

PROVISIONAL APPLICATION COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION under 37 C.F.R. 1.53 (b) (2).

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INVENTOR(s)/APPLICANT(s)							
Name (last, first, middle initial)				RESIDENCE (CITY, AND EITHER STATE OR FOREIGN COUNTRY)			
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TITLE OF THE INVENTION (280 characters max)							
SYSTEM AND METHOD FOR COMMUNICATION OVER TV CABLES							
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ENCLOSED APPLICATION PARTS (check all that apply)							
XXX	Specification	Number of Pages	54		Small Entity Statement		
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

XXX No.

Yes, the name of the U.S. Government agency and the Government contract number are: _____

Respectfully submitted,

SIGNATURE Daniel J. Kluth

Date April 12, 1999

TYPED OR PRINTED NAME Daniel J. Kluth

REGISTRATION NO. 32,146

Additional inventors are being named on separately numbered sheets attached hereto.

PROVISIONAL APPLICATION FILING ONLY

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPRO

In re **PROVISIONAL** Patent Application of: Mati Amit et al.

Title: SYSTEM AND METHOD FOR COMMUNICATION OVER TV CABLES

Patent No.: 299.024PRV

04/12/99



PROVISIONAL APPLICATION

Assistant Commissioner for Patents
Washington, D.C. 20231

We are transmitting herewith the following attached items (as indicated with an "X"):

- X A PROVISIONAL Patent Application comprising:
- X Specification (54 pgs.)
- X A check in the amount of \$150.00 to cover the Provisional Filing Fee.
- X Provisional Application Cover Sheet (1 page).
- X A return postcard.

Please charge any additional required fees or credit overpayment to Deposit Account No. 19-0743.

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CERTIFICATE UNDER 37 CFR 1.10:

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I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Attn: BOX PROVISIONAL APPLICATION, Washington, D.C. 20231.

By: Chris Hammond
Name: Chris Hammond
(NEW FILING)

System and Method for Communication Over TV Cables

Abstract

The invention is a system and method for communication between subscribers' devices over cable infra-structure designed to carry video signals, using pass-band frequency bands, without transmission through a CATV headend device. A particular application of this system and method is home networking over coaxial TV cables. The disclosed system will allow very high speed digital and analog communications within the home and from the home outside using low cost devices.

Background

Home networking is a key technology for the evolving home infotainment market, and it is expected to become a very large market by itself within the next decade. Home networks will connect between computing devices (personal computers, palm computers, network computers, etc.), entertainment devices (TV, VCR, DVD player, video camera, audio systems, etc.), I/O devices (printer, scanner, head-sets, keyboards, remote controls, mouse, loud-speakers, etc.), home appliances, and modems (such as cable modems, DSL modems, and PSTN modems) that connect the home outside. The home network will enable a wide range of application such as internet sharing, peripheral sharing, file and application sharing, and home automation (see section 2.1 part II of the patent).

The home network will distribute the computation power of the computer from the study room to the living rooms.

There are several home networking solutions that have already been proposed (see section 2.5 in part II), including networking over the existing telephone wiring (e.g. HomePNA), networking over the existing power lines, short range wireless networks (Bluetooth), medium range wireless networks (e.g. HomeRF, IEEE802.11), and solutions that require new wiring, such as IEEE1394 (I.LINK) or CAT 5 Ethernet wiring.

In many, if not most, of US residential homes, there are several TV inlets, connected by coaxial (coax) cables to either a municipal CATV network, or to a TV antenna. The coax cable is an excellent communication medium, as it has a high bandwidth and it is shielded to noise. This patent is a method and system which allows home networking over these coaxial cables, allowing very high data rates and low cost implementation. We denote the proposed method by the name Home Coaxial Network (HomeCN).

In prior art (e.g. the DOCSIS 1.0 spec) CATV infra-structure is utilized for communication between the subscribers' devices (e.g. cable modem) and a headend, thus, two subscribers' devices can communicate via the headend. The disclosed system and method is based on direct communications between two subscribers' devices, without transferring the data via a headend, and thus allows high data rates between home units without reducing the capacity of the regional CATV network.

In prior art, coaxial cables have been used for local area networks (LAN) and for analog communications. The disclosed system and method is designed for cable

networks that carry video, or other information, from a headend or an antenna, and thus it is different from prior art LAN over coaxial cables. Furthermore, the disclosed method is using a new digital modulation scheme based on pass-band RF signaling, which is fundamentally different than prior art LAN and analog modulation over coaxial cables.

Summary of key principles

The proposed system and method is described in depth in part II of the patent. A summary of some of the key principles of the disclosed system and method is given below.

1. Subscribers' devices are communicating directly (not via the headend) using RF signaling over the coax cable. These signals will typically propagate between the devices via reflections from e.g. splitters or amplifiers in the line.
2. When the home coaxial cables are connected to a regional CATV network, the signaling is done in out-of-band frequency (i.e. band that is not in use, e.g. above 860 MHz), or in part of the downstream band (e.g., within the range of 100-860 MHz) which is allocated (e.g. by the cable operator) for home networking applications.
3. When the home coaxial cables are connected to a regional CATV network, there is frequency re-use between portions of the CATV plants (i.e. same frequency range is allocated to different users in a CATV plant), taking into account the isolation between those users due to the attenuation of the cable plant.

4. The frequency re-use can be improved by adding filters within the signal path in the regional CATV network. The quality of the signal transmitted by one subscriber device to another subscriber device can be further improved by deliberately using splitters with high reflections.
5. The home devices may also be capable of connecting to the headend, e.g. operate as a DOCSIS or DVB cable modem or set-top box, either simultaneously with connecting to other devices at the home, or in alternation mode in which the devices switches between cable modem functionality and connecting to the other home devices. Parts of the devices that are capable of connecting to a headend can be used for both home networking and for cable modem functionality, thus reducing the implementation cost of the home networking functionality. We particularly propose a low cost architecture in which the home network includes only one device which can operate both as a cable modem and as a home networking device. In this architecture, all the other devices can communicate only over the home network, and if one of these devices need to communicate outside the home it is communicating via the device with the cable modem functionality. We also propose that the home networking functionality will be implemented in cable modems, and particularly in host-based cable modems, which are installed in personal computers and are using the processor of the personal computer to perform some of the functionality of the cable modem and the home cable networking. More generally, we propose that the home networking devices will be installed in various kinds of devices that employ general purpose computers (such as a palm computer or a network computer or even certain cellular phones), and use their general purpose processors to perform home networking functionality, thus reducing the implementation cost of the home networking functionality.
6. In a particular implementation of the method, when the home coaxial cables are connected to a regional CATV network, each home device is addressing

the headend, and the headend is assigning carrier frequency, and bandwidth to each home network, and power levels to each device. In another implementation of the method, the devices are searching for a non occupied frequency sub-band within a band that is pre-assigned for home networking, and once such a sub-band is found they take for their needs. When a home CN device is initialized it is trying to "join its home network", that is trying to communicate with other devices in the same home and adopt their frequency band and protocol.

7. In a particular implementation of the method, the devices that share a home network are using a TDMA protocol. The line access protocol in this network may be a token ring protocol, wherein devices with higher priority which are sensitive to delay may receive the token which gives access to the line more frequently than lower priority devices. In another implementation, a collision sense multiple access protocol is used, wherein devices with higher priority which are sensitive to delay may wait a shorter period of silence before they start transmitting, compared with lower priority devices.
8. In a particular form of the patent, the splitter at the input to the user premises is replaced by a device that receives signals from a TV antenna or a regional CATV network and receives signals from subscribers' devices via the home coax lines, and functions as a repeater for communications signals between subscribers' devices as well as between subscribers' devices to a headend (in case the home is connected to a regional CATV network), while still allowing transparent transition of video signals from the TV antenna or the regional CATV network into the home.
9. In a particular form of the patent, the home coax network is connecting portions of the home (e.g. rooms or floors), and its terminals have inputs and outputs for wireless connections within these portions.

10. In a particular application of the patent, home CN devices has interface to another communication link, such as IEEE1394 link (I.LINK), thus the home coax network is used to extend the range of the other link.

11. In cases where direct communications between home devices is not feasible (e.g. due to highly balanced splitter that has very low reflections), the home devices may have a fallback option of communicating via a regional CATV headend.

12. The data transmitted in the coax home network may be secured (i.e. encrypted)

Comment:

- “home network” means “local network” – it does not necessarily have to be at a home. For example it can be at an office, or at a complex that contains several homes (e.g. an apartment building).

Example of a Preferred Embodiments

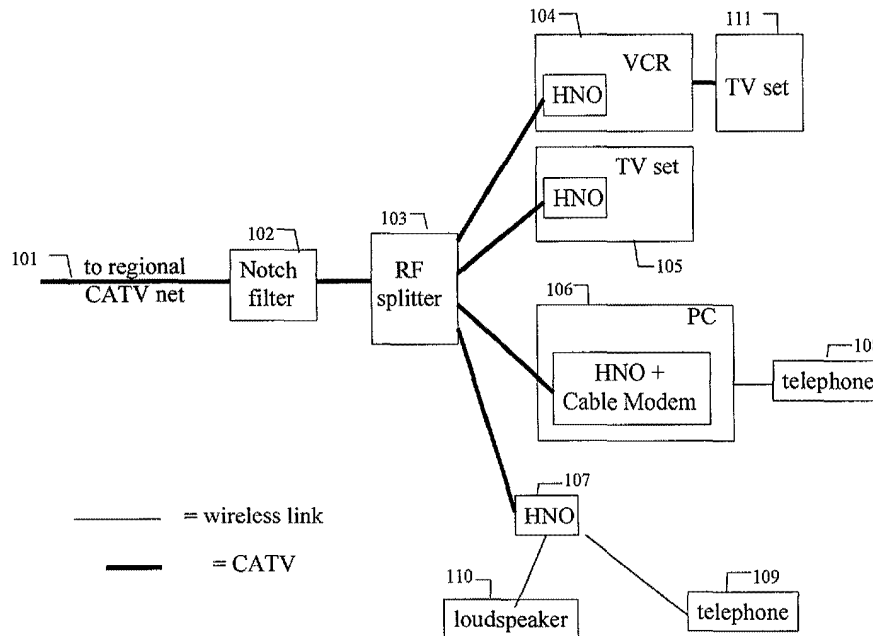


Figure 1 – HomeCN within a regional CATV network

Figure 1 above shows an example of a preferred embodiment of the disclosed method and system. A wider class of examples and embodiments of the disclosed patent are shown in part II.

Figure 1 shows a home that has 4 nodes of the CATV network, and it is connected to the regional CATV plants via cable 101. Notch filter 102, is a band reject filter that does not pass a certain RF range that is used by the home networking devices 104, 105, 106 and 107. This filter improves the isolation between the home network and other homes as well as the regional network. However, the use of such a filter is optional, as we believe that the disclosed system and method is functional with the isolation levels of the CATV network without the additional notch filtering 102. RF splitter 103 splits the signal coming from and to the regional CATV plant 101, to the signals coming to and from units 104-107

respectively. The signals arriving to RF splitter 103 from units 104-107 are partially reflected back to units 104-107. It may be recommended to use splitters that deliberately have high reflection levels (although we believe that the method and system can operate with typical commercial splitters). Units 104 and 105 are Video Cassette Recorder (VCR) and TV set that include Home Networking Only (HNO) devices. Unit 106 is a Personal Computer (PC) that includes a Home Networking +Cable Modem (HNO+CM) device. Unit 107 is an HNO that is connected to the CATV and has a wireless output (e.g. Bluetooth or infra-red) which connects to devices within the vicinity of the device 107, such as wireless telephone unit 109 and wireless loudspeaker 110). The HNO devices are capable of transmitting and receiving digital communications signals between them. These signals propagate in the CATV wires and are reflected by the RF splitter 103. The HNO+CM device is further capable of operating as a DOCSIS cable modem and communicating with a headend of a regional CATV plant 101. The HNO's and the HNO+CM are using TDMA access protocol, that can be either a token ring or a collision sense protocol (see

We note that the method and system will still be capable to perform home networking if the home coaxial wiring is not connected to a regional CAT plant 101, but connected to TV antenna, or even dis-connected. However, in such cases the home network will not allow the capability of connecting the home outside through the CATV, as done by unit 106.

Part II – Detailed Description

1. Summary of the Invention

The present invention provides home networking solutions that utilize the in-home TV wiring, supplying high rate connectivity between any two home networking nodes. The presented solution does not load the city cable TV (CATV) network.

The present invention enables installation of modems, connected to different types of nodes of the CATV; to enable communication between these nodes.

The presented invention presents solution of transferring the data between these nodes, when the data is not required to be transferred to the headend.

The presented invention presents a low cost solution, which is very importance to enable solution to the mass market.

2. Background of the invention

2.1. The need for home networking

While Local Area Networks (LANs) constitute a well-accepted part of the communications environment for businesses, LANs infrastructure is not commonly deployed in the home. This is due to several technical and logistical reasons.

The major driving force behind creating new home connectivity products is the growing number of homes with two or more PCs.

In the prior art, home networking systems are designed using the existing copper-based (twisted pair) wiring or using wireless solutions. The present invention seeks to provide system and apparatus for designing home networking over the in-home TV wiring, used to connect the antenna or the cable TV to the TV sets in the home.

The following key applications drive the demand for home networking:

- **Internet Sharing**

Sharing simultaneous access to the Internet is a major driving factor for home networking. Today, when multiple home users want to enjoy Internet access without constraint, separate telephone lines and Internet accounts are required. Since this is costly, multiple users are typically restricted to using the Internet one individual at a time. Home networks can deliver significant savings and greater utility by enabling shared access to a single Internet connection. The need for this shared access will grow as today's 28.8K, 33.6K, and 56K analog connections are replaced by higher-speed "always-on" connections such as cable modem, Universal ADSL, ADSL, or satellite. Standardizing on a high-speed local-area home network interface insulates installed home networked devices from changes in Internet access technologies.

- **Peripheral Sharing**

Today, in a home with multiple PCs, each computer needs a duplicate set of peripherals, such as printers or scanners. With a home network, the limited budget can optimize for one higher-end shared peripheral rather than many low performance units. With a network standard for

the home, future peripherals can be designed to connect directly to the network, simplifying installation.

- **File and Application Sharing**

Multiple users can easily share applications, move files, or back up data, saving time and money. Automatic software updates are enabled by a network connection.

Other applications enabled by home networking:

- **Entertainment**

Easy-to-use home networks will also enable popular multi-player network games, either within the home or over the Internet.

- **Home Automation**

A ubiquitous, easy-to-install home network will also foster home automation applications, such as environmental control and security systems.

- **Voice and Video over IP**

New digital voice and video services are being introduced into the home. All these digital services—whether data, voice, or video—need to be accessible anywhere in the home by any device. All digital devices, including PCs, digital televisions, and digital telephones, will require a high-speed connection to the home network.

2.2. The market today

Today, it is estimated that over 15 million of the 100 million homes in the United States have two or more PCs, and 60% of new consumer PC purchases are by families that already have at least one computer. This number is expected to double by the year 2000¹.

2.3. Home Networking Challenge

¹ According to the research firm *Dataquest*

Chief among these is the fact that the widely adopted and supported enterprise networking technologies require a technically skilled individual capable of designing and maintaining complex network architecture. Enterprise networks also require the use of high-grade wiring typically not found in most homes.

Also, few home users are willing to master the art of installing and maintaining an Ethernet repeater, learn even the basics about network protocols, or drill holes through their walls to run new network-capable wiring throughout their home.

2.4. Home Networking Requirements

Success in the consumer market requires that a home networking technology be inexpensive, easy to install, and easy to use. To be truly effective and embraced by consumers, a home networking solution must meet these criteria:

1. No new wiring.

Most existing homes are not wired for traditional networking equipment. Rewiring the home is too expensive and a hassle for most consumers.

2. Simple to install and use.
3. Must be low cost to allow the mass market to enjoy the benefits of home networking.
4. The range must be adequate to operate within a typical home.
5. Support high-speed data rates.
6. The networking capability must grow with user applications without obsoleting existing devices.
7. The network must be secure.
The network data must remain private; it must not be accessible to neighbors or anyone outside the home.
8. The solution must not interfere with other systems, appliances and services.

2.5. Prior Art Home Networking Technologies

2.5.1. Existing Telephone wiring (HomePNA)

These solutions generally allow ordinary voice telephone calls to be carried over the wire, while at the same time providing up to several megabits of data throughput. Because the existing telephony wiring is already in place, these solutions may provide an extremely easy and cost-effective way to create a data network in the home. Some solutions require installing some sort of gateway where the Public Service Telephone Network (PSTN) interfaces with the wiring in the house. However, this gateway can also serve as a Voice-over-IP (VoIP) telephony gateway.

2.5.2. Existing electrical wiring (Power lines)

It is also possible to use the normal AC electrical wiring in the home for data transmission. Electrical wiring has been used in the past for low bit-rate data applications (e.g. home automation). Technologies for achieving multi megabit throughput on existing residential electrical wiring are under investigation in the industry. However, this approach has significant challenges, given that electrical wiring is not designed for data transmission. Also, a privacy concern exists here, as multiple homes are generally served off the same electrical transformer. Appropriate encryption will need to be deployed with these solutions. Because the electrical wiring is the most ubiquitous in the home and because virtually every digital device in the home connects to the electrical wiring, it would seem to be one of the easiest ways to create a data network in the home.

2.5.3. Wireless (Short-range wireless; Bluetooth; HomeRF)

Such technologies provide several megabits of throughput; however, their effectiveness can vary, depending on the size of the house, the proximity of other wireless networks, and other sources of noise.

These technologies are based on IEEE 802.11 – wireless LAN.

2.5.4. Fire-wire - IEEE 1394 (i.LINK)

The IEEE 1394 standard defines a serial interface between digital devices. This inexpensive, easy-to-use and high-speed bus handles multimedia bandwidth requirements and provides a universal interface for a variety of devices. By allowing seamless data exchange between devices such as workstations, personal computers and digital televisions, VCRs, camcorders and set-top boxes, it enables a new generation of computers and consumer electronic devices to operate in a common environment.

Originally developed as an interface to replace SCSI, IEEE 1394 offers bi-directionality, high data transfer rates and isochronous data transfers. It provides "hot plug" capability i.e. the ability to connect or disconnect equipment with the power on. It also enables devices that require audio, video and control signals to be connected with a single cable.

The fire-wire technology required special wires. The range between two adjacent components is limited, therefore, it required amplifiers to supply the connectivity in house.

Note:

- Industry analysts predict a surge in IEEE 1394 product shipments and expect the market to grow from less than 2 million devices in 1997 to more than 460 million by 2011.

2.5.5. Category 5 twisted pair

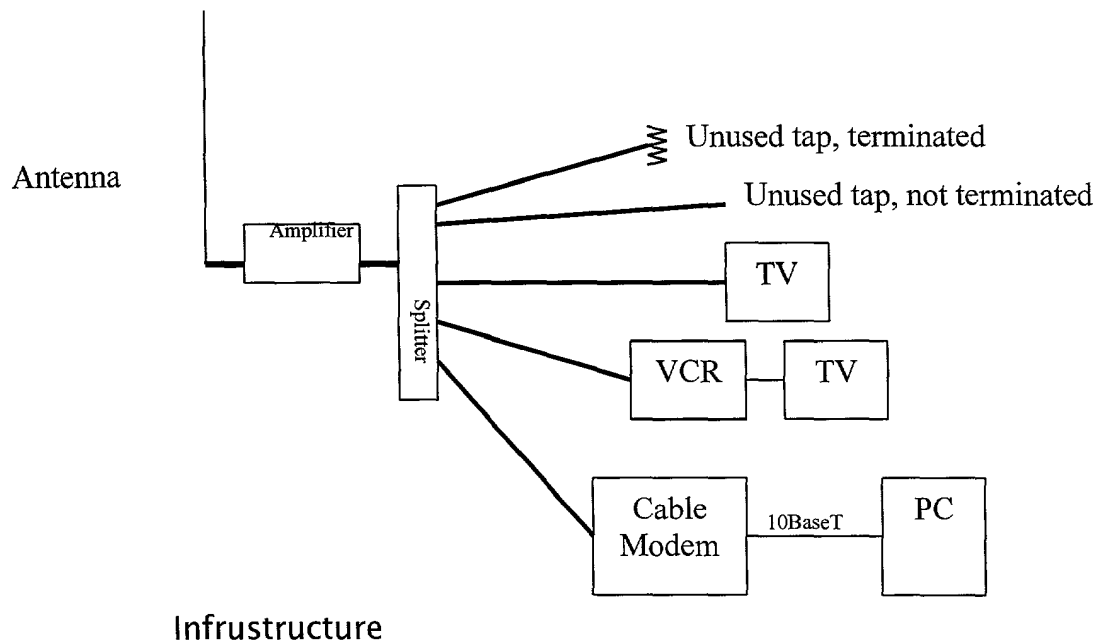
For new homes, it is anticipated that standard Category 5 wiring can supplement twisted-pair telephone wiring. The added cost of including this extra wiring is low and the benefits reaped can be great, because 100BaseT and other high-speed network types work well over this cable.

2.6. Existing TV Wiring

2.6.1. Availability

TV wiring that consist of coaxial cables are used to connect the antenna/cable TV output, typically via passive splitters, to the cable outlets at specific points in the home. A typical home TV wiring scenario is depicted in Figure 1.

Figure 2: TV Wiring at home – Connected to Cable



2.6.2. Usage

The signals transmitted over the in-home TV wiring may include regular video channels, data channels for fast Internet access (using e.g., DOCSIS cable modem), voice channels for telephony over cable, pay-per-view, control signals and more.

2.6.3. Home Networking Using Existing TV Wiring

Technically, to use the in-home TV wiring for home networking applications, one may connect standard cable modems through the cable TV (CATV) system. Data from one cable modem can be transmitted to the other cable modem via the CATV head-end.

Such configuration has several drawbacks:

- It loads the system, possibly above the system capacity.

- It introduces large delays that can not be tolerated by at least some of the applications.

Therefore the cable operators will not adopt such configuration.

It should be noted that a cable modem could be used to connect any type of home networking system to external (out of the home) networks, such as the Internet.

On the other hand the home networking solution can be built at home that does not connect to the cable infrastructure (i.e. a home that connected to standard home antenna).

Home Networking Using Cable Infrastructure

3. Invention Description

3.1. Required Key Feature

Requirements:

1. The home networking equipment coexists with the other services on the cable network. In particular,

It is spectrally aligned with any combination of television and other signals in the cables; and

It does not cause harmful interference to any other services that are assigned to the cable network in spectrum outside of that allocated to the home networking. Therefore,

- The solution should not interfere with the TV/video channels.
- The solution should not interfere with any cable modem channels.

2. Answer to the general home networking requirements.
3. Verify that the technology does not limit the number of cable modems or the number of home networking modems. Due to using HNCM technology, each home will include more than a single CM. It is required that the cable headend will support the increased amount of CM's. For example DOCSIS protocol can support high quantity of CM's (up to 8,000 CM's for a MAC chip) in particular DOCSIS1.1.
4. The Home Networking (HN) is required to supply a scaleable bandwidth range (100Kb-10Mb and more).
5. The number of nodes that are connected to the home network should not be limited by the presented solution. The only limitation should be the identification method in layer two (e.g. the limitation of using MAC address).
6. The connection method and the connection rate from home to the Internet using any technology (e.g. xDSL, cable modem) should not be influenced by the home networking technology.

The only difference may be the ability to use this Internet connection for central

management.

For example, the Ethernet protocol, as a home networking protocol, answers this requirement. It does not create any limitations to the protocol that is used for connecting the home to the Internet. The HomePNA is a home networking protocol that adds limitations and does not answer this requirement. HomePNA enables the G.Lite protocol to be used for connecting the home to the Internet, but it does not enable the use of ADSL (10Mbps) or VDSL protocols because it uses the same medium (phone line) and the same frequencies.

7. The ability to create a component that supplies the functionality of home networking and the functionality of connection to the Internet.

Objective:

1. The ability to create a component that supplies the functionality of home networking and does not supply the functionality of connection to the Internet.
2. Home Networking might be able to operate without connection to the headend.
3. An important point is to define this protocol to use limited “cable” resources. It should not use the limited US (up stream) frequencies. It can use some of the DS (down stream) frequencies or higher frequencies (even if their distance is limited).

3.2. Home Networking Using Cable Infrastructure

3.2.1. The Infrastructure: TV Cable

The infrastructure that is going to be used in our solution is the TV Cable infrastructure.

There are some advantages in using this infrastructure:

- No new wiring is required. Usually there are some ports of the TV cable in each home. These ports are usually located in the appropriate location, because one of the major aspects of home networking is to connect your TV environment (that already has some interfaces to the cable infrastructure) to the computer environment (that already has an interface for the current cable modem).
- The capacity of data that can be transferred using this infrastructure is very high (Order of Gbps).

- There is no radiation. Wire radiation is very low, in particular Coax wire radiation is negligible. Compared to wireless solutions this point is of great importance.

The coax cables are also not sensitive to external radiation.

The TV cable can supply wide spectrum connectivity. Therefore, it can be used to transfer some group of channels simultaneously. Our solution is based on adding a specific channel for home networking.

The definition of the home networking channel and the design consideration (that presents the different alternatives for this channel) are described in this section.

3.2.2. The Apparatus

The apparatus described by this invention is a modem similar to a cable modem equipment that are now being deployed in the US and elsewhere with home networking capabilities. For the purpose of this invention such apparatus is identified by HNCM - Home Networking Cable Modem.

A reduced cost apparatus that supplies home networking" capabilities only is also made part of this invention, and it is identified by HNO - Home Networking Only.

Both apparatus implement the Home Networking Cable Modem Protocol (HNCMP).

The HNCM is a cable modem that implements the standard cable modem requirements (e.g. DOCSIS or DAVIC requirements) and in addition it implements the HNCMP.

The HNO implements the HNCMP but it does not include the cable modem components.

Notes:

- The Home Networking Only component can not exist according to some of the alternatives that are presented in this document, because this alternatives required synchronization with the headend. But it can exist according to the selected alternative.
- Usually home network requires having at least one Home Networking Cable Modem.

3.2.3. Home Networking Channel

Home Networking Cable Modem Protocol (HNCMP) includes a special independent channel for Home Networking. I.e. it is not coupled to the any cable modem channel (e.g. DOCSIS channel).

Notes:

- According to some of the alternatives that are presented in this document the couple between these two channels is required for synchronization. i.e. the synchronization that exists in the cable modem channel will also be used in the home-networking channel.
- The management of the HNCMP can be handled by the Cable Modem Terminating System (CMTS). This method enables the cable operator to manage all the components that are connected to the cable infrastructure from a single location.

3.2.3.1. Home Networking Cable Modem data channels

A Home Networking Cable Modem (HNCM) has at least two physical interfaces.

- HNCM interface to the cable side.

This single physical interface contain two data channels (that use different frequencies):

1. *Cable Modem Channel.*

The cable modem channel (e.g. DOCSIS), containing two sub-channels: up stream channel (US) and down stream (DS) channel.

2. *Home Networking Channel.*

The Home Networking channel (a single channel that is used for sending and receiving information).

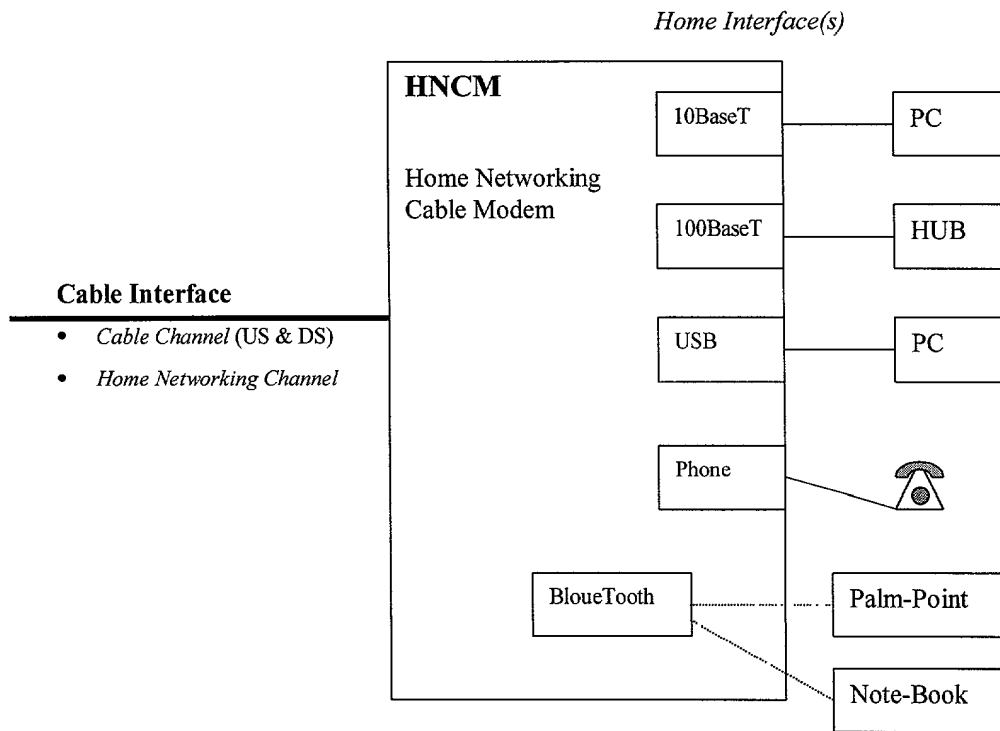
- HNCM interface to the home side – *Home Interface.*

The home interface might be a single interface or it might contain some interfaces. This / these interface(s) are connected to the equipment at home. This / these interface(s) can be Ethernet (10/100/1G BaseT) (or some Ethernet ports), USB, Phone connection, Bluetooth, wireless, or other.

Notes:

- The HNO component does not contain the Cable Modem Channel.
- The HNCM can be host-based, i.e. a card that inserted into the PC and connected to the PCI bus.

Figure 2: HNCM Interfaces



The following figure present an example of HNCM equipment that contains some interfaces. Usually HNCM will include one or two interfaces, but the presented example illustrate an example of “many interface HNCM”.

The HNCM bridges messages between the home interface to these cable channels and vice versa. In addition it might support the capability to bridge information between cable modem channel to the home-networking channel and vice versa (This capability is only required when HNO components exists).

The following table describes the bridging requirements for HNCM:

Bridging Type	Description
Cable Modem Channel - Home Interface	According to cable modem standard's specifications.

Home Networking Channel - Home Interface	Bridge the messages between the stations at the home networking and the stations that are connected to the HNCM home interface(s).
Cable Modem Channel - Home Networking Channel	Bridge the messages between the Cable Modem Channel and Home Networking Channel in the following conditions: • This component was configured to do Cable Modem channel – Home Networking channel bridging; and • The message should be transferred between Cable Modem Headend system and HNO component.

Notes:

- CMO is only required to handle the Home Networking Channel - Home Interface bridging.
- The HNCM gets the information from these channels/interfaces simultaneously.

3.3. Home Networking Cable Modem Protocol (HNCMP)

The following section specifies the Home Networking Cable Modem Protocol (HNCMP).

The HNCMP is defined by specifying the communication layers. The most important layers are the two lower layers: the physical layer and the data link layer.

This section also contains the design considerations.

Note:

- For each subject that includes some option, the preferred option is presented, but future investigations might change this decision.

3.3.1. HNCMP - Frequency

There are some frequency-ranges that might be used.

The preferred frequency range is higher than 860 MHz.

RF channel spacing (design bandwidth): 8 MHz or lower, according to the required rate.

Note:

There are some existing chips (low price) that supply two-direction filtering and tuner functionality for the specific 900-1000 MHz frequency-range (Note: These chips were designed for the cellular market).

3.3.1.1. Design Considerations

The following table presents the comparison between these frequency-ranges.

Frequencies Range	Pros	Cons
< 5 MHz	- Not used by DOCSIS and by the TV. - Tuners are not required. - Low attenuation of the Coax Cable enables low power.	- The capacity is very low. - The quality of this frequency-range is low. - The cable network contains amplifiers for part of this frequency-range. These amplifiers are designed to amplify in the US direction, therefore the segmentations to 'branch' are limited. - Low attenuation of the Coax Cable increases the 'branch' size.
5-42 MHz	- Tuners are not required. - Low attenuation of the Coax Cable enables low power.	- The DOCSIS channels use this frequency-range. - The frequency-range resource is very limited. - The cable network contains amplifiers for this frequency-range. These amplifiers are designed to amplify in the US direction, therefore the amplifier may be saturated. - Low attenuation of the Coax Cable

		increases the 'branch' size.
42-88 MHz	Not used by DOCSIS and by the TV, these rates are the gap between DOCSIS US channels to TV channels and DOCSIS DS channels.	- This range is not free all over the world. For example, in the DEVIC standard this range is reduced. - The cable network contains amplifiers for part of this frequency-range. These amplifiers are designed to amplify in the US direction, therefore the amplifier may be saturated.
88-860 MHz	- The standard tuner can be used. - The capacity is not limited. - There is good isolation between different home segments, therefore, 'branch' separation can be used.	The TV channels and the DOCSIS channels use this frequency-range; therefore the cable companies probably prefer to use this resource for the TV channels and DOCSIS channels.
> 860 MHz	- Not used by DOCSIS channels and by the TV channels. - There is a good isolation between different home segments, due to the non - matched impedance (Z_0). - There are some existing chips (low price) that supply two-direction filtering and tuner functionality.	- The attenuation is high, therefore there are some distances limitations in very high frequencies. (Note: The distance limitation is not relevant to home networking). - There are some FCC limitations. These limitation probably not relevant for coaxial wires

3.3.2. HNCMP - Modulation

3.3.2.1. Modulation Method

The modulation method is going to be QPSK, QAM 16, QAM 64 or QAM 256 according to the channel conditions, and according to the equipment capabilities.

The modulator of the home networking device **MUST** provide QPSK and QAM 16.

The modulator of the home networking device **MAY** provide QAM 64 and QAM 256.

3.3.2.2. Modulation Rates

The modulator **MUST** provide 160, 320, 640, 1,280, and 2,560 ksym/sec.

The modulator **MAY** provide 5,120 ksym/sec.

FEC (Forward Error Correction) **MUST** support R-S (Reed Salomon) $T=0,..,10$.

3.3.2.3. Design Considerations

Various types of modulation can be used.

The modulation method should answer the following requirements:

- Can be used in the required frequency range.
- Should support high bandwidth rate (more than 10Mbps).
- Should support bursts with short learning time.

3.3.3. Dividing the network to "Branches"

An 'branches' will be defined as sub-networks that can use any home networking frequency without interference another sub-network that exist in another 'branch' and use the same home networking frequency. The main benefit of dividing the network to 'branches' is enabling *frequency reuse*.

The cable network can be divided to 'branches' because the tree structure supplies attenuation between its branches. The attenuation is granted by the coaxial cables and by components that

include filters. Some of the splitters also and provide good isolation between the sub networks that are connected to these components.

The cable operator can add filters that enable reducing the size of the 'branches'. I.e. these filters will enable increasing of the frequency reuse. These filters are usually passive filters that are relatively small and can be added easily by the cable operator, or by the user at the home entrance.

The following chapter describes the different 'branches' aspects.

3.3.3.1. The importance of "Branches"

The frequency resource is limited. To increase the frequency resource you can use one (or more) of the following methods:

- Frequency Reuse: Enabling simultaneous usage of the same frequency by some customers.
The 'branches' method is a method to support the isolation of group of customers to enable reusing of the same frequency. This method uses the filtering capabilities of the existing components. The disadvantage of this method is the management complexity. The operator should be aware of its physical infrastructure filtering capabilities.
- Supports wider frequency range.
This option can be handled by building equipment that supports a wider range. The disadvantage of this method is higher price is required to support wider range. Because, wider range support increases the complexity of each component.

The 'branches' method is very cost effective, and it increase the robustness of the home networking solution. Therefore, this document includes a detailed definition of this method.

The 'branches' approach enables reuse of the same RF frequencies, witch allows the following benefits:

- It enable the manufactures to reduce the price of the home networking equipment, because home networking equipment can support a smaller range of frequencies.
- It enables allocating a larger frequency range for each home / flat. This wider range can supply higher network capacity.

3.3.3.2. 'Branches' Based on Cable Infrastructure

The structure of the cable infrastructure enables as to divide the network to "branches".

The cable network connectivity is built like a tree.

3.2.3.3.1. HFC Components

The following are the component types that built the tree:

- Headend with fiber output.
- Fibers that exist only in HFC (Hybrid Fiber Coax) environment and connect the CMTS to the cabinets (Fiber Nodes).
- Fiber to Coax converters (O-E).
- The coax wires that connects the different components.
- Amplifiers that increases the signal power, and usually also filter the frequencies that are not amplified.
- Splitters that get a single wire as input, and some wires as output.

The splitters are divided into two types: Active splitters that usually include the amplifier inside, and passive splitters, that usually only divide the power between the different ports.

The active splitters will usually be used close to the CMTS (headend) side. The passive splitters are usually used in the house entrance and in the flats (near to the home end equipment).

The splitters also provide isolation. This isolation is relatively low in passive splitters and high in active splitters that usually contains filters inside, and is designed to be in high quality.

3.2.3.3.2. Splitter Isolation

The following table describes the isolation between the splitter ports.

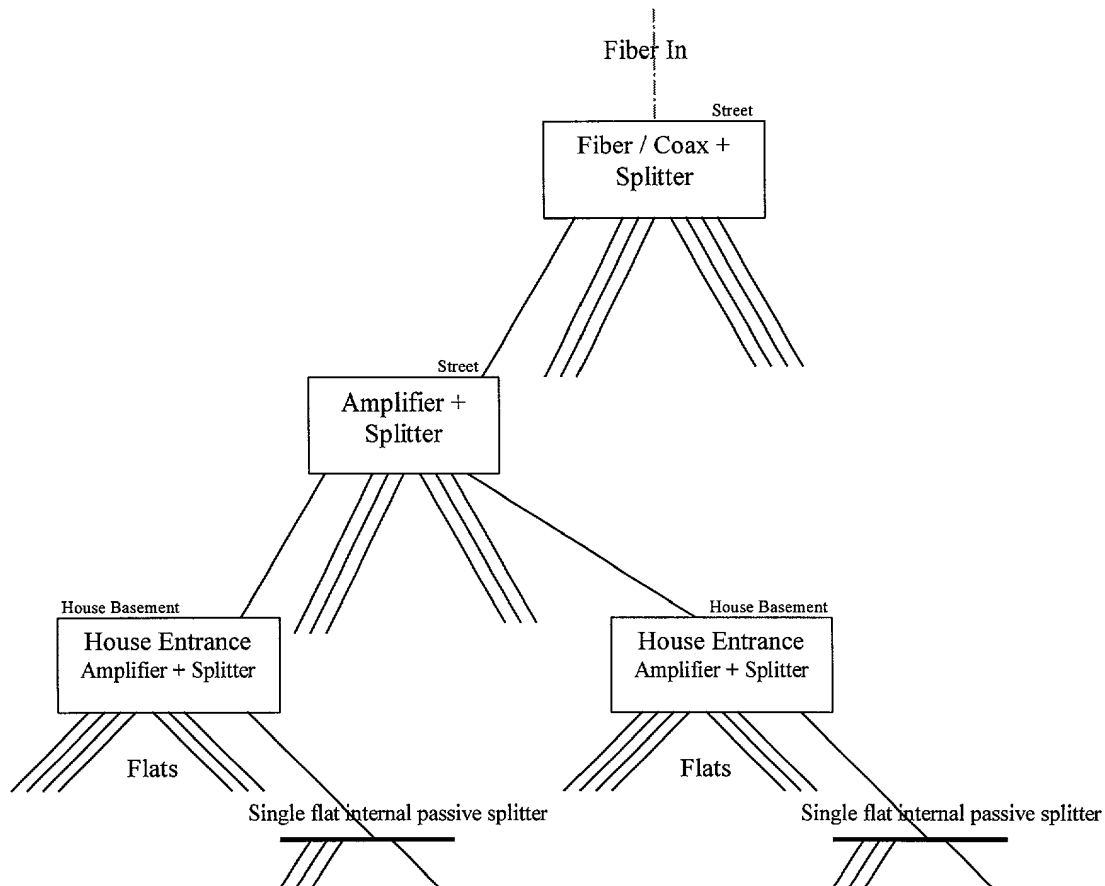
Splitter Type	Passive Splitter	Active Splitter	Special Home-Networking Filter or Splitter -Filter (Passive)
Isolation Type			
Isolation between the output to the input	Relatively low	Very high for frequencies that are higher then 100MHz.	Very high for frequencies that are higher then 100MHz.
Isolation between the different outputs	Relatively low	Medium (because the quality of the splitter is good).	Very high for frequencies that are higher then 100MHz.

3.2.3.3.3.

HFC Cable Infrastructure

The following figure presents the HFC cable infrastructure

Figure 3: The HFC infrustructure

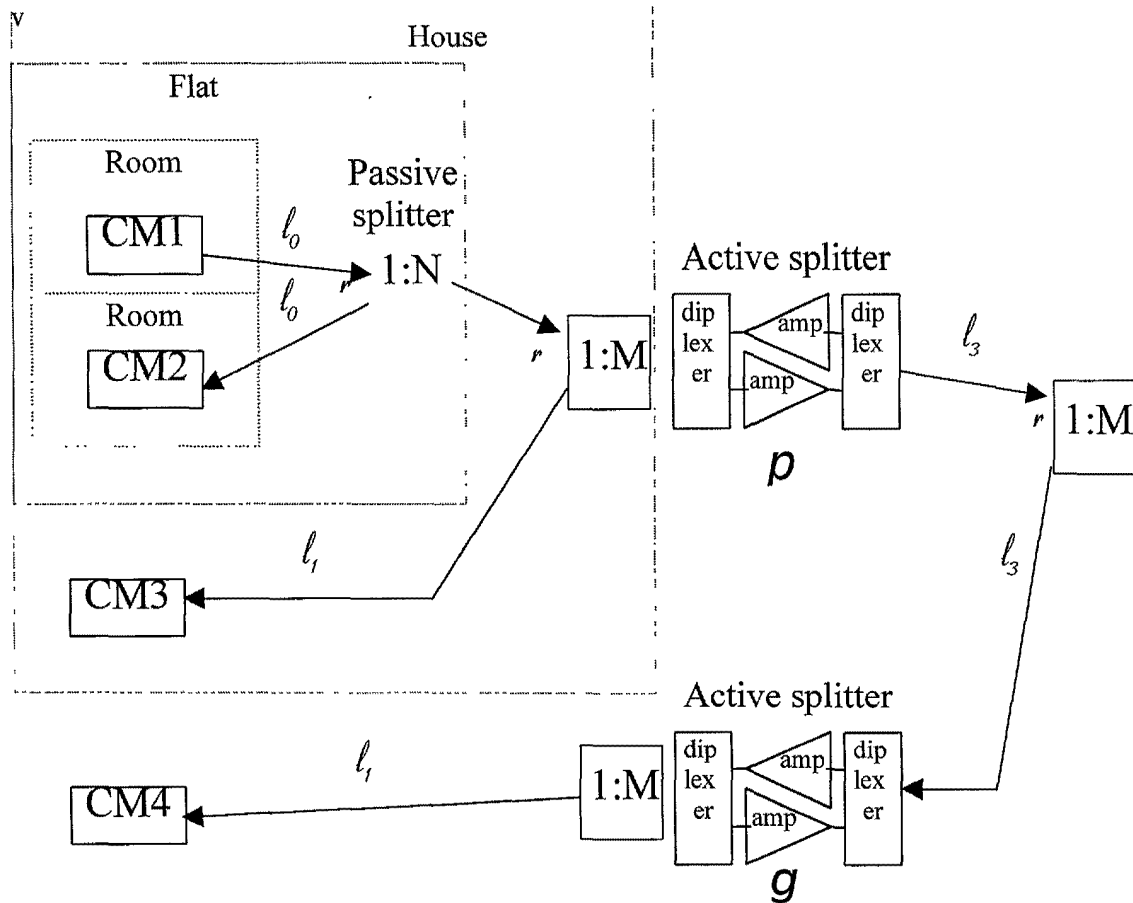


Each connection point supplies isolation between the tree branches that are connected to this point. The active connection points that include amplifiers and filters typically supply higher isolation.

According to the fact that the home networking signal can be very low and each connection (passive or active splitter) reduces the signal, there is good isolation between two branches that are separated by some connection points. The active splitter is usually supplying isolation between the branches.

The size of the 'branches' can be reduced by adding filtering in specific points (e.g. at the entrance of a specific / each home / flat). This mechanism of adding low cost filters at the entrance of a home / flat enables a *single home / flat branch*.

HFC Isolation Calculation



notation	range	comments
s	[dB]	
$l_0 - l_3$	3-10	Cable attenuation. Depends on cable length and signal frequency
r	10-20	Reflection of splitter (including amplifier, if splitter is active).
g	10-20	downstream amplifier gain
p	>2g	backward attenuation of downstream amplifier

Typical Calculations:

1. Loss between two modems in the same flat that are sharing the same splitter
(E.g. from CM1 to CM2):

$$2l_0 + r \quad (16-40 \text{ dB})$$

2. Loss between two modems in neighbor homes before active splitters:

- If one flat does not have a local splitter (E.g. Loss from CM1 to CM3)

$$l_0 + l_1 + l_2 + r + 10\log_{10}(N) \quad (22-60 \text{ dB})$$

- If both flats have a local splitter

$$2(l_0 + l_2 + 10\log_{10}(N)) + r \quad (28-80 \text{ dB})$$

3. Loss between two modems in homes separated by an active splitter (e.g. from CM1 to CM4)

$$l_0 + l_1 + l_2 + 2l_3 + r + 10\log_{10}(N) + 20\log_{10}(M) + (p-g) \quad (45-120 \text{ dB})$$

3.3.3.3. HNCM – Branch Calculation

The cable operator should do the calculation and the measurements of the “branches”. The calculation of the ‘branches’ can be done by the following methods:

- Calculations that are based on preceding knowledge of the cable operator. The cable operator can do calculations that are based on its network structure and its network components.
E.g. defining a rule that each port that connects directly to a filter / amplifier unit specify an “branch”; Homes / flats that are connected using passive filters will be on the same “branch”.
- The cable operator can use spectrum measurement equipment.
This equipment will usually be used to enable the cable operator to define the rules according to its own infrastructure.
- The cable operator can use a specific mode of the home networking equipment that enables ‘branch’ calculation.

3.3.3.4. HNCM – Branch Calculation Mode

Each HNCM should have a specific mode that enables the management system to calculate each ‘branch’ member.

This mode contains the following base features:

- Lock on a specific frequency, and on a specific frequency range.
- Transmit a signal of specific power for a specific period (The pattern of this signal is known).
- Measure the power of the input signal (The pattern and the measurement period are known).

The specification of the automatic ‘branch’ calculation mechanism is presented in the “*Automatic Branch Calculation Mechanism*” appendix.

3.3.3.5. Filter Adding Methods

- Adding a filter at the flat / single user home entrance.
- Adding a filter at the house splitter that split the signals between the flats.

3.3.4. Channel Allocation and Channel Coding

The Channel Allocation method is FDM - a specific frequency for each home network.

3.3.4.1. Design Considerations

There are some alternatives for channel allocation. The mechanism of channel allocation should answer the problem that a sub-network (“branch”) usually contains some home networks. The number of home networks that should use the same frequency range can be changed according to the physical layer condition i.e. according to the ‘branch’ size.

There are some known methods to allocate channels for each home-network. The following table compares between them. This table does not present methods that are a combination of two base methods, because these combinations are not required (e.g. combination of FDM and TDM) in our simple problem:

Method	Pros	Cons

FDM - Frequency Division Modulation	• Simple • The frequency range can be updated according to the number of home-networks that share the same frequency, and according to the required bandwidth. • Can use wide spectrum for the whole solution, when each home is required to use narrow range (less than 6 MHz). • Very efficient, in particular when the number of home-networks in a specific 'branch' is low. • Does not require synchronization and does not require CMTS for synchronization.	• Not efficient in case of many home-networks on the same "branch". According to our estimations, this case is probably rare. • CBR based, therefore it is not affective when the traffic is not CBR type.
FDM with frequency hopping	• Does not require any configuration. I.e. not required configuration of the frequency that each home should use. • Very efficient when the traffic is ABR type.	• More complex then FDM. • Hard to be managed by the Cable Operator. • It is not efficient when the traffic is CBR type (e.g. digital movie playing on the DVD in the leaving room, when the TV is in the bad room).

		• It has only disadvantage when the home is the only home on the branch.
TDM – Time Division Modulation	• The bandwidth allocation can be dynamic – according to the needs.	• Requires synchronization, therefore, it require CMTS for synchronization. • Can not use the wide spectrum (more then 10 MHz) in each channel group. • Making Home Networking Only (HNO) equipment is very complex, because this equipment is required to get the sync from the cable modem network. • It his similar to FDM, but more complex, when the home is the only home on the branch.
CDM – Code Division Modulation	• The bandwidth allocation can be dynamic – according to the needs.	• Very complex • Requires synchronization, therefore, it require CMTS for synchronization. • Making Home Networking Only (HNO) equipment is very complex, because this equipment is required to get the sync from the cable modem network. • Can not use wide spectrum (more then 10 MHz) in each channels

		group. • The performances are low unless you are using complex equipment that supports wide spectrum sampling. • It his similar to FDM, but more complex, when the home is the only home on the branch.
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3.3.4.2. Frequency Plan

The following section describes the frequency planning mechanism.

The configuration for the specific frequency will be dome by the management system. The calculation is based on the ‘branch’ calculation, because the process of frequency allocation is done separately in each “branch”.

The following are base rules that are used in the calculation of each *home-network frequency-range*.

- The *home-network frequency-range* is specified by the required home-networking bandwidth. The required bandwidth is specified for each home-network separately.

E.g. the required *home-network frequency-range* to transfer 40Mbps is 6MHz.

- The *total frequency-range* is specified by the capability of the home networking equipment.

E.g. the *total frequency-range* can be 40MHz.

- The *total frequency-range* should be larger then the summaries of the *home-networks frequency-range* of all the home-networks that are exist in each “branch”.

If this condition is not met, the cable operator can decrease the bandwidth of its customers, or divide the network into smaller “branches”.

E.g. If a ‘branch’ contains 16 flats and each one of them ask for the higher bandwidth and the *total frequency-range* is 40MHz, each one of the flats can get $40\text{MHz}/16 = 2.5\text{MHz}$ *home-networks frequency-range*. The

operator can also divide the *total frequency-range* in other method, 4 flats will get 5MHz each, and the other 12 flats will get 1.6MHz each.

3.3.5. CMHNP - Layer Two Protocol

The data link protocol should be the 802.11 MAC layer CSMA/CA.

Note:

The CSMA/CA can be used with or without ACK protocol. The need for immediate ACK should be verified according to the quality of the infrastructure.

3.3.5.1. Design Considerations

There are some options to define the layer two (data link) protocol.

The major aspects that should be considered are:

- The number of stations that use the home networking is variable (usually 2-15).
- Station can be added to the network or removed from the network during the home network operation.
- Collision prevention is required, because collision detection in the QAM technology is complex.
- It is preferable that all the components will be similar, so that the home network will not require a special head component.
This method usually increases the robustness of the network, and does not require special addition of equipment.
- A standard protocol or protocol that is close to a standard protocol is preferred.

There are some protocols that answer to these requirements, following two examples:

- The 802.11 MAC layer CSMA/CA.
This protocol is used today by many vendors, usually, in the wireless LAN equipment. Consider the fact that Bluetooth interface might be required to be exist on the HNCM / HNO components, it would be much simpler to support a single MAC protocol.

- The Token Bus 802.4.

This protocol is not common, and it is very complex. Building a reduced version of this protocol can simplify the protocol, but it will not be a standard protocol.

3.3.6. CMHNP - Component Layer Two Identification

The components (HNCM and HNO) will be identified according to their own MAC address.

Note:

All the components that are members in a specific home networking should be specified in the configuration process in each component that is member of this group.

3.3.7. CMHNP – Security (Layer Two)

The security that is required in this protocol is the base line privacy plus. The specification for this protocol is presented in DOCSIS 1.1.

The management of the security keys should be done by the CMTS.

Note:

Home networks that are not connected to the CMTS will use a single key.

3.3.8. CMHNP – Priority (Layer Two)

CMHNP does not include priority in phase 1.

Priority support should be added in phase 2.

3.3.8.1. Design Considerations

Priority should be defined for the two channels separately.

The priority for the cable modem channel:

The need for priority for this channel was investigated. Cable modem protocols such as DOCSIS include this capability for services that require this capability e.g. VoIP.

Example:

The priority mechanism for the DOCSIS standard is well defined in DOCSIS 1.1.

The priority for the Home Networking channel:

The priority for this channel is divided into two aspects:

- Priority required in the home networking channel for application that is required to be connected to the standard cable modem channel but they are using the home networking as

transport media. The solution for these applications is to use HNCM and not HNO, and to use the cable modem channel directly.

- Priority is required in the home-networking channel for applications at home. e.g. CBR priority for transferring a video from the DVD reader to the digital TV on another floor, high priority for games, low priority for backup.

The priority requirements for these applications probably will be added soon. But the basic requirements of the home networking does not require priority capabilities, and the bandwidth of the home networking is high therefore “best effort” is good enough.

According to the presented analyses, specifying the priority for the home networking can be handled in the 2nd phase.

3.3.9. CMHNP - Network Layer

The purpose of the home networking system is to transport IP traffic transparently through the system.

The Network Layer protocol is the Internet Protocol (IP) version 4, as defined in [RFC-791], and migrating to IP version 6.

3.3.10. CMHNP - Above the Network Layer

The higher layers will be identical to DOCSIS 1.1 higher layers.

3.4. Home Networking Management

The home networking management can be done by two methods:

- Local management that is done at home.

This option can be done when the house is not connected to the cable infrastructure, or when the house has isolation (for the home networking frequency) from the cable network and the CMTS does not support the home networking management capability.

Local management might not include all the capabilities that the central management supports.

- Central Management

Management from the CMTS that is done by the cable operator.

This option is the preferred method. It can be used for the modems that contain standard cable modem interface (e.g. DOCSIS interface). Home Networking Only (HNO) modems are required to have minimal configurations using local connections (e.g. configuration of the frequency). The other configurations can be done by the CMTS via bridging from the cable modem channel to the home network channel.

The parameters that are required to be configured and the detailed management protocol will be specified in the Management appendix (TBD).

3.5. Solution Advantage

There are some advantages in using this solution:

- No new wiring is required. Usually there are some ports of the TV cable in each home.
- The capacity of data that can be transferred using this infrastructure is very high.
- There is no radiation. Wire radiation is very low, in particular Coax wires radiation is negligible. (Compared to wireless solutions this point is very important).
- Simple to installed and to use.
- It can be low cost to allow the mass market to enjoy the benefits of home networking.
- Supports high-speed data rates.
- It enables a secured network. The network data can remain private; the information can not be accessible to neighbors or anyone outside the home.
- The range limitation is negligible compared to the typical home.
- The networking capability grows with user applications without making the existing devices obsolete.
- Total isolation from the home network to the cable infrastructure (filters) can be added, although it is not required.

- | Parameter | Value | Unit | Source |
|-------------|-------|--------------------|---------|
| α | 0.001 | cm ² /s | Table 1 |
| β | 0.001 | cm ² /s | Table 1 |
| γ | 0.001 | cm ² /s | Table 1 |
| δ | 0.001 | cm ² /s | Table 1 |
| ϵ | 0.001 | cm ² /s | Table 1 |
| ζ | 0.001 | cm ² /s | Table 1 |
| η | 0.001 | cm ² /s | Table 1 |
| θ | 0.001 | cm ² /s | Table 1 |
| ι | 0.001 | cm ² /s | Table 1 |
| κ | 0.001 | cm ² /s | Table 1 |
| λ | 0.001 | cm ² /s | Table 1 |
| μ | 0.001 | cm ² /s | Table 1 |
| ν | 0.001 | cm ² /s | Table 1 |
| ξ | 0.001 | cm ² /s | Table 1 |
| $\omicron$ | 0.001 | cm ² /s | Table 1 |
| π | 0.001 | cm ² /s | Table 1 |
| ρ | 0.001 | cm ² /s | Table 1 |
| σ | 0.001 | cm ² /s | Table 1 |
| τ | 0.001 | cm ² /s | Table 1 |
| υ | 0.001 | cm ² /s | Table 1 |
| ϕ | 0.001 | cm ² /s | Table 1 |
| χ | 0.001 | cm ² /s | Table 1 |
| ψ | 0.001 | cm ² /s | Table 1 |
| ω | 0.001 | cm ² /s | Table 1 |
| φ | 0.001 | cm ² /s | Table 1 |
| ϑ | 0.001 | cm ² /s | Table 1 |
| ϖ | 0.001 | cm ² /s | Table 1 |
| ς | 0.001 | cm ² /s | Table 1 |
| η | 0.001 | cm ² /s | Table 1 |
| θ | 0.001 | cm ² /s | Table 1 |
| ι | 0.001 | cm ² /s | Table 1 |
| κ | 0.001 | cm ² /s | Table 1 |
| λ | 0.001 | cm ² /s | Table 1 |
| μ | 0.001 | cm ² /s | Table 1 |
| ν | 0.001 | cm ² /s | Table 1 |
| ξ | 0.001 | cm ² /s | Table 1 |
| $\omicron$ | 0.001 | cm ² /s | Table 1 |
| π | 0.001 | cm ² /s | Table 1 |
| ρ | 0.001 | cm ² /s | Table 1 |
| σ | 0.001 | cm ² /s | Table 1 |
| τ | 0.001 | cm ² /s | Table 1 |
| υ | 0.001 | cm ² /s | Table 1 |
| ϕ | 0.001 | cm ² /s | Table 1 |
| χ | 0.001 | cm ² /s | Table 1 |
| ψ | 0.001 | cm ² /s | Table 1 |
| ω | 0.001 | cm ² /s | Table 1 |
| φ | 0.001 | cm ² /s | Table 1 |
| ϑ | 0.001 | cm ² /s | Table 1 |
| ϖ | 0.001 | cm ² /s | Table 1 |
| ς | 0.001 | cm ² /s | Table 1 |
| η | 0.001 | cm ² /s | Table 1 |
| θ | 0.001 | cm ² /s | Table 1 |
| ι | 0.001 | cm ² /s | Table 1 |
| κ | 0.001 | cm ² /s | Table 1 |
| λ | 0.001 | cm ² /s | Table 1 |
| μ | 0.001 | cm ² /s | Table 1 |
| ν | 0.001 | cm ² /s | Table 1 |
| ξ | 0.001 | cm ² /s | Table 1 |
| $\omicron$ | 0.001 | cm ² /s | Table 1 |
| π | 0.001 | cm ² /s | Table 1 |
| ρ | 0.001 | cm ² /s | Table 1 |
| σ | 0.001 | cm ² /s | Table 1 |
| τ | 0.001 | cm ² /s | Table 1 |
| υ | 0.001 | cm ² /s | Table 1 |
| ϕ | 0.001 | cm ² /s | Table 1 |
| χ | 0.001 | cm ² /s | Table 1 |
| ψ | 0.001 | cm ² /s | Table 1 |
| ω | 0.001 | cm ² /s | Table 1 |
| φ | 0.001 | cm ² /s | Table 1 |
| ϑ | 0.001 | cm ² /s | Table 1 |
| ϖ | 0.001 | cm ² /s | Table 1 |
| ς | 0.001 | cm ² /s | Table 1 |
| η | 0.001 | cm ² /s | Table 1 |
| θ | 0.001 | cm ² /s | Table 1 |
| ι | 0.001 | cm ² /s | Table 1 |
| κ | 0.001 | cm ² /s | Table 1 |

4. CONCLUSION

- Home Networking is required and can be achieved using cable TV infrastructure.
- Home Networking Cable Modem Protocol is specified in this document.
- The technology for this solution is available.

Approved for Release

5. Other Applications

This section describes other applications that can be operated using the same physical layer.

5.1. Layer Two Transporting over Home Networking

These applications are a group of applications that can be built on the same infrastructure. Transporting of variety classes of layer two protocols through the home cable infrastructure. These applications are based on home networking layer one that is described in this document, and used the specific application layer two.

5.1.1. Design Considerations

The HNCMP is a protocol that includes layer one and two. There are two options to transfer different layer two over this infrastructure:

- To transfer different layers two using the same layer one.
This method is used in the presented application.
- To transfer different layers two over the layer two of the HNCMP.
This method is not used in this presented solution because the capacity and the delay are not good enough for the presented applications.

5.1.2. The Applications

Following some examples of layer two protocol that can be used:

- USB
- IEEE 1394 (fire-wire)
- Ethernet (10BaseT, 100BaseT)
- Wireless

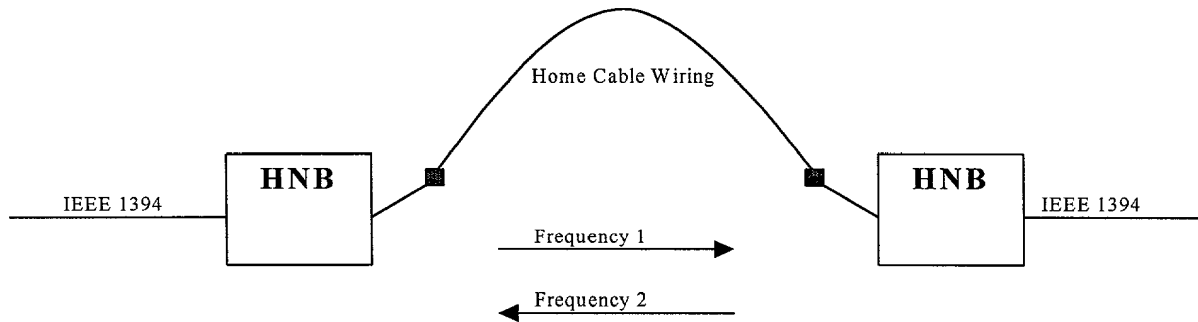
This system enables high rate connection between two points at home.

5.1.3. System Description

The system contains two Home Networking Bridges (HNB) that are connected through the home cable wiring, each one of them has the same layer two interface e.g. IEEE 1394.

The system structure is presented in the following:

Figure 4: Layer Two Transporting over Home Networking



This structure enables information sending in very high rates (e.g. 40Mbps) for each direction.

Note:

This system does not required burst modulator / demodulator. It can use a "standard" one.

5.2. Bluetooth Home Networking Using Cable Infrastructure

The Bluetooth technology is design to supply connectivity of components that are located in the same area. The distance between the components should be less then 10 meters (This range probably does not include wall interference). When you build your home network, and your home is larger then a small flat. You need to connect component when the distance between them is larger then 10 meters.

The idea is to build a network at home that connects the Bluetooth sub-networks.

Advantages

- You can use the benefits of the Bluetooth connectivity.
- You can cover much larger range.
- The location of the cable infrastructure port in the room is going to be less important because all the room is “covered” (connected) by the network using Bluetooth connectivity.
- The Bluetooth CM can be very simple, and cost effective.

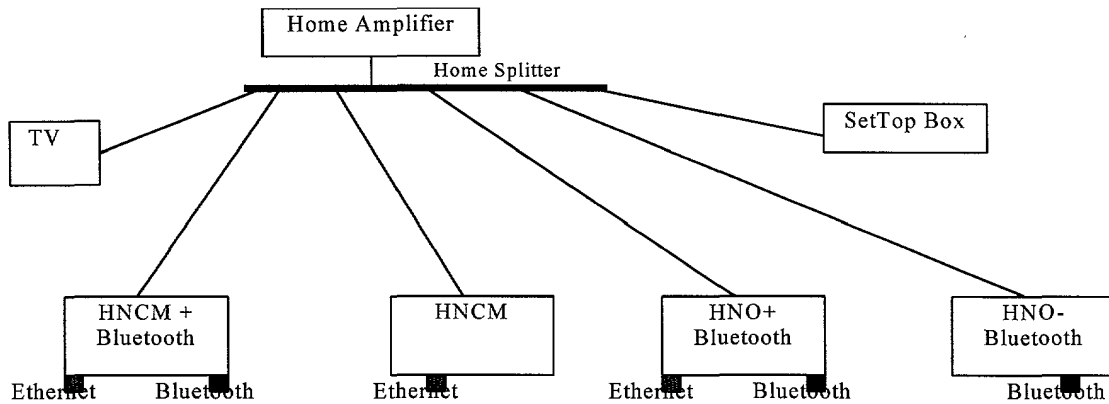
Disadvantages

- Adding Home Networking protocol that connects all the sub-networks of Bluetooth is required.
- You have two types of networks at your home.
- The rate of Bluetooth is less then 1Mbps. If a higher capacity is required, an additional connector type should be added (HNCMP capacity is 10-50Mbps). This additional type might make your network more complex, and will required an appropriate network management.

Note:

- Adding Power-supply capabilities to the home amplifier enable very simple Bluetooth-CM component. Bluetooth-CM component is required to include the following: Tuner, CM-chip, Bluetooth-chip, and very small CPU (only is the CM-chip and the Bluetooth-chip does not contain CPU). The installation procedure is going to be very simple, Just plug it to the cable interface, no other wire are required. The BOM of this component is going to be very low.

Figure 5: Bluetooth Home Networking Using Cable Infrastructure



Notes:

- Figure 5 present an example of network.
- The HNO-Bluetooth can be a very simple component if the network is required to have at least one component of HNCM + Bluetooth that has the capability to manage the simple HNO-Bluetooth components.
- The management of the Bluetooth sub-networks and the ability to transfer the connection of a network element from one Bluetooth sub-network to another required a specific layer two Bluetooth rooming-in protocol.

6.We Claim

1. A communication system, comprising:

a plurality of information processing devices, two or more should be inter-connected for the purpose of information exchange;

a transmission medium comprising a single coaxial (coax) wire and/or a plurality of inter-connected coax wires of any designed to carry TV signals; and

a plurality of communication devices, each connected to the transmission medium, and are operative to provide the inter-connectivity between the information processing devices.

Each of the devices operative to receive and transmit over the transmission medium according to a pre-defined communication protocol and are used to transmit information from one or more general device.

The protocol may be secured to enable privacy.

2. The communication system according to claim 1 where it is used for home networking applications.
3. The communication system according to claim 2 where it is used the typical home coax, designed to carry TV signals.
4. The communication system according to claim 2 or claim 3 where it use a specific frequency range that is not used by other signals that are transferred over the cable infrastructure.
5. The communication system according to claim 4 where it use in particular the frequencies over 860 MHz.
The preferred frequencies are the cellular phone frequencies 900-1000 MHz or 1800 MHz, or the free licensed frequencies 2.4 GHz or 5 GHz.
6. The communication system according to claim 4 where it use the cable infrastructure to specify 'branches' that can use the same frequency.

7. The communication system according to claims 4,² 5 and/or 6 where it uses the QPSK or QAM modulation.
8. The communication system according to claims 4, 5 and/or 6 where it uses channel allocation according to FDM method.
9. The communication system according to claims 4, 5 and/or 6 where it supply different capacity for each home network.
10. The communication system according to claims 7, 8 and/or 9 where it supply different capacity for each home network using different frequency range.
11. The communication system according to claims 4, 5, 6, 7, 8, 9 and/or 10 where it use different type of components that supplied different functionality. These types include Cable Modem (CM), Home Networking Cable Modem (HNCM), and Home Networking Only (HNO).

Each one of them can handle in addition one or more other applications.

12. The communication system according to claims 4, 5, 6, 7, 8, 9, 10 and/or 11 when the protocol may use the following features:
 - It MAY use MAC address for identification.
 - It MAY include security.
 - It MAY include DOCSIS standard security.
 - It MAY include priority.
 - It MAY include local Management.
 - It MAY include Central Management That MAY be handled from the CMTS management system.
13. The communication system according to claims 4, 5, 6, 7, 8, 9, 10, 11 and/or 12 when the protocol is based on the following standards:
 - The data link layer (Layer 2) MAY be Token Bus (IEEE 802.4).

² Coma “,” related to “and/or”.

14. The communication system according to claims 4, 5, 6, 7, 8, 9 and/or 10 where it uses to bridge protocols. The protocols MAY be any Layer 2 or Layer 3 protocols. The protocols MAY be in particular IEEE 1394, USB, and/or Ethernet.

This bridging can be handled using a single channel for the two directions or it can use a specific channel for each direction, Each one of the single direction channels is used to send information from the source node to the destination node.

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7. Abstract

The need for home networking is clear. The base requirements from the home networking are clear. The presented invention present the ability to use the existing cable TV wires for home networking.

The presented invention contains a detailed description of the Home Networking Cable Modem Protocol (HNCMP) that can be used to answer the requirements of the home networking.

The HNCMP Layer one is based on the following elements: a specific range of frequencies that can be used for this purpose, and can be operated in the existing environment, It uses the FDM for specifying the channel of each home networking, It uses QPSK or QWAM modulation. The HNCMP Layer two is based on component identification using MAC address, The Token Bus (IEEE 802.4) protocol, It also may include the DOCSIS security mechanism.

The presented invention contains a detailed description of the Home Networking Cable Modem (HNCM) and Home Networking Only (HNO) components that can supply all the required services.

The presented invention also contains some additional applications that can be operated using the same layer one.

8. Appendix A: Automatic Branch Calculation Mechanism

The 'branch' calculation is required for efficient frequency allocation.

8.1. The Topology Database

The algorithm is based on the structure of the cable infrastructure. A tree data structure is built in the computer memory. This data structure represents the existing infrastructure.

The tree is built according to the following:

- Tree nodes are the splitters (the splitters can be active or passive).
The splitter capability to isolate between two sub-trees is saved as data in these nodes.
- The leaves are the CM, HNCM or HNO.
The identification of these nodes is saved in these leaves.

8.2. The Processes

8.2.1. Building The Topology Database

The main process is to build the topology database. This process can be done by the following methods:

- Load the tree structure from the cable operator database.
This process is simple but it required an updated database.
- Automatic generation of the tree structure based on measurements of the isolations of between two components using the *HNCM – Branch Calculation Mode*.

Note:

The base idea in automatic tree building is to calculate the isolation between two leaves. If the some leaves have similar isolation between themselves they can be connected to the same nodes. If there are two leaves with the same isolation, and an additional leaf that has a higher isolation this leave connect to the previous two leaves using additional higher level node.

After building the topology database, it is required to verify that the nodes contain the isolation values. These values are usually loaded in the previous stage, but if this information is not entered, the system can use the *Branch Calculation Mode* to find the isolation of the nodes.

Note:

It is very hard to calculate these numbers when the tree is calculated automatically, and the splitter supplies different isolations between the wires that are connected to the same node.

8.2.2. Branches Specification

This 'branch' specification is based on the data structure that was built.

'branch' is specified by the isolation between this 'branch' to the other "branch". This isolation enables the systems in two different 'branch' to use the same frequency without (or with negligible) interference.

A 'branch' is defined by specifying a threshold of the minimal isolation between this 'branch' to the other 'branches'. When the isolation value in the tree nodes (or in summary of some layers that does not include leaves) is greater than the specified threshold all the nodes that are member in the specified sub-tree will be defined as nodes in a specific 'branch'.

Note:

When the system is not occupied as a balanced tree, the 'branch' calculation might be less effective. In this case it might be required to divide the frequency range to some sub-ranges, and define a 'branch' for each one of them. The algorithm for these calculations will not be specified in this document, because we do not think that the common network includes such complex structure.

9. Appendix B: MNCMP - Management

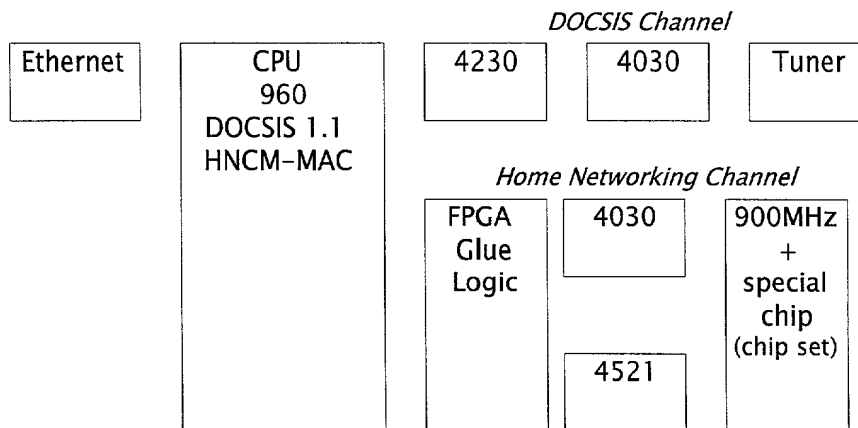
Home Networking Using Cable Infrastructure

10. Appendix C: MNCM – Proof of concept

The following chapter contains a description that was build in Libit to proof the concept of HNCM.

10.1. The Card

Figure 6: HNCM – Card



"Express Mail" mailing label number: EL334876280US

Date of Deposit: April 12 1999
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