White Paper

Multimedia in the Home -
What Infrastructure is Needed?

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More and more multimedia gizmos and technologies are finding their way into residential properties and there is no let up in the number of new services being offered by telecommunications and cable providers. Buzzwords such as HDTV, IP-TV, Video on Demand, Voice over IP, Wireless LAN, EIB, DSL, Triple Play are on everybody's lips. At the same time, anybody buying a new television would like to be able to use the existing antenna as long as possible, just as they would their trusty stereo equipment. Media technologies of the present and future are clashing with one another in private households. How does all this fit together; how can the plethora of gadgets, new services and multimedia possibilities intertwine? Electricians and consumers are seeking flexible and secure solutions, and, above all, solutions that function flawlessly. The focus today is on home networks and cabling.

This white paper is intended as a guide to provide arguments for installation decisions involving residential properties. Solutions with a guaranteed future for terminals and networks are illustrated on the basis of structured cabling (EN 50173-1 and -4).

Application:	Residential Cabling
Technology:	Copper wiring, POF, Ethernet, TCP/IP
Format:	White Paper
Topics::	Multimedia systems in the home, Triple Play, IP-TV, CATV, HDTV, TVB-T and -C, Video on Demand, VoIP, DSL, decoders, set-top boxes, W-LAN, Ethernet, TCP/IP, home wiring, multimedia outlets, coax, Cat. 5e, Cat. 6, EN 50173-1 and -4, structured cabling
Objective:	To examine the cabling and network requirements, or strategies in the home, basic knowledge for planning and decision-making purposes
Target group:	Marketing, technicians, property buyers, housing economy, planners, interior architects, designers, banks, real estate sector
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1 Introduction

1.1 New Media and Communication Needs

Today, nobody buys an automobile without central locking, electric window openers and on-board stereo equipment. A lot of money is spent on comfort and then written off in just a few years. In contrast, when building or renovating a house, the choice is often made in favor of rudimentary electrical, telephone and television wiring. State-of-the-art multimedia cabling takes a back seat although property tends to span more than a lifetime.

If not today, data compliant infrastructure will certainly be needed tomorrow if a digital lifestyle is going to be pursued. The need for comprehensive communications exists. The majority of households in Western Europe boast a computer and want to be able to use the Internet. This requires appropriate networking capability. Home office and home entertainment are the undeniable needs of the moment. This includes the integration of TV, radio, telephone, entertainment and information over the Internet, the integration of A/V equipment, central storage and decentralized reproduction of movies, images, music and documents.

Even building security and building services, energy and lighting management could be linked to one another. The demographic future means that there will be a requirement in the home for the provision of healthcare, child or senior citizen monitoring, based on interactive communication devices. Anybody hoping to stay in their own home until a ripe old age is in need of security in every respect and is grateful for easy to use systems that enable quick access to video surveillance, the integration of an emergency call for a physician, or remote diagnosis (Fig. 1.1).

At the same time, the technical infrastructure required should be available at a reasonable price, it should be transparent and offer performance with adequate reserves. The experts, on the whole, are unanimous: This is only possible with a standardized, modular basic structure comprising interfaces to the outside world, centralized generation and decentralized provision of information and entertainment content, suitable distribution structures with optimal utilization and the possibility of upgrading or adapting at a later date.

Fig. 1.1: Scenarios for changing communication needs in the home, e.g. a panel in the bedroom to control the music equipment and building services (above), webcam in the children's room (right). Photos: R&M

These scenarios are challenging for the trade but also represent a great opportunity. Only companies that are fully committed to the latest technologies and integrate them in their service portfolio will be able to survive.

1.2 Flexibility in the Home

The possibilities today for space utilization are governed by needs that just a few years ago would have been unthinkable. Minimalist equipment in an apartment comprising a two-wire telephone outlet in the corridor and an antenna socket in the living room no longer provides the type of comfort we have come to expect. Today, the resident of an apartment would like to be able to determine himself how the rooms are to be used and have a number of options at his disposal at any time.

In addition, consumers want to be able to switch between various media throughout the home and use the multimedia service that takes their fancy. Today they might want to access the Internet or telephone via a television cable in the living room; tomorrow, the need might be to change to another provider in the home office in order to use the company's virtual private network, receive video on demand or Voice over IP.

Flexibility and mobility are features of our fast-moving era. The changing stages of life involving employment, being self-employed or working from home are no longer exceptions. Working from home to generate additional income, changed layouts to rooms after the children have flown the nest or looking after parents in need of care etc. Nobody knows today what tomorrow might bring (Fig. 1.2).

Can the children's room be used as a place of work? How is media access in the bedroom and access to the media server from every room to be resolved? What do I have to do now to make sure I will still have access to all kinds of services later even if I cannot, or do not want to, decide now?

Planners, electricians and real estate agents have to be able to answer these questions. The trend towards individual, multi-optional utilization of media as a means of being able to choose the systems to access and interconnect various devices, places high demands on home cabling and presumes the availability of simple plug & play solutions. A standardized network is thus all the more valuable as its universality provides a simple technical basis for the constantly changing scenarios.

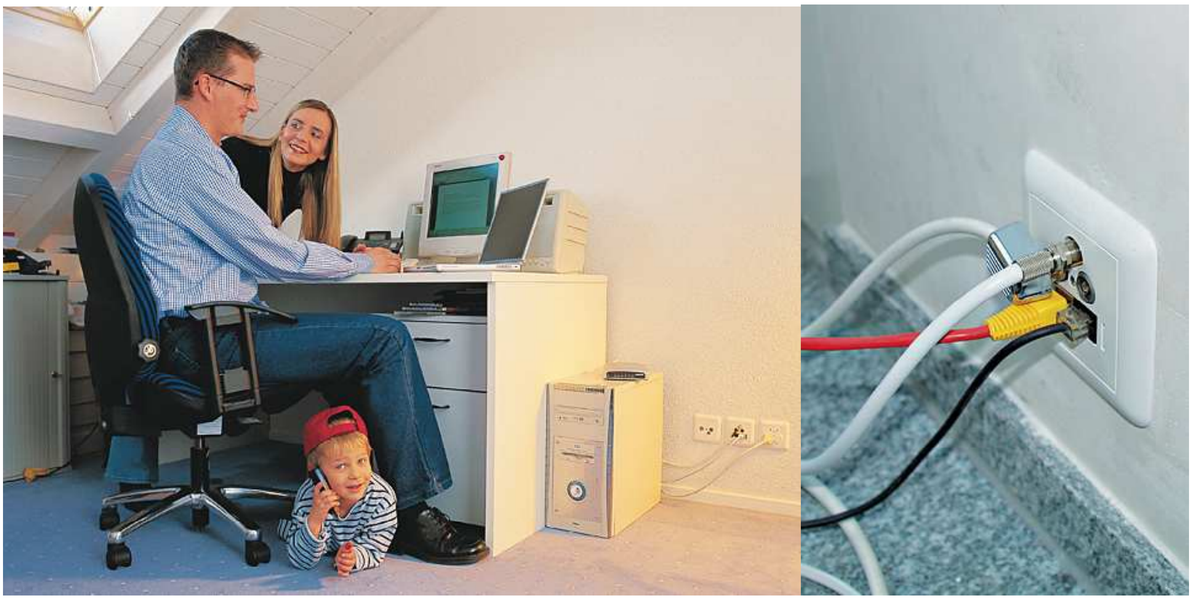

Fig. 1.2: Home office today, children's room tomorrow ... or vice-versa (left). Homes have to fulfill many purposes today and the infrastructure must be able to cope with the options available (right). Photos: R&M

1.3 Convergence – From the Vision to Reality

One trend has become increasingly noticeable in recent years: The borders between IT (Information Technology), TC (Telecommunication) and radio and TV via satellite, terrestrial, cable and Internet have become more and more blurred. Former well-defined technological and application-related domains are merging more and more without any sign of slowing down. The notion of convergence of the media has taken shape and is evident in a huge number of applications.

Back in the mid-90s, Martin Polon forecast the convergence of the telecommunication and entertainment industry. In his view the consumer would accept new forms of service and content distribution. A quote from the Movie Business Book[1)] published in 1995: "Private households will be connected to sources of entertainment and information via video cable and/or fiber optic lines provided by the telephone company and/or direct satellite transmission. The terminals facilitate a certain degree of two-way communication in much the same way as with duplex cable." In his book, "Being Digital", published in 1995, Nicholas Negroponte[2)], the visionary founder of the MIT Media Lab, forecast the convergence of entertainment and computer technology. Many other forward-thinkers come to mind whose views contrasted with the large number of skeptics, persisters and scorners.

In the meantime, it is possible to come to an interim conclusion: All the prognoses have been fulfilled faster and with greater precision than expected. The vast majority of households in Western Europe possess a computer, purchase new multimedia devices and use the Internet…. and sooner or later intend to have everything interconnected. Analysts from Arthur D. Little have stated that the market volume for home networks has tripled in recent years to between US$ 6 and 8 bn. In other words, home installations are in the process of a quantum leap.

A quote from an IBM study[3)] confirms: "The media world of tomorrow will be dominated by a greater dynamic of change and a higher degree of innovation potential. For content and service providers, regardless of whether new or established, local or global, they will have to adapt to innovation and transformation. Innovations are to be found where customer expectations, competitiveness, established business structures and cash flows can be changed for the long term. At the moment, this mostly succeeds in the form of bundles involving terminal devices, services and contents being offered."

The Swiss telecom company, Swisscom, for example, has been offering television, video on demand, radio, telephone, fax, Internet, in fact all types of communication services via one house connection point – with television and radio via Internet Protocol (IP), since 2006; and this is only the beginning.

1.4 From Living to "Intelligent" Living

Along with media convergence the trend towards the "intelligent home" is gaining ground. Intelligent living is to be understood as the interaction between sensors, actuators, and processing hardware and software, with the aim of relieving the occupant of unnecessary work, giving him a clear overview and convenient access to his resources, increasing his safety and well-being while reducing energy consumption and environmental pollution. In other words, in the "intelligent home" technology should assist the occupants but without treating them like children!

An example highlighting the use of smarter technology is in reducing the temperature in a child's bedroom whilst he or she is at school. Adapting the temperature of the room to take account of school hours would be a sensible approach. Another possibility would be to detect the presence of a child in the room by the use of sensors and adjust the heating intensity accordingly.

The catchword is adaptive control or situation and need-related supply. The English-speaking world talks about "ambient assisted living" and thinks of the interactive and supporting technology that enables people to remain in their own four walls even when they are getting on in years. There is no disputing that a "smart home" or an eHome saves energy. The energy saving effect alone, surely, is reason enough for the implementation of the latest technology.

Whether media convergence, digital lifestyle or smart home, it is clear that the corresponding infrastructure has to be in place. A multimedia and intelligent residential landscape can only function with a high performance and integrated network. The backbone for this is provided by structured, multimedia or generic cabling based on ISO/IEC 15018 and EN 50173 parts 1 and 4 (Fig. 1.3). It is estimated that barely 1 percent of households in Western Europe are equipped with structured cabling (beginning of 2008) which of course means enormous potential for the installation industry.

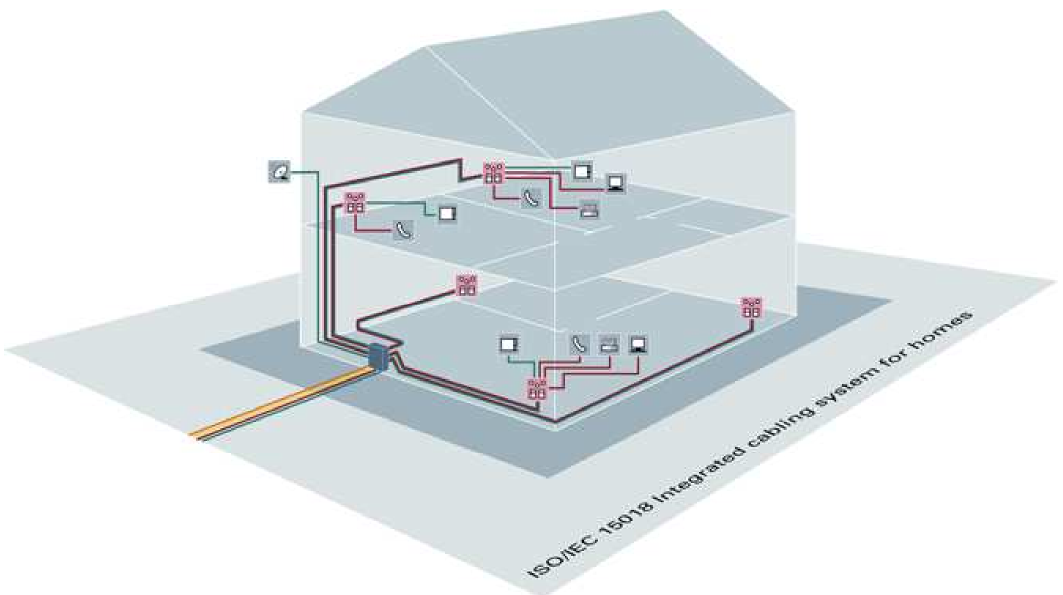

Fig. 1.3: Structured, integrated and generic – this is the guiding principle for home cabling. Illustration: R&M

2 Generic Cabling: Flexible and Value Adding

2.1 The Approach to the Solution

The ins and outs of home automation still have to be determined from an international perspective. Classical cabling, bus systems such as KNX/EIB, BACnet, LCN or LON and proprietary solutions are the choices currently available on the market.

For multimedia system solutions embracing communications and information, a number of international and European cabling standards are already in place. They take future developments, which as yet cannot be predicted precisely, into consideration as best they can.

ISO/IEC 15018	Information technology – Generic cabling for homes
EN 50173-1	Information technology – Generic cabling systems – Part 1. General requirements
EN 50173-4	Information technology – Generic cabling systems – Part 4. Homes

These standards see home cabling as the third level in the hierarchy of a structured cabling concept. This comprises three levels:

- Campus backbone cabling system
- Building backbone cabling system
- Premises-specific cabling subsystem(s)

The focus of this white paper is therefore on the European standards EN 50173-1 (General requirements) and EN 50173-4 (Homes).

In spite of high performance wireless transmission methods for local use, such as WLAN based on IEEE 802.11 a/b/g/n, Bluetooth, Zigbee, NanoNet etc., a wired distribution network is a must. It is reliable, secure against eavesdropping, scalable and offers enormous reserves for the future if the correct network cable is chosen.

Twisted pair Category 5e copper cable is thus a good and reliable choice in the home for running a network with a bandwidth of up to 1 GHz and fast Internet access. For Category 6a and above, copper cabling is capable of supporting transmission speeds up to 10 Gbit/s based on Ethernet standard IEEE802.3an. With transmission speeds > 100 Mbit/s all four twisted pairs are occupied and the cable cannot be used by any other services (no cable sharing). It cannot be denied that the wired distribution network is the most robust and resilient basis of modern in-house communications. In future, polymer optical fiber (POF) will also play a role in the home environment.

Furthermore, generic, structured cabling is the most suitable platform for network operations running either the Ethernet or Internet protocol (TCP/IP), and it is very flexible in its use. This already enables telecommunications, video surveillance, Internet services, entertainment electronics and building service bus systems to be integrated over TCP/IP. Cost-effective data technology solutions with simple and universally compatible connection and distribution technology also support this route. The RJ45 connector is the synonym for this (Fig. 2.1).

Fig. 2.1: The RJ45 connector – a synonym for universally compatible terminal technology. Photo: R&M

2.2 One Cabling System – Three Groups of Users

Both ISO/IEC 15018 and EN 50173-4 define a common cabling system for three groups of users in the home (house or apartment):

1. Voice and data	**ICT = Information and Communications Technology**
	ICT includes PABX systems (analog, ISDN, IP), equipment for Internet access (xDSL) and computer networks such as switches, routers, modems (LAN), house intercom systems, surveillance cameras etc.
2. Broadcasting and audio	**BCT = Broadcast and Communications Technology**
	BCT applications are to be understood as the distribution of high frequency broadcasting (radio and TV) over coaxial cable (cable TV, sat TV, DVBx), but also access to audio and video programs on the Internet or other IP-based sources including a HiFi and video home server.
3. Building services	**CCCB = Control / Command Communications in Buildings**
	Emergency and intruder detection systems, intelligent security applications, emergency call systems, paging systems, entry controls, electronic locking systems, temperature, light and ventilation regulation, etc.

The application groups, ICT, BCT and CCCB, specified under 1 to 3, are no longer as clearly definable as was the case a few years ago. This can be attributed to the convergence of technologies or the merging of hitherto strictly separated proprietary technologies. Broadcasting today is no longer simply a question of high frequency, wireless or wired transmission but increasingly seeks recourse to the Internet in the form of IP streams or podcasts. It is not just a change in the communication medium that can be observed but also a change in the service itself. Broadcasting is now an interactive service and consumers are not bound to any fixed times. Instead of a series of broadcasts over which the consumer had no influence, it is now possible for a person to determine himself what he wants to listen to, and when.

2.3 Sustained Added Value

Discerning tenants or house purchasers, who are technically up-to-date, are no longer simply content with a minimal installation configuration comprising a telephone socket in the corridor and antenna outlet in the living room. Standardized multimedia home cabling, as described in the following, thus increases the attractiveness and value of a property considerably. The benefits of this are:

1. All currently feasible IT scenarios can be implemented easily and with minimum effort.

2. As far as future multimedia developments offering greater bandwidth, new transmission technologies and services are concerned, modifications to the home cabling system (even if necessary) would be child’s play.

3 Fundamentals of Generic Cabling

3.1 Cenelec Standard EN 50173-1 and -4

3.1.1 General Requirements

Starting point for home cabling (based on EN 50173-1: Information technology – generic communication cabling systems – Part 1: General requirements) is the home distributor (=HD), which corresponds to the floor distributor (= FD) in the hierarchy of typical structured building cabling (Fig. 3.1.1). It forms the interface to higher-ranking network levels, provides users with the resources needed and permits cost effective and flexible activation of the desired signals to the multimedia outlets in the different rooms.

In order to fulfill the tasks, the home distributor must include the following as a minimum:

1. **Interface to the telecommunication network**
   This could be the typical two-core cable provided by the telephone company. It is the carrier for baseband analog telephony signals and, in the higher frequency range, the digital telephone service (Integrated Services Digital Network = ISDN) as well as broadband data services (symmetrical or asymmetrical Digital Subscriber Line = xDSL). For analog telephony alone (outdated), only an analog PABX is required to handle incoming, outgoing and internal home traffic. In order to be able to take full advantage of the terminal, a splitter, to separate the telephone signals (ISDN or analog) and the higher frequency DSL signals should be borne in mind. With ISDN, the telephone outlet of the splitter has a two-wire connection to an NTBA (Network Terminator Basic Access) device. The outlet of the NTBA is the four-wire S_0-bus that is occupied by the ISDN telephone PABX with its external S_0-terminal (and, where appropriate, up to 7 additional ISDN terminals). The internal ISDN ports are able to operate internal ISDN buses (usually one) throughout the home which can accommodate up to 8 ISDN telephones or other ISDN terminals connected with four wires. ISDN telecommunications equipment is often equipped with two-wire analog ports to operate standard analog telephones or fax machines with a and b connections. This configuration enables dedicated call distribution and internal home telephony to be undertaken. The DSL outlet of the splitter is connected to the DSL modem. The Ethernet output is distributed to all sockets via a data switch so that several PCs can access the DSL link. In many cases the switch and modem functions are combined in a router.

Fig. 3.1.1: Communication distributor – interface between the house entry point and the home network. Photo: R&M

2. **Interface to the BC network**
   In many places broadcast providers have upgraded their former program distribution structures to bidirectional broadband distribution systems via cable network (cable network providers) offering Triple Play in the form of radio and TV (analog and digital), telephone and high-speed Internet access. If there is a requirement for this service a bi-directional home distribution amplifier for high frequency radio programs, a cable modem as data interface and a VoIP router (Voice over IP) for telephony have to be included in the home distributor. For the subscriber the cable modem incorporates an RJ45 connector for commercially available Ethernet cables. As a rule this terminal is connected to a switch (or hub) where the ports can be wired in a star configuration.

3.1.2 Requirements of Home Cabling

The section dealing with the home (EN 50173-4: Information technology – generic communication cabling systems – Part 4: Homes) defines the structure and properties of general home cabling for ICT and BCT in detail.

The functional elements of generic cabling are (Fig. 3.1.2.1):

a.	The obligatory primary home distributor (HD)	
b.	The primary cabling	
c.	A secondary home distributor (SHD), if necessary	
d.	The secondary cabling (if there is a SHD)	
e.	The terminal outlets	
	MATO	Multi-Application Telecommunication Outlet
	TO	Telecommunications Outlet (RJ11, TAE, RJ45) for telephone/data services (IEC 60603-7-X series)
	BO	Broadcast Outlet (IEC, F) for radio/television (IEC 61169-2 type 9.52 or 24 type F)

At the HD it must be possible to gain access to the telephone network (usually a two-core cable) and to the antenna system and/or a local provider's cable network (Fig. 3.1.2.2). For future upgrades – e.g. broadband fiber optic connections – empty conduits must be provided at the Building Entrance Facility (BEF) and all outlets in the apartment. The use of combination cables with co-axial, twisted pairs and empty fiber optic conduits makes planning sense. In the home distributors, a 230-V power outlet for the active components is required.

To accommodate the HD, an installation box with sufficient space should be considered. It should be sited centrally in the apartment so that the star configured cabling is kept as short as possible. The provision of empty conduits is advisable as a matter of principle as this avoids the need for chasing into the walls and having to plaster and paint (Fig. 3.1.2.3) if new cables are installed at some time in the future. Exchanging a defective (e.g. cable that has been drilled into) cable is also made that much easier.

Fig. 3.1.2.3: As a matter of principle, adequately dimensioned empty conduits should be planned in new buildings (left). This simplifies subsequent upgrading for fiber optic communication (right), for example. Photos: R&M

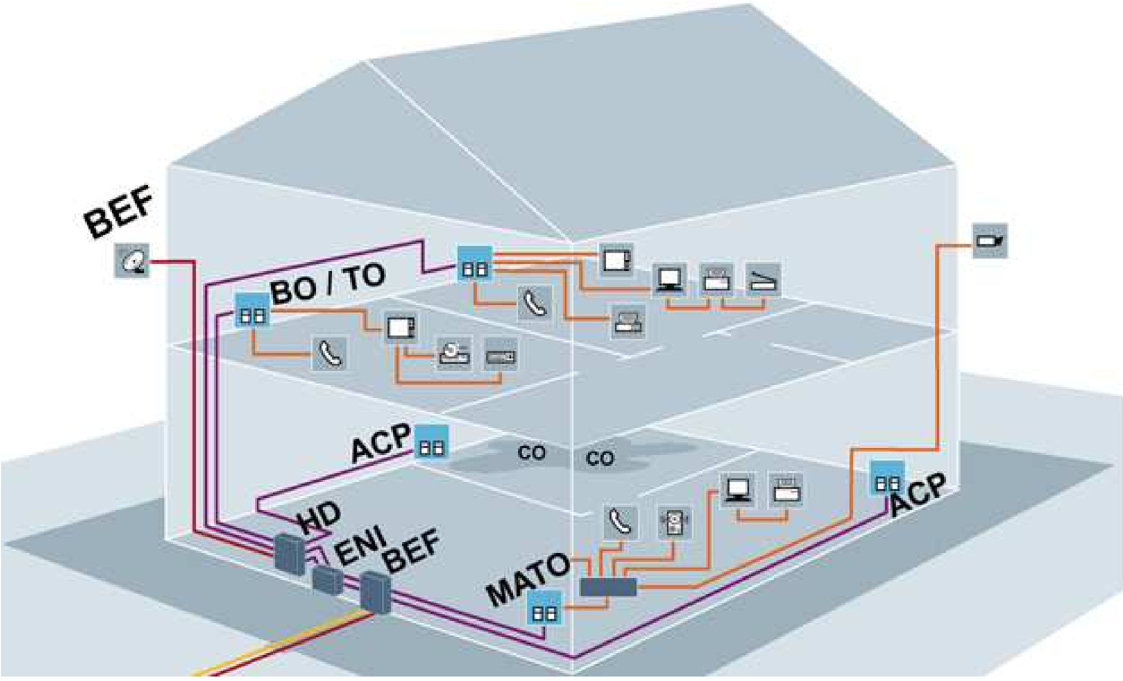

Fig. 3.1.2.1: Illustration of generic communication cabling. HD = Home Distributor, MATO = Multi-Application Telecommunication Outlet, BO = Broadcast Outlet, TO = Telecommunication Outlet. For CCCB applications: ACP = Area Connection Point, CO = Control/Command Outlet. Illustration: R&M

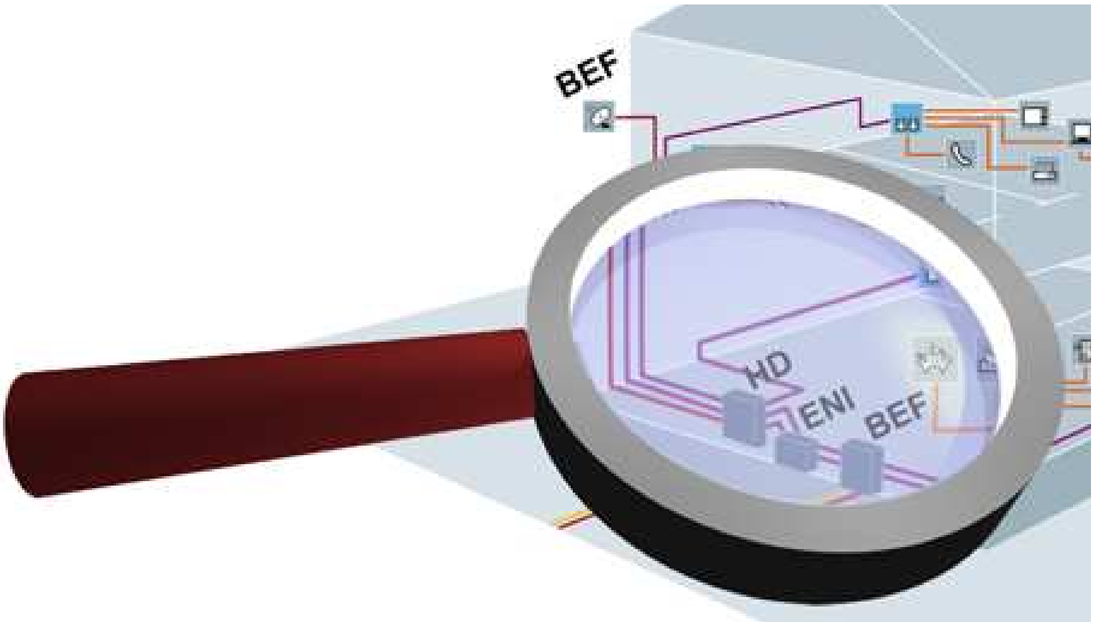

Fig. 3.1.2.2: Building Entrance Facility (BEF), External Network Interface (ENI) and Home Distributor (HD) establish the connection between the access and home network. Illustration: R&M

3.1.3 Hierarchical Structures

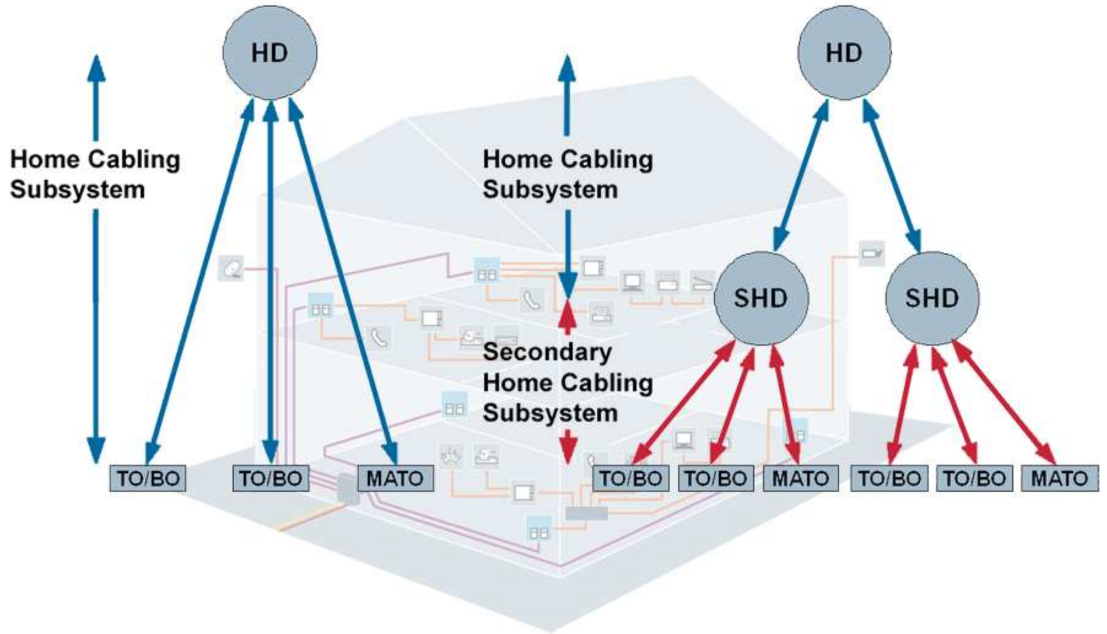

Fig. 3.1.3.1: Hierarchical structures for ICT and BCT from the Home Distributor (HD) – with and without a Secondary Home Distributor (SHD) that supplies a floor or apartment, for example. Illustration: R&M

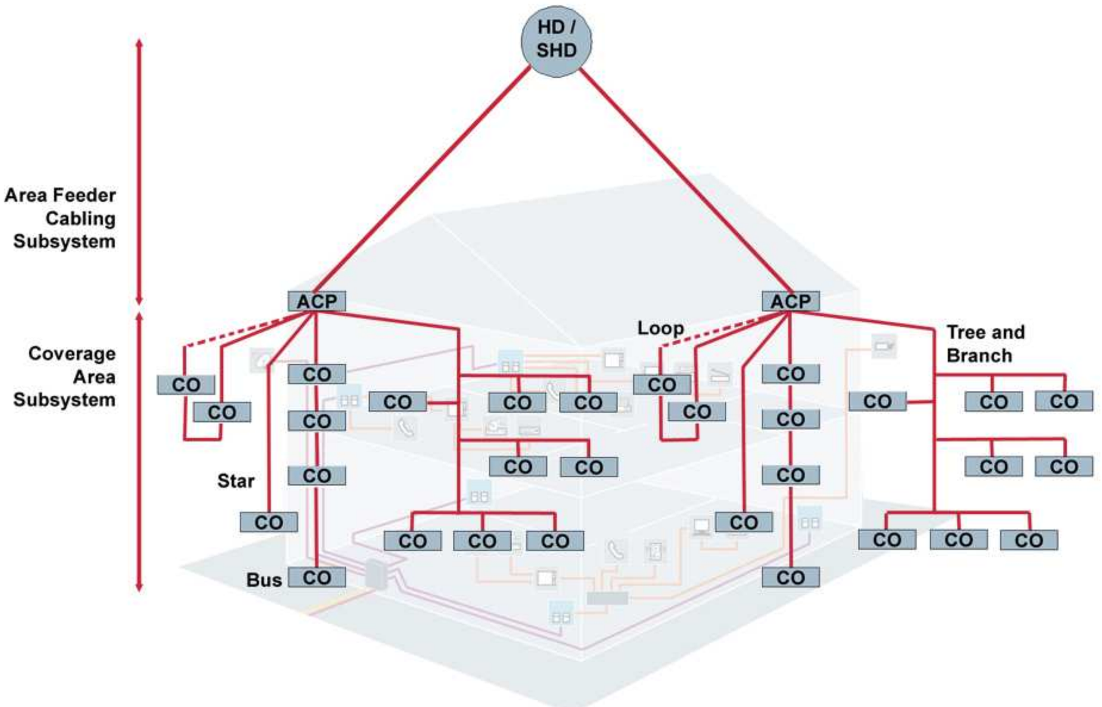

Fig. 3.1.3.2: Hierarchical structure for CCCB cabling from the HD or SHD (- - - - - = point of loop closure). Illustration: R&M

4 Structure of a Multimedia Home Network

4.1 Integrated and Yet Separate

The multimedia home network should be a powerful and reliable transport structure capable of transmitting high frequency radio signals on the basis of coaxial cable and high-speed data transmission using twisted-pair copper cables. Twisted pairs are often implemented as Cat. 5e UTP (unshielded). If there is a need to avoid radio frequency interference emitting from or entering the distributor system, high-quality, shielded cable (Cat. 6 S/FTP) should be used.
Cat. 7 S/FTP cabling that is also available on the market is a high-end solution for high frequency requirements and requires a properly dimensioned hood.

A 230V multiple power outlet should be planned in addition to each terminal outlet. To avoid equalizing currents in the coax and twisted pair cable sheaths, the ground conductor must not carry any load-dependent currents. Ideally the electrical installation should be implemented as a TN-S system with PG and N running separately.

The principle of optical waveguides (fiber optic or POF) and their use eliminates the problem of shielding and equalizing currents.

4.2 Ideal Standard Topology: Star

The transparency and administration of a star-configured distribution network mean it is far superior to other network topologies. If a room is suddenly to be used for another purpose or re-equipped, the home distributor can easily be reconfigured and documented even by specialists who were not involved in setting up the original distribution system. This clearly highlights the advantages of a standardized architecture.

Fig. 4.2.1 shows the easy to understand topology of the home network with a central home distributor. Configured for telephony, data and broadcasting it is the star node for two identical but completely independent networks: The coaxial cable transports the high frequency signals from a satellite multi-switch and/or a BC distributor to the coax outlets of the MATO (Multi Application Telecommunications Outlet) device. The twisted pair network is used to distribute data and telephone services.

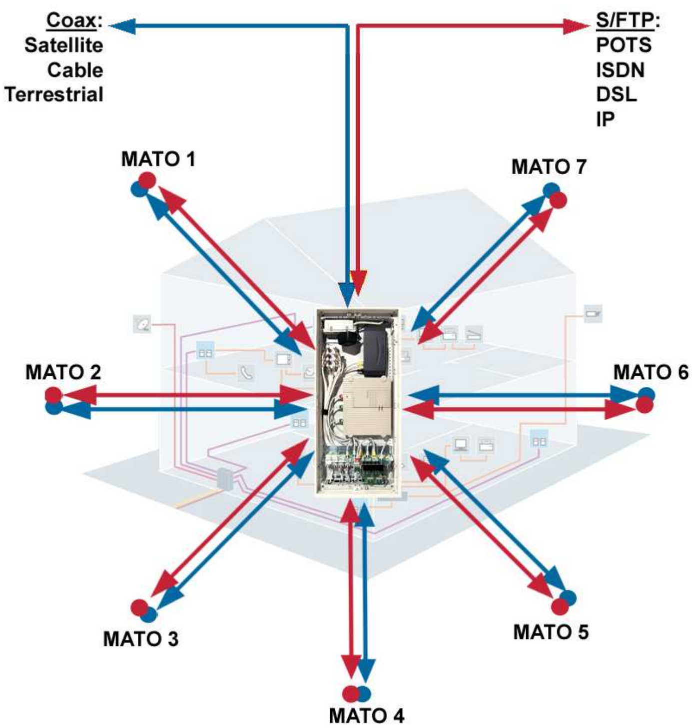

Fig. 4.2.1: Star configured cabling – the efficient way to construct the home network. Illustration: R&M, Karsten Jungk

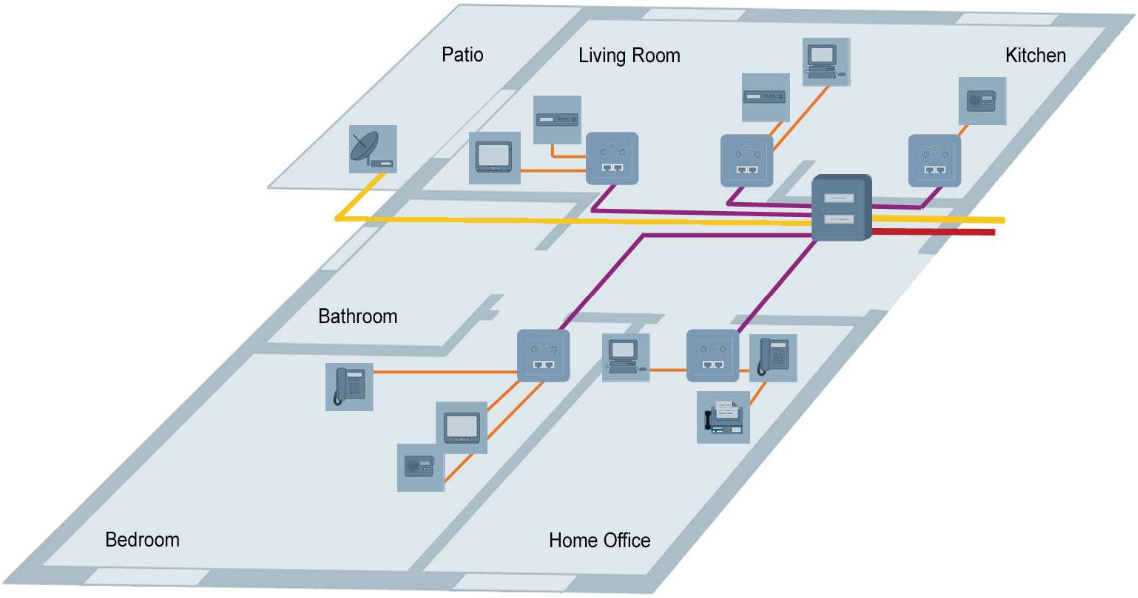

Fig. 4.2.2 shows an example of the floor plan of an apartment and how the home network could appear in practice. From the central communication distributor the star-configured cable looms comprising twisted pairs, coaxial and fiber optics runto the group of wall outlets (Fig. 4.2.3) or a combination socket (MATO). Each room is equipped with at least one outlet and bigger rooms with one for each 3.75 meter of wall length. If required a WLAN access point can be set up to obtain wireless access to the TCP/IP network via a laptop or PDA.

Fig. 4.2.3: Example of a group of sockets with (from left) Power, TO, MATO. Photo: R&M

4.3 Cable Sharing – Possible up to 100 Mbit/s

For Ethernet data rates of up to 100 Mbit/s only two twisted pairs are needed with two further pairs being available for telephony and other purposes. Cable sharing is the term used when a cable is able to support a number of different services. It must be possible to gain access to the required twisted pair at the subscriber socket – e.g. R&M's Multimedia Economy wall outlet. With RJ45 sockets a Y cable (splitter) is required at the input and output. This enables access to two twisted pairs for cables having a total of four twisted pairs.

Another approach to the use of the wires is provided by the new, easy to assemble plug & play solutions such as R&M's universal RMS45 microsplitter incorporated in RJ45 sockets (Fig. 4.3.1). The RMS45 converts an RJ45 socket into four terminals. There are also adapters and external splitters or outlets with solutions in the sockets, Tera connectors based on IEC 61076-3-104 or the EC-7 4-chamber system. Whilst this last solution displays sound technical properties it is not a manufacturer neutral solution in the same way as the RJ45 as it requires appropriately terminated cables. With R&M's RMS45, the patch cable connections can be terminated on site.

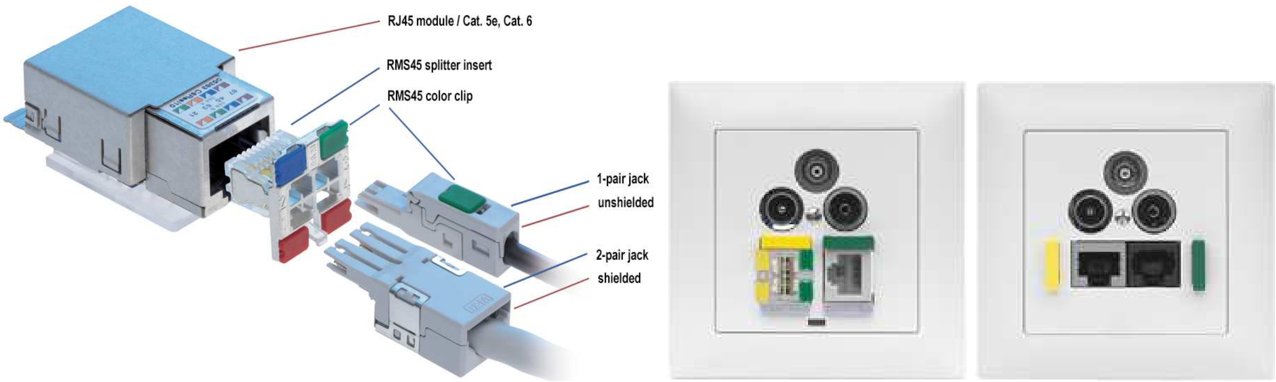

Fig. 4.3.1: Cable sharing with an RMS45 microsplitter (left) in the Freenet (middle) multimedia outlet. Up to four interfaces per RJ45 jack are possible and thus up to eleven applications per outlet if three cables are installed. The Multimedia Economy outlet (right) supports cable sharing in the socket (printer solution) and five applications with two cables. Illustration / Photos: R&M

4.4 The Choice of Location

As stated previously the siting of the HD in relationship to the cable should be chosen so that the length of the cable is kept as short as possible. This avoids unwanted attenuation and guarantees excellent signal quality at each subscriber outlet on the one hand, whilst making it easier to feed the cables through the empty conduits on the other. Because these requirements apply in the same context to power distribution it is sensible to choose the biggest possible meter and fuse box so that it can also accommodate the home distributor. Alternatively, the two boxes can be placed alongside one another.

This is particularly important considering that TP, coax and power cables are often fed to a socket group comprising a MATO, or single outlets with RJ45 (Ethernet), IEC (radio, TV, BC), WICLIC (cable modem) and F (satellite) terminals and Schuko sockets (Fig. 4.2.3). In cases such as these, the installation of empty conduits chased into a single wall opening saves time and is transparent.

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4.5 Functional Components

4.5.1 Home Distributor

The home distributor or communication distributor is the home network interface to telecom, BC and terrestrial or satellite signals. Ideally it should be dimensioned so that all the required devices can be accommodated centrally. These include:

- PABX with emergency power supply, DSL splitter
- Ethernet switch, modem, router
- Multiswitch for broadcasting via satellite
- Possibly a home relay amplifier and coax home distributor for broadcasting via BC
- Media server for music, movies and image files.

The illustrations in Fig. 4.5.1 show an excellent example of a wiring diagram and its use in practice.

In choosing and perusing media offerings, an increasing trend towards simple input and output devices (thin clients) is becoming evident. These so-called thin clients are devoid of storage capacity and lack processing intelligence. Instead, they obtain all the contents for reproduction over the data network from a central media server as a data stream (streaming media). Thus, in principle, receivers can be installed in the home distributor where they are supplied with high frequency or IP-based input signals. The clients request the desired program stream over the Ethernet and it is supplied accordingly. Should the media server be equipped with a hard disk it is possible to play the recording with a delay (time shifting) or at a later date.

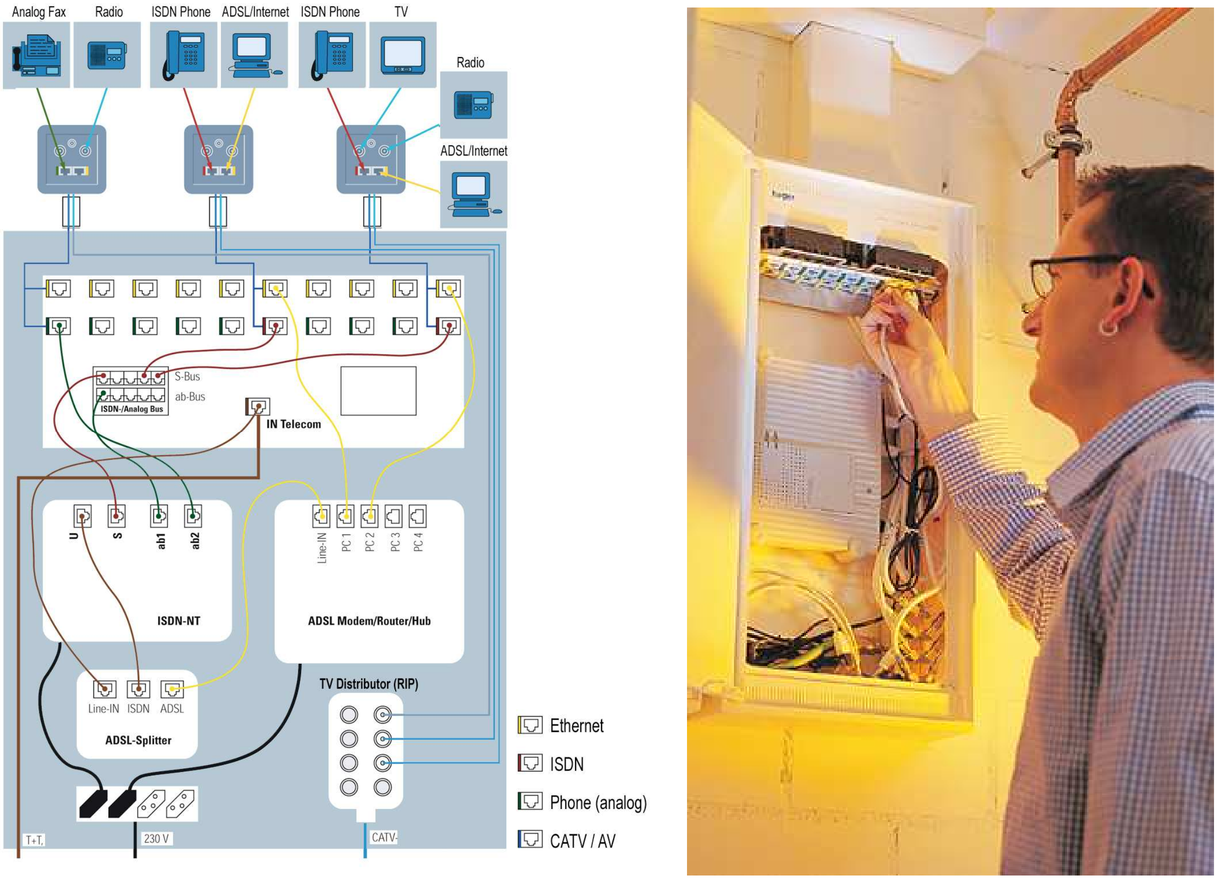

Fig. 4.5.1: Example of a wiring diagram for the practical use of the distributor (RIP = Residence Interconnection Point). Illustration & Photo: R&M

4.5.2 Twisted Pairs and Coaxial Cable

A transmission path is only as good as its weakest link. This means that all elements receiving a signal make a contribution towards the overall performance of the transmission path. Connectors, sockets, patch panels and cables make up a transmission channel which, depending on the cabling, may be of different lengths (Table 4.5.2).

Fig. 4.5.2.1 shows an example of an Ethernet channel: The transmission channel stretches from the connector socket in the terminal device via the device connecting cable with two RJ45 connectors to the wall outlet (TO), continues over the max. 90 m in length permanent cable path to the patch panel in the distributor and via a patch cable with two RJ45 connectors to the TC component, e.g. a router. The quality of the channel is ascertained by making a channel link measurement based on IEC 61935-1.

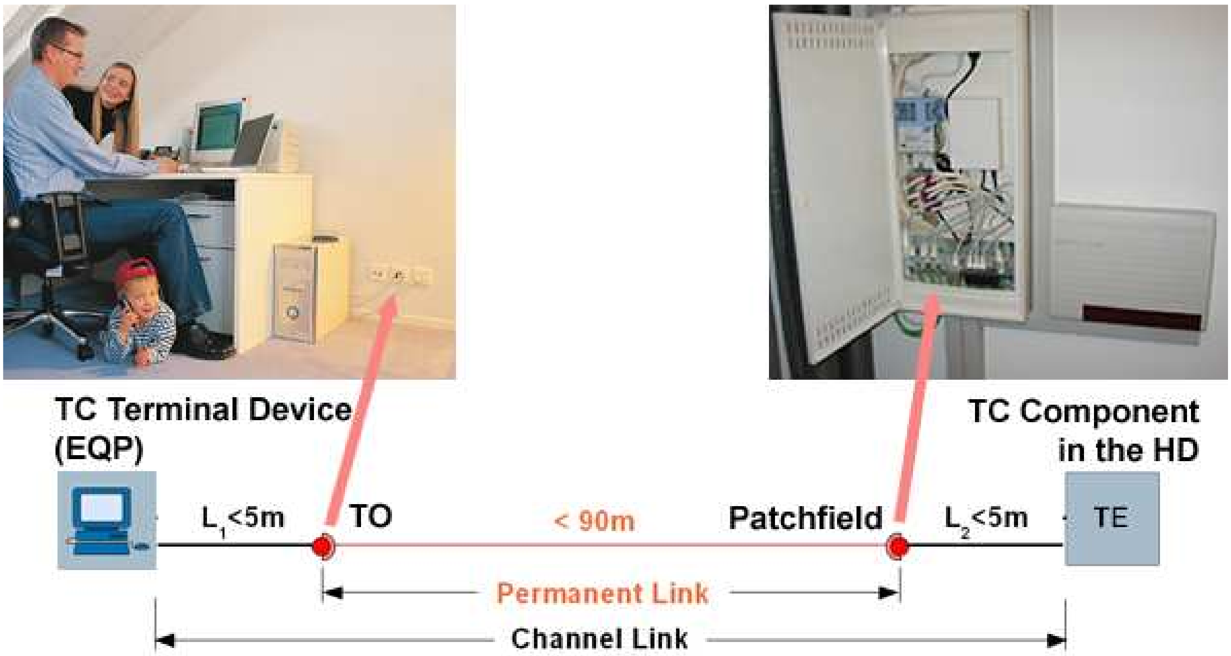

Fig. 4.5.2.1: With structured cabling for a local data and communication network the maximum length of the transmission path must be observed. Photos: R&M, Illustration: Karsten Jungk

Cabling	ICT sym. data cable	BCT sym. data cable	BCT coaxial cable
Topology	Star	Star	Bus, tree, star
Channel length	Up to 100 m	Up to 50 m	Up to 100 m
Frequency range	Up to 100 MHz (Cat. 5) Up to 250 MHz (Cat. 6) Up to 600 MHz (Cat. 7)	Up to 1.0 GHz	Up to 3.0 GHz
Channel class	Classes D, E, F	--	--

Table 4.5.2.: Standardized maximum lengths for different types of cabling

Twisted pair copper cables (Fig. 4.5.2.2), as used in generic home cabling, comprise four twisted and color coded pairs of cables (TP = Twisted Pair). In the shielded S/FTP version, each pair of cables is screened by a foil (F = Foiled). The twisted pair assembly is screened a second time either with aluminum foil or possibly copper braiding (S = Screened). This construction has also established itself under the common name PiMF (Pairs in Metal Foil). S/FTP cables based on Category 6 (Cat. 6) provide considerable reserves of bandwidth and are not prone to radio interference. Frequently, unscreened (UTP) and single screened (FTP) cables are used in the living area as they are generally considered to provide an adequate and reliable solution.

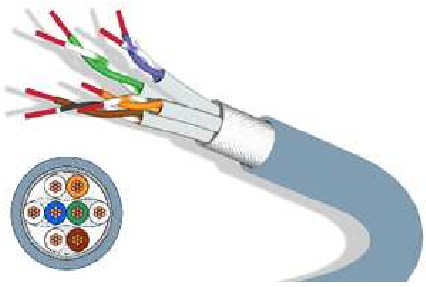

Fig. 4.5.2.2: Twisted pair cable with double screening for core pairs and twisted pair assembly (S/FTP). Illustration: R&M

With the help of Power-over-Ethernet adapters (PoE), the supply for the terminal device can be transported together with the data over the S/FTP cable in specific cases – e.g. for IP telephony and web cameras.

4.5.3 MATO: Wall Sockets for TC, Radio, IT

The MATO is a combination outlet for connecting S/FTP and coaxial cables. It replaces at least two single outlets. Fig. 4.5.3.1 shows the example of an outlet configured for cable modems (WICLIC, at the top), TV and radio (IEC male and female, middle) that also provides two additional RJ45 sockets (at the bottom) for IP and telephone connection. Up to five terminal devices can be connected to this R&M multimedia outlet. It complies with IEC 60603-7-X (telephone, LAN), IEC 61169-2 type 9.52 (radio) and 24 type F (sat.)

Fig. 4.5.3.1: Multimedia outlet with five sockets and terminals for twisted pair and coax cables. Photos: R&M

The technically more elegant solution is to accommodate the cable modem in the home distributor. On the subscriber side the Ethernet outlet is connected to an Ethernet switch whose ports supply the IP terminal devices. This reduces the ingress problem (unwanted noise in the uplink path) and out of band disturbance of the radio signals by the high level modem signal.

For new installations, and if there are no problems with regard to space, an empty blind socket should be planned in addition to the multimedia and Schuko sockets. This ensures that the building is equipped for the installation of additional cables or fiber optic waveguides. In this case the empty conduit must provide sufficient room.

The number of outlets depends upon the wall length of the room. One combination outlet should be planned for each 3.75 meters in length. This ensures convenient access regardless of how the room is furnished and equipped.

4.5.4 Fiber Optics

The prices of devices for data transmission based on fiber optics are tumbling. This means that optical transmission has become attractive for use in the home. Duplex-POF, (POF = Polymer Optical Fiber) is the preferred medium. In full duplex mode with an Ethernet media converter it is possible to transmit a fast Ethernet data rate of 100 Mbit/s (Fig. 4.5.4.1) over a distance of 50 m. Transmission rates of up to 1 Gbit/s are already feasible with POF cables.

Fig. 4.5.4.1: Media converters convert electrical signals into optical signals and vice versa. They are the link between copper and POF cables or between standard patch cables and an optical multimedia home network. Photo: R&M

The optical waveguide made of synthetic material is a powerful addition or alternative to coax, Cat. 5e, bus and wireless LAN. As the backbone in the home it is able to support broadband Internet, telecommunications, TV, home office, video surveillance and building automation services all at the same time. The technology is even suitable as a replacement for the twisted-pair copper cable in home cabling, not least because of the comparatively simple termination process.

Fig. 4.5.4.2: The SC-RJ POF can be terminated on site in just a few minutes. Photo: R&M

The approx. 1 mm thick POF cables – thinner than a standard twisted pair copper cable – can be terminated with very little effort (Fig. 4.5.4.3). They are cut to length with a straight cut from a POF cutter, razor blade or knife. A ferrule is placed on the end of the fiber which is then polished and inserted in a connector, e.g. in the SC-RJ POF, in just a few easy steps (Fig. 4.5.4.2). Some media converters enable the fiber to be inserted and firmly secured directly without the need for a connector. The polymer fiber is not very demanding and is resilient, durable, easy to handle and more flexible than optical fiber. It can easily be installed behind skirting boards, in old installation conduits or in conduits carrying high voltage cables. In contrast to copper cables, optical waveguides cannot be disturbed by electrical or magnetic fields; and there are no problems of potential differences.

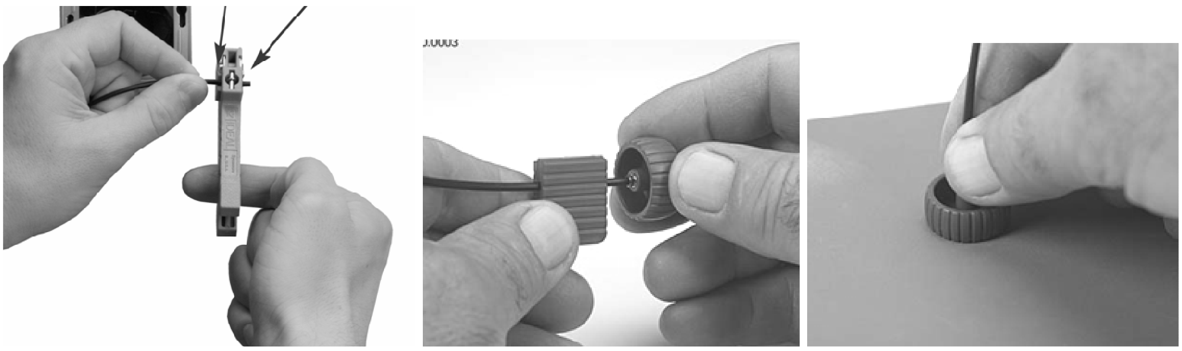

Fig. 4.5.4.3: Terminating POF connections – cut the fiber, screw on the ferrule, polish or sand the end of the fiber. Mount in the connector. Photo: R&M

One advantage of the POF solution is the fact that the required transmission method is determined by the choice of media converter. Changing from Ethernet to IEEE 1394 (FireWire, iLink) is accomplished by the use of two IEEE-1394 media converters instead of the Ethernet converters. With the increasing popularity of generic distribution systems it will not be very long until socket inserts are on the market with all the relevant media converters and at a reasonable price.

The transmission diodes in the media converters correspond to radiation class 1, i.e. the intensity of the light presents no danger to the human eye so that it is possible to check the direction of transmission or reception just by observing the diodes.

It is reasonable to assume that the price of optical transmission equipment will continue to fall whilst performance will increase. To design and construct a distribution system without giving thought to installing empty conduits for upgrading at a later date, therefore, would almost border on negligence. In future, the equipment in the home distributor, data switches in particular, feature optical ports (probably with a choice of transmission method). The same applies to the terminal devices which, today, can already be supplied with optical inputs and outputs.

In a situation where the fiber optic continues right up to the building (FTTB: Fiber to the Building) or to the home (FTTH: Fiber to the Home), a fiber node can be employed to create the interface between the optical external and wired internal system. In the longer term, if the requirements for bandwidth continue to increase as in the past, a fiber node with optical inputs and outputs and integrated electronics to convert and generate optical signals in both directions is conceivable. The conversion to a fully optical network would then be complete.

4.5.5 Wireless Subsystems

Wireless transmission systems in the home are already very common. One only has to think of the cordless phone based on the DECT standard, the outside sensor for the thermometer or weather station, the wireless baby phone, the cordless USB mouse, garage door opening equipment etc.

Ideally, wireless transmission systems combine a number of advantages, in particular their convenience, the mobile or nomadic use of terminal devices within the radio cell range, and the ability to upgrade them. One disadvantage is that the radio channel used is very unpredictable and in densely populated areas is subject to cross echo and frequently degraded performance. Even a person entering a room can result in distortion and have a negative impact on the radio field.

The following is recommended as a matter of principle: only resort to as much wireless transmission as necessary and as little as possible. The conversion of radio, TV and video into an IP stream makes it possible to obtain wireless access throughout the home to all services via a wireless LAN (WLAN). With corresponding data rates a number of TV programs in standard and HD resolution, radio, video and audio are available. With the current IEEE 802.11n standard, up to 720 Mbit/s should be possible under ideal conditions. That is a considerably higher data rate than is possible at the moment with the vast majority of wired LANs.

It should not be forgotten, however, that frequencies are becoming scarce and wireless communications are prone to hackers and not particularly robust, i.e. the transmission rates depend on constraints such as signal strength, utilization of the frequency band by other users, electrical interference etc. In big houses, in particular, or if there are a number of floor levels, several WLAN antennae may have to be positioned – with the associated cabling infrastructure.

Thus in spite of the numerous wireless alternatives, the wired generic network is by no means a thing of the past. Rather, it provides the ideal conditions to set up wireless applications so that by choosing the correct siting of the access points (AP, interface between the wireless and wired network) maximum efficiency is assured. If access to the generic network is provided every 3.75 meters, as specified in the norms, low power wireless subsystems can be implemented, which are then less likely to interfere with other wireless subsystems in the neighborhood.

For universal deployment of the next generation of broadband wireless communication technologies at local level (UWB = Ultra Wide Band, also referred to as Wireless USB), extensive cabling of the living area is a basic precondition. Even the aspiring femtocell technology, where a miniature mobile radio cell in the user's local surroundings allows cell phones to be used for making cheap calls, can be optimally implemented in existing multimedia generic cabling.

5 Measure, Control and Regulate (CCCB)

Monitoring and security applications are to be understood in the context of EN 50173-4 as a CCCB subset (Control/Command Communications in Buildings) (Figs. 3.1.2.1 and 3.1.3.2). There are a number of proprietary systems on the market to fulfill these tasks including intrusion detection, entry controls, fire detection, water or gas pipe fractures etc. Each of these tasks can be approached with a wide variety of technologies that mostly employ the use of sensor signals for analysis purposes (passive IR sensors, smoke detectors, ultra-sound sensors, glass breakage sensors, water or gas sensors, microphone, cameras, etc.).

Bus, tree and star topology cabling structures are permitted although sensors and actuators should be firmly secured (no plug-in connections). The site of the home distributor is the obvious place to arrange the equipment and, wherever possible, process some of the tasks over the TCP/IP network (Ethernet). This is particularly sensible for surveillance with a camera and microphone. IP-based high-resolution CCTV with integrated microphone and supplied with power over the Ethernet (PoE: Power over Ethernet) can easily be integrated in the network. Password-protected administration of the cameras can be undertaken via any web browser and from any location and recordings of alarm sequences stored on hard disks connected to the network (NAS: Network Attached Storage) or on the media server. In principle, the communication of events and their transmission throughout the world wide web is entirely feasible.

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6 Conclusions and Recommendations

The technical transformation in consumer electronics, media, information, communication and building services together with the requirements for comfort in the home place considerable demands on the performance and structure of home cabling. Based on the new EN 50173-1 and -4 standards and taking account of the appropriate, state-of-the-art cabling solutions, planners and technicians are able to fulfill requirements flexibly with an eye to the future. The principle of generic, structured cabling facilitates the integration of a plethora of technologies, systems and devices. As far as passive infrastructure and cabling are concerned, nothing stands in the way of the wide-ranging use of multimedia, digital lifestyle and "intelligent living." A property will be all the more valuable if it is equipped with a sophisticated home network.

When planning new buildings or renovations consideration should be given to the following points:
- Current and future networking requirements of the residents
- Structured cabling based on EN 50173-1 and -4
- Layout and diameter of empty conduits
- Capacity of the communication distributor
- Number and siting of the wall outlets
- Universally usable and compatible connection technology (RJ45, coax)
- Home services to be provided: telephone, xDSL, FTTx, Sat, CATV with/without Internet access
- Structure and regulation of the utilities (heating, air conditioning, light, security etc.)
- Protection from electromagnetic fields

7 Further Links and Sources

Footnotes for chapter 1

1) Jason E. Squire: Movie Business Book. Cologne: Könemann, 1995, P. 491
2) http://www.media.mit.edu/people/bio_nicholas.html
3) Convergence or divergence? Consumer expectations and preferences regarding the telecommunications and media offerings of tomorrow (German only) http://www-935.ibm.com/services/de/bcs/html/konvergenz_divergenz.html

Other sources

- Home Electronic System Standards (HES) Organisation
  ISO/IEC JTC1 SC25 WG1 http://hes-standards.org
  with document register http://hes-standards.org/document_register.html
- *Gebäude-Netzwerk-Institut Zürich* http://www.g-n-i.ch
- *Initiative Smarter Wohnen NRW* http://www.smarterwohnen.net
- *Initiative Intelligentes Wohnen* http://www.intelligenteswohnen.com
- *Das intelligente Haus* http://www.das-intelligente-haus.de
- *POF Application Center Nürnberg* (www.pofac.de
- *Multimediales Wohnen* http://www.multimedialeswohnen.at
- *Project Futurelife Hünenberg* http://www.futurelife.ch
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- http://de.wikipedia.org/wiki/Gebäudeautomation
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Abbreviations

AAC	Advanced Audio Coding
ACP	Area Connection Point
AP	Access Point
A/V	Audio Video
BACnet	Building Automation and Control Network
BALUN	BALanced UNbalanced
BCT	Broadcast Communications Technology
BEF	Building Entrance Facility
BC	Broadband cable
BO	Broadcast Outlet
CCCB	Control/Command Communications in Buildings
CO	Control Outlet
DECT	Digital European Cordless Telephone
DIN	German Industrial Standard
DSL	Digital Subscriber Line
DVB-C	Digital Video Broadcasting–Cable,
DVB-S	Digital Video Broadcasting–Satellite,
DVB-T	Digital Video Broadcasting–Terrestrial,
EIB	European Installation Bus
EN	European Norm
ENI	External Network Interface
FD	Floor Distributor
FTP	Foiled Twisted Pair
FTTB	Fiber To The Building
FTTH	Fiber To The Home
GA	Building Automation
HD	(primary) Home Distributor, High Definition
HDTV	High Definition Television
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
IP-TV	TV via Internet Protocol
IR	Infra Red
ISO	International Standards Organization
IT	Information Technology
JPEG	Joint Photographic Experts Group
KNX	Konnex Association Bus Standard based on EIB and EN 50090
LAN	Local Area Network
LCN	Local Control Network
LON	Local Operating Network
MATO	Multi Application Telecommunications Outlet
MIT	Massachusetts Institute of Technology
Modem	Modulator demodulator
MPEG	Moving Pictures Experts Group
MP3	MPEG-1 Audio Layer 3 (audio-compression format)
NAS	Network Attached Storage
NTBA	Network Termination (for ISDN) Basic (rate) Access
PDA	Personal Digital Assistant (Handheld)
PHD	Primary Home Distributor
PoE	Power over Ethernet
POF	Polymer Optical Fiber
RA	Radio outlet
QoS	Quality of Service
POTS	Plain Old Telephone Service
RJ	Registered Jack (standard jack, e.g. RJ-11, RJ-45)
SHD	Secondary Home Distributor
S/STP	Screened Shielded Twisted Pair
TAE	Telephone Socket
TCP/IP	Transmission Control Protocol / Internet Protocol
TN-S	Terre Neutre Separé (separation of ground and neutral)
TO	Telecommunications Outlet
TP	Twisted Pair Triple Play: Internet, telephony and TV via one access network
TV	Television
USB	Universal Serial Bus
UTP	Unshielded Twisted Pair
UWB	Ultra Wide Band
VoD	Video on Demand
VoIP	Voice over IP (telephony via Internet)
WLAN	Wireless Local Area Network
WWW	World Wide Web

The main cable categories and link classes for twisted pair copper cables

Cable category 3 (Cat 3)	Up to 16 MHz	Voice communications
Cable category 5 (Cat 5)	Up to 100 MHz	Data transmission and voice communications
Cable category 6 (Cat 6)	Up to 250 MHz	Fast data transmission
Cable category 7 (Cat 7)	Up to 600 MHz	Very fast data transmission, BC
Link class D (Class D)	Up to 100 MHz	All current services
Link class E (Class E)	Up to 250 MHz	With reserves for the future
Link class F (Class F)	Up to 600 MHz	With enormous reserves for the future

Relationship of additional, relevant standards

Cabling Design	**Specification**	**Installation**	**Operation**
EN 50173-4	**EN 50174-1**	**EN 50174-2**	**EN 50174-1**
4 and 5: Structure 6: Channel quality Requirements for: 8: Cables 9: Connectors 10: Patch cables A: Link quality	4: Specification considerations for installations 5: Quality assurance Requirements for fitters	5: General installation practices 6: Additional installation practices for data and power circuits	4: Requirements for the specification of installations
	Planning	**and** **EN 50346**	
	EN 50174-2 4: Safety requirements 6: Additional installation practices for data and power circuits	4: General requirements 5: Test parameters for balanced copper cabling	