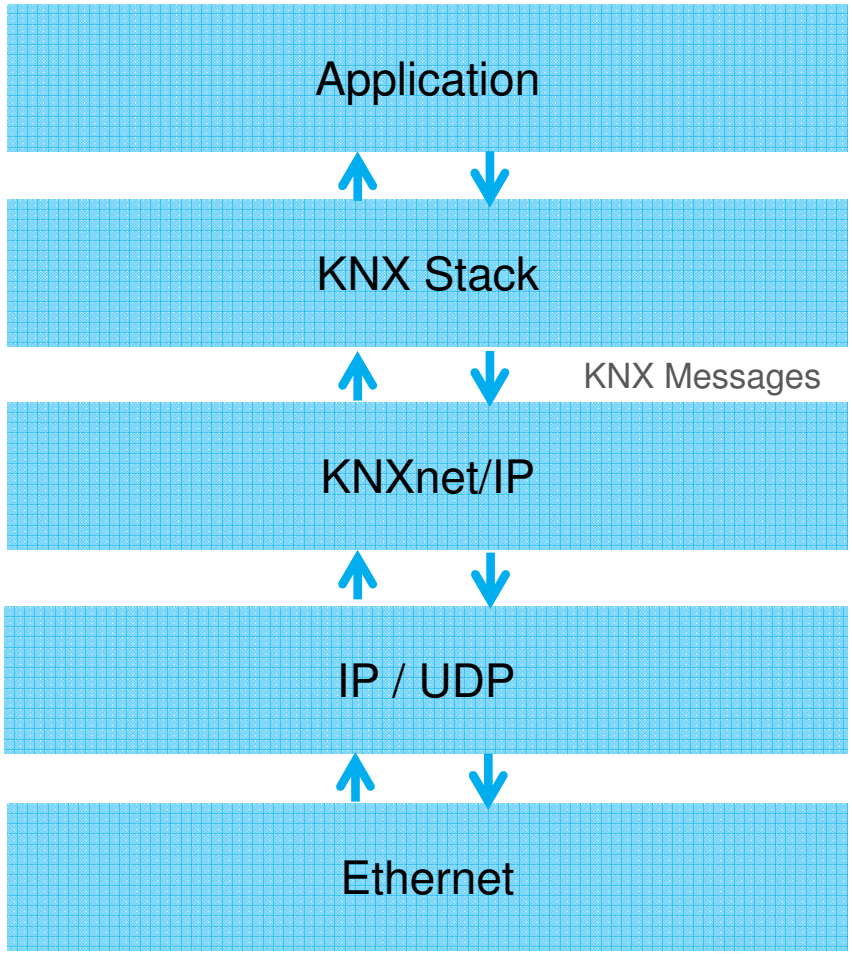
KNX IP BAOS 777 - API

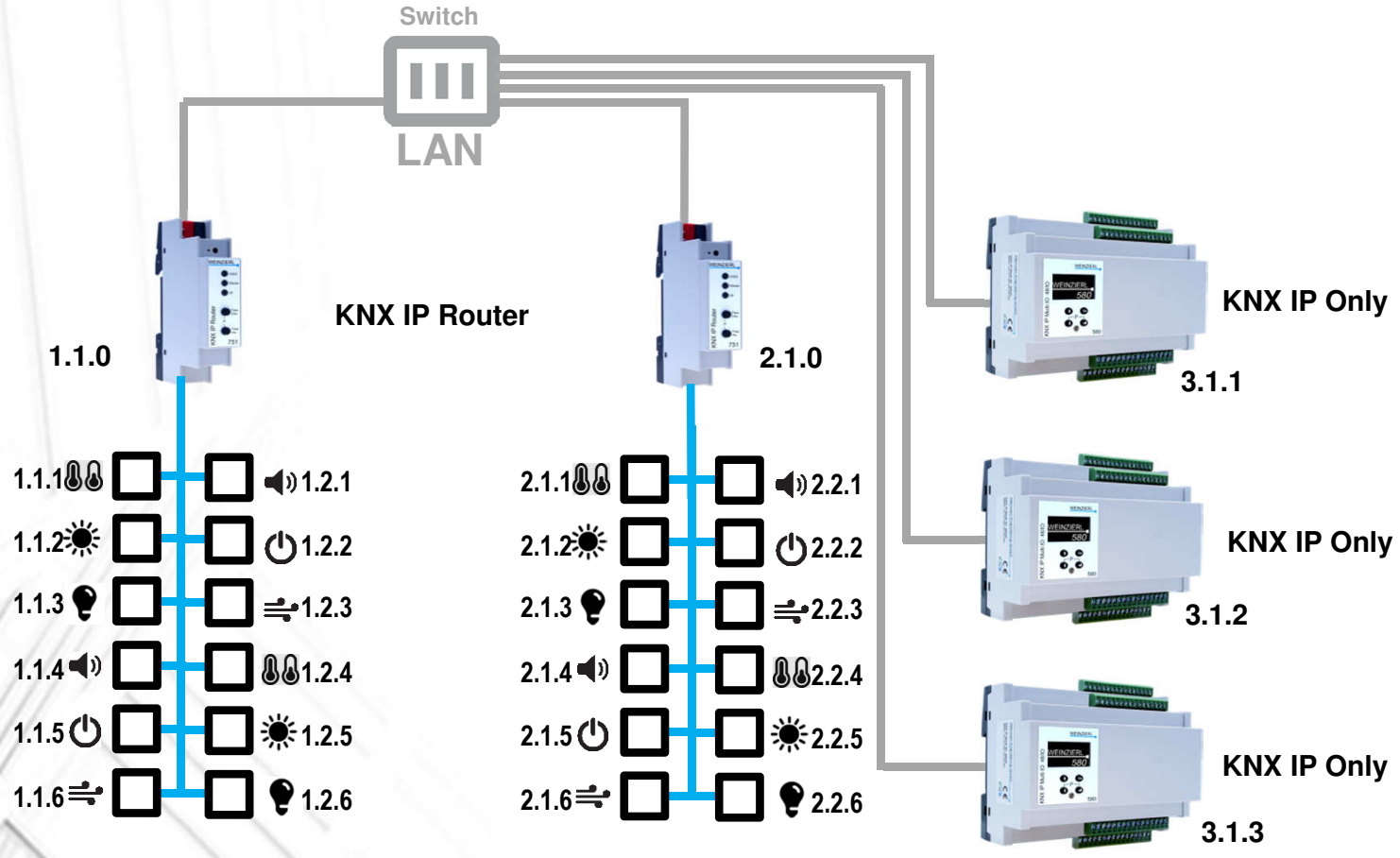
- Software-Development-Kits (SDK's)
- RESTful web services
- Get data point value description
- Get/Set data point value
- Get meta-data (rooms and functions)
- Get/Set Timers
- Get/Set history configuration
- Get history values

KNX Medium IP

- IP is one of four media in KNX
- Supported since ETS4
- KNX Interworking
- Mixed installations possible



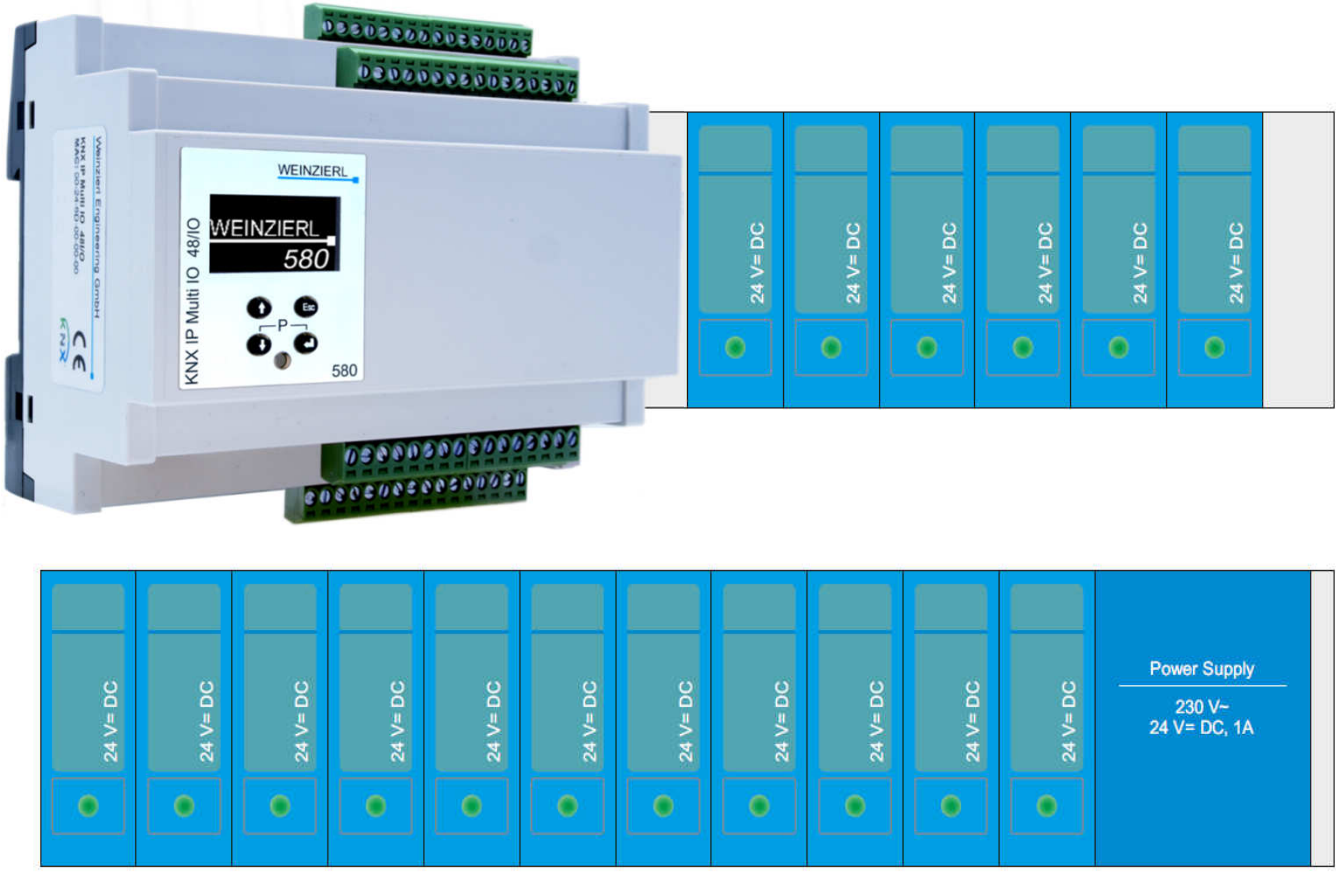
Topology with KNX IP only



KNX IP Multi IO 580

- KNX IP only device
- Universal IO device
- Width only 6 units
- 48 free configurable IO channels
- Power supply of IOs
  via external 12 .. 24 V
- Diagnostic and manual operation
  via menu

KNX IP Multi IO 580 – Installation example



Remote Control (NAT)

KNX IP Router/Interface works as server

Available beyond the private Network

IP-Address has to be known

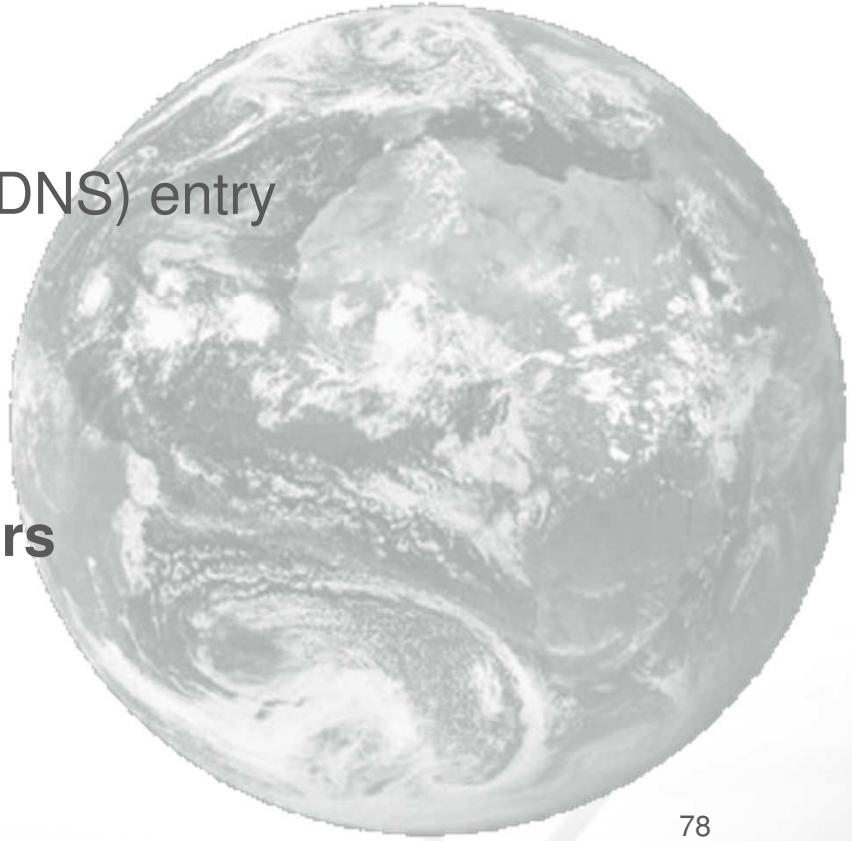
- Static
- Dynamic Domain-Name-System (DNS) entry

NAT (Network Address Translation)

Routing to a private Network

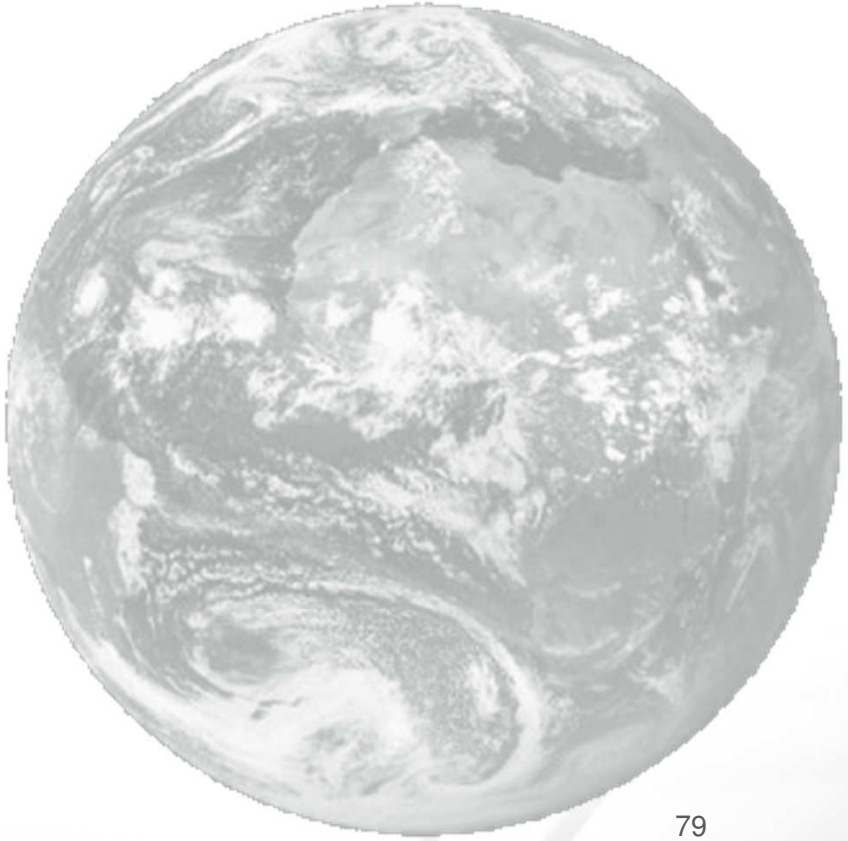
Implemented in common DSL-Routers

Possible with ETS from version 3.0f



Remote Access (VPN)

- Access via NAT: unsecure
- Usage of VPN (Virtual Private Network)
- Common VPN-Routers available
- Connecting by PC to external VPN
- More effort during Installation



Optical Media

Bridging of distances > 100 m

Electrical Decoupling (Lightning protection)

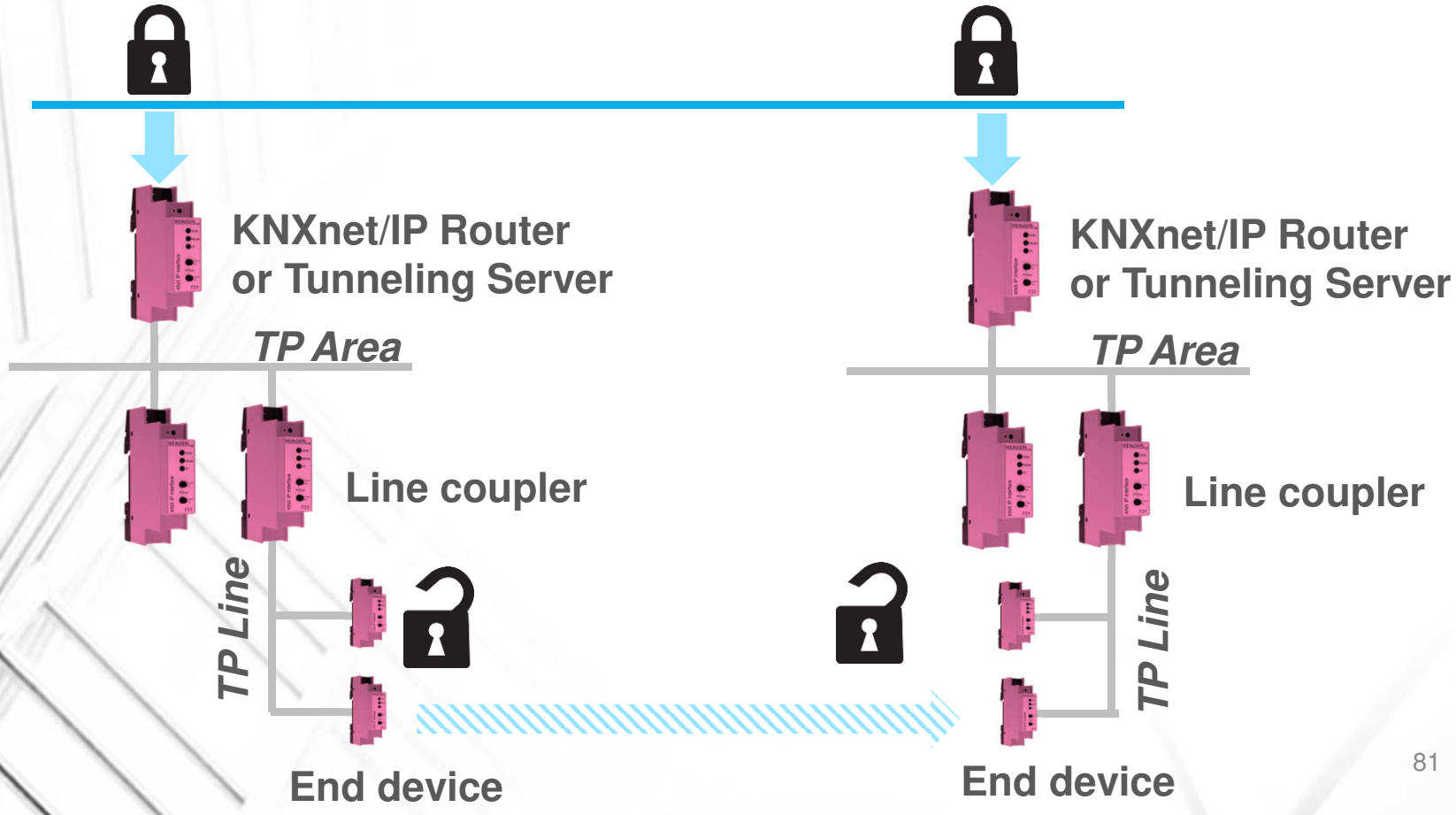
Usage of optical fiber

- Multimode
  - Range < 2 km
- Mono mode / Single mode
  - Range < 40 km

Media converter

KNXnet/IP Security

- Protects data within IP network (Routing)
- Protects access to KNX network (Tunneling)



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KNXnet/IP Security - Characteristics

Data Integrity

- Prevents an attacker from manipulating KNX telegrams (MAC)

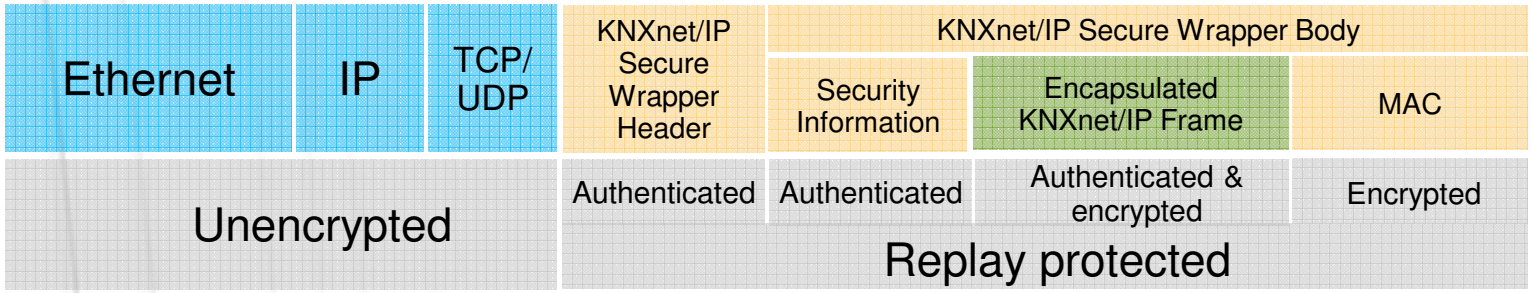
Freshness

- Prevents messages from being recorded and used unchanged (Sequence No)

Confidentiality

- Data is encrypted (AES)

KNXnet/IP Security - Secure frame



IP header

- Ethernet – IP – TCP/UDP

KNXnet/IP header

- Service: KNXnet/IP secure wrapper frame

KNXnet/IP secure wrapper frame

- Security Info: Session ID, SeqNo, Serial No, Message Tag
- Original KNXnet/IP frame
- Message Authentication Code (MAC)

Future Prospects

KNX over IP increasingly more important

KNX/IP-only Devices

- No TP-Connector
- KNXnet/IP as protocol
- Interworking KNX
- Management KNX
  - Commissioning using ETS
- Databases like TP-Devices
- Link to multimedia

Expansion of KNXnet/IP

- Remote logging
- Security (ongoing)
- IP V6

Overview: KNX IP Devices

	KNXnet/IP Tunneling (Interface e.g. for ETS)	KNXnet/IP Routing (Line Coupler over LAN)	BAOS Object Server (Access to data points)	Integrated power supply for bus	Bus powered	Wireless (WLAN/ Wi-Fi)	Web server with visualization
 KNX IP Interface 731	✓				✓		
 KNX IP Interface 740 wireless	✓					✓	
 KNX IP Router 751	✓	✓			✓		
 KNX IP LineMaster 762	✓	✓		✓			
 KNX IP BAOS 773/774	✓		✓		✓		
 KNX IP BAOS 777	✓		✓				✓

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KNX & IP

Thank you for your attention.