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Cable modems

Functional requirements for high speed transmission over coaxial networks connected with fibre to the building

Recommendation ITU-T J.195.1

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Summary

Recommendation ITU-T J.195.1 specifies the functional requirements of high performance network over Coax (HiNoC) for high-speed data transmission over coaxial networks in the cable industry. IP technology is one of the foreseeable trends of the next generation broadcasting network, which needs to fully support triple-play services and the rapidly increasing bandwidth demands for multi-channel video services. Therefore, it is necessary to define the functional requirements of HiNoC. This Recommendation contains descriptions of functional requirements for general system, physical layer and MAC layer functions over coaxial networks connected with fibre to the building.

This Recommendation also provides a HiNoC operation-deployment scenario (see Appendix I) and HiNoC use cases (see Appendix II).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Introduction

This Recommendation defines one solution, namely HiNoC, to address high-density small office, home office (SOHO) end user requirements by using fibre to the building (FTTB) infrastructure and Coax architecture. HiNoC is layered into the Media Access Control (MAC) layer and the Physical (PHY) layer to fully utilize the unassigned spectrum of the 'last 100-meter' coaxial network in order to provide more bandwidth and improve the spectral efficiency. HiNoC also maintains the operations of the existing TV broadcasting services.

Recommendation ITU-T J.195.1

Functional requirements for high speed transmission over coaxial networks connected with fibre to the building

1 Scope

This Recommendation defines the functional requirements of HiNoC for high-speed data transmission over coaxial networks connected with fibre to the building (FTTB). The functionalities described in this Recommendation are based on FTTB+Coax architecture. HiNoC provides more bandwidth with the unassigned spectrum of the 'last 100-meter' coaxial network. HiNoC also maintains the operations of the existing TV broadcasting services.

2 References

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 access network [b-ITU-T Q.1742.1]: A network that connects access technologies (such as a radio access network) to the core network.

3.1.2 data encryption [b-ITU-T J.191]: Data encryption prevents the unauthorized disclosure/access of data. Data encryption does an excellent job at providing data confidentiality and protection against theft of service. Encryption prevents making data unable to read without the correct decrypting key; however, it does not validate the source/receiving entities and it does not provide copy protection after the data has been decrypted. It also does not prevent DoS attacks.

3.1.3 dynamic channel allocation [b-ITU-T F.723]: The principle of allocating in a flexible way the available channel capacity between various types of data, comprising audio, video, control information, still pictures and other application specific data to maximize the quality of service.

3.1.4 key management [b-ITU-T J.160]: The process of distributing shared symmetric keys needed to run a security protocol.

3.1.5 out-of-band attenuation [b-ITU-T G.671]: The minimum attenuation (in dB) of channels that fall outside of the operating wavelength range.

3.1.6 packet classification [b-ITU-T Y.1222]: The process of distinguishing Ethernet frames for the purpose of applying appropriate traffic control and congestion control mechanisms is called Ethernet frame classification.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 address learning: Address learning establishes the mapping between higher layer PDU addresses and HiNoC node addresses.

3.2.2 centralized distribution structure: A physical structure of a passive coaxial access network and a multiple stage power distribution network realized by splitters only.

3.2.3 constellation mapping: The process of mapping the data bits to the constellation symbol.

3.2.4 link maintenance: The function of estimating and exchanging parameters of links between a master node and client nodes to adapt to the variation of channel characteristics and maintain the steady working of the system.

3.2.5 node quitting/deletion: The function to support a client node quitting a HiNoC system or a master node deleting a client node from a HiNoC system.

3.2.6 package filter: The process of analysing and selecting a data packet according to the established rule set.

3.2.7 packing: A procedure of combining multiple Ethernet MAC frames with the same destination and priority to form a HiNoC MAC frame.

3.2.8 passive coaxial access network: An access network composed of a coaxial network and passive power distribution components such as splitters and taps.

3.2.9 service priority mapping: A function whereby the MAC layer maps the service stream matching the message features into the assignment priority queue of QoS level and simultaneously re-labels the priority level of the service stream.

3.2.10 stream classification: The process of distinguishing higher layer protocol data units (PDU) in order to apply appropriate traffic and congestion control mechanisms.

3.2.11 tree distribution structure: A physical structure of a passive coaxial access network and a multiple stage power distribution network realized by splitters and taps or by taps only.

3.2.12 unpacking: A procedure of dividing a HiNoC MAC frame into individual Ethernet MAC frames; the opposite of packing.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AWGN Additive White Gaussian Noise

BER Bit Error Rate

CPS Common Part Sublayer

CS Convergence Sublayer

DBA Dynamic Bandwidth Allocation

DQPSK Differential Quadrature Reference Phase Shift Keying

FEC Forward Error Correction

FTTB Fibber To The Building

HB HiNoC Bridge

HiNoC High performance Network over Coax

HM HiNoC Modem

MAC Media Access Control

OFDM Orthogonal Frequency Division Multiplexing

ONU Optical Network Unit

PDU Protocol Data Unit

PHY Physical layer

PON Passive Optical Network

QAM Quadrature Amplitude Modulation

QoS Quality of Service

SAP Service Access Point

SOHO Small Office, Home Office

SS Security Sublayer

STB Set-Top Box

TDD Time Division Duplexing

TDMA Time Division Multiple Access

5 Conventions

In this Recommendation:

The keywords "**is required to**" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "**is recommended**" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.

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The keywords "**can optionally**" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

In the body of this Recommendation, the words shall, shall not, should, and may sometimes appear, in which case they are to be interpreted, respectively, as is required to, is prohibited from, is recommended, and can optionally. The appearance of such phrases or keywords in an appendix or in material explicitly marked as informative are to be interpreted as having no normative intent.

6 Architecture

The logical architecture model of HiNoC is shown in Figure 1. The model includes two parts: a master node and client nodes. The master node links the PON network and the client nodes link home terminals.

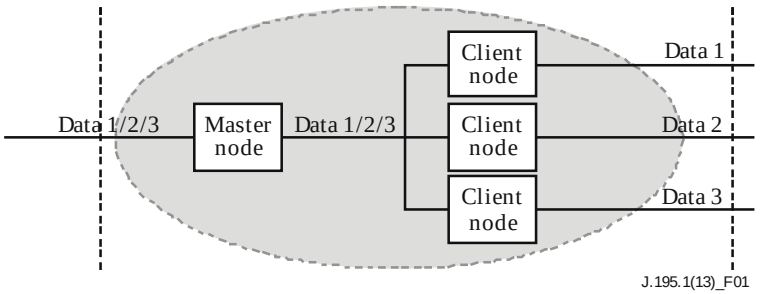

Figure 1 – HiNoC logical architecture

A master node supports several registered client nodes and may have an upper limit for the number of registered client nodes. In a network there may be one or several master nodes.

The master node manages the allocation of global coaxial network resources and matches the uplink PON transmission capacity. With reference to the uplink bandwidth availability, the master node assigns each client's upstream and downstream bandwidth based on the balance between the client's bandwidth requests and the dynamic bandwidth allocation (DBA)/QoS/priority configuration. The master node detects and maintains the linkage with clients.

The client node communicates with the master node and provides bandwidth to the connected terminals. The client node identifies the requests of the service flows supported by the terminal and negotiates with the master node for the upstream and downstream bandwidth.

The protocol stack of HiNoC is defined in Figure 2. The protocol stack includes the physical layer (PHY) and media access control layer (MAC).

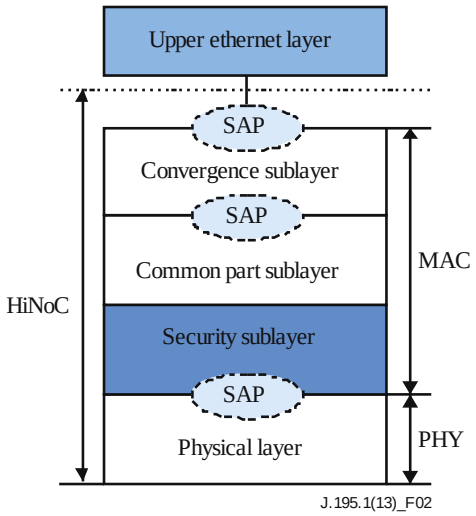

Figure 2 – HiNoC protocol architecture

The PHY layer frames the data fed from the MAC layer, modulates the frame after the appropriate channel coding and transmits into the coaxial network, and vice versa.

The MAC layer provides media access control and service adaptation functions and includes the common part sublayer (CPS) and convergence sublayer (CS) and may also include a security sublayer (SS).

The CS provides the adaptation between CPS and the higher layer including address learning, packet forwarding table generation, service priority mapping and data frame pack/unpack functions.

The CPS provides media access control, channel and bandwidth allocation, node registration and abortion and linkage maintenance functions.

The SS provides identity authentication, data encryption and key management functions.

7 Functional requirements

7.1 General requirements

[HiNoC-Gen-1] HiNoC is required to be applied to the passive coaxial access network in the premises.

[HiNoC-Gen-2] HiNoC is required to support any IP-based services such as SD/HD TV, 3DTV, UHDTV, interactive services, VoIP and Internet access.

[HiNoC-Gen-3] HiNoC is required not to affect the adjacent channels which provide services and deployments such as analogue broadcasting, digital broadcasting and data services.

[HiNoC-Gen-4] HiNoC is required to support the tree distribution structure and centralized distribution structure of the coaxial cable access network.

[HiNoC-Gen-5] HiNoC is recommended to be applicable below the 1.2 GHz frequency band on a coaxial network.

[HiNoC-Gen-6] HiNoC is required to be robust enough to resist the interference and micro-reflection in a short-range coaxial environment.

[HiNoC-Gen-7] HiNoC is required to allocate downstream/upstream bandwidth flexibly (symmetrical/asymmetrical scenario).

[HiNoC-Gen-8] HiNoC is required to support 16 MHz bandwidth per channel.

[HiNoC-Gen-9] HiNoC is required to support channel bonding to provide more transmission rate.

[HiNoC-Gen-10] HiNoC is required to be able to schedule the time-slot for the master node and client node to send or receive.

[HiNoC-Gen-11] HiNoC is required to support the end-to-end OAM integration with PON.

[HiNoC-Gen-12] HiNoC is required to avoid spectrum overlap to existing cable services.

7.2 System requirements of the PHY layer

[HiNoC-PHY-1] HiNoC PHY is required to be based on the OFDM modulation.

[HiNoC-PHY-2] HiNoC PHY is required to support the adaptive constellation mapping function for each OFDM sub-carrier in accordance with channel conditions in the coaxial network.

[HiNoC-PHY-3] HiNoC PHY is required to support the flexible FEC encoding rate in accordance with channel conditions in the coaxial network.

[HiNoC-PHY-4] HiNoC PHY is required to satisfy out-of-band attenuation to reduce the adjacent channel interference in the coaxial network.

[HiNoC-PHY-5] HiNoC PHY is required to perform channel estimation in the connections between the master node and client nodes.

7.3 System requirements of the MAC layer

7.3.1 System requirements of the CS layer

[HiNoC-MAC-1] HiNoC MAC is required to support the address learning function.

[HiNoC-MAC-2] HiNoC MAC is required to support the packing/unpacking of data frames function.

[HiNoC-MAC-3] HiNoC MAC is required to support IPv4 and IPv6.

[HiNoC-MAC-4] HiNoC MAC is required to support the DBA function.

[HiNoC-MAC-5] HiNoC MAC is required to support the service priority mapping function.

[HiNoC-MAC-6] HiNoC MAC is required to support the stream classification function.

[HiNoC-MAC-7] HiNoC MAC is required to support the QoS control function.

[HiNoC-MAC-8] HiNoC MAC is recommended to support the multicast services management and packet filter function.

7.3.2 System requirements of the CPS layer

[HiNoC-MAC-9] HiNoC MAC is required to support the channel allocation function.

[HiNoC-MAC-10] HiNoC MAC is required to support the node quitting/deletion function.

[HiNoC-MAC-11] HiNoC MAC is required to support the link maintenance function.

7.3.3 System requirements of the SS layer

[HiNoC-MAC-12] HiNoC MAC is required to support the identity function.

[HiNoC-MAC-13] HiNoC MAC is required to support the authentication function.

[HiNoC-MAC-14] HiNoC MAC is required to support the data encryption function.

[HiNoC-MAC-15] HiNoC MAC is required to support the key management function.

Appendix I

Scenario for HiNoC operation-deployment

(This appendix does not form an integral part of this Recommendation.)

Cable operators around the world are interested in deploying triple-play services over cable television systems while maintaining the existing analogue/digital TV broadcasting services. Most triple-play services with video contents require a very high speed access network.

In high-density residential or office areas, the "fibre to the building (FTTB) + Coax" solution has been introduced. A typical network scenario is shown in Figure I.1. The "FTTB + Coax" network can be realized by the PON system in the distribution network and the HiNoC system in a coaxial network. Services such as analogue/digital TV, VoIP, Internet access and interactive services can be transferred over the network.

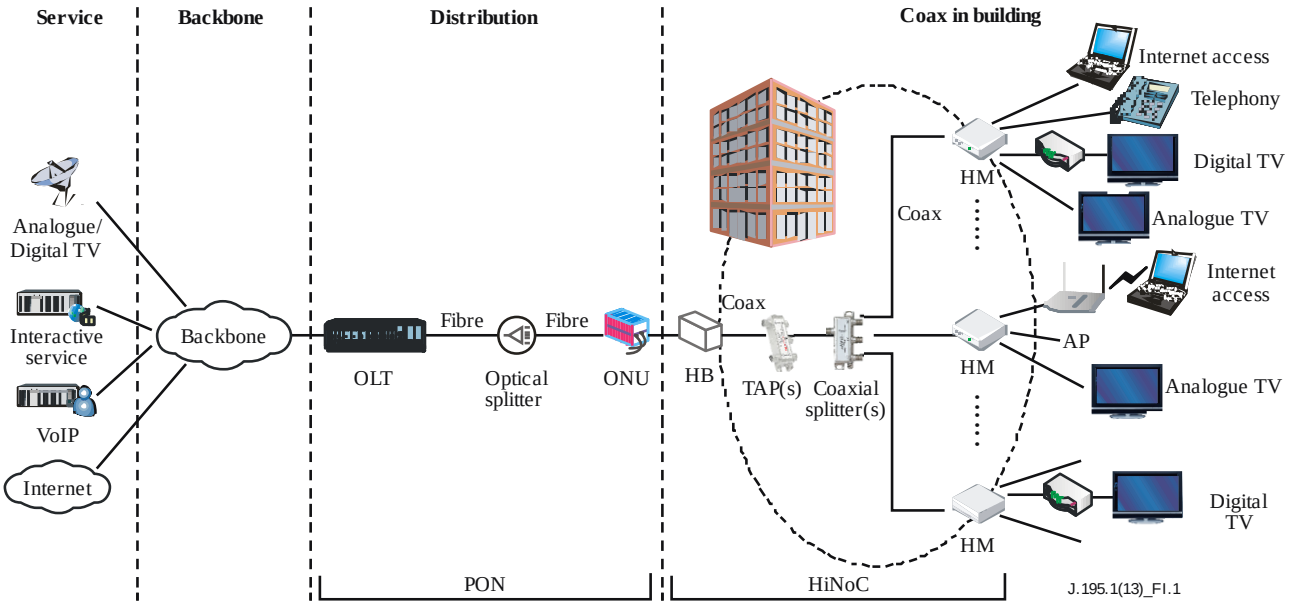

Figure I.1 – FTTB + Coax

HiNoC is a broadband access technology over Coax. It is designed to provide high performance bidirectional data transmission by improving the spectral efficiency of the cable.

The intended services such as IP traffic can be transferred transparently and bidirectionally over a passive coaxial access network. The overall transmission paths between the head-end and the customers are realized by the HiNoC system, which includes the HiNoC bridge (HB) at the head-end and HiNoC modem (HM) on the customer side. With reference to Figure 1 of clause 6 of this Recommendation, a HB is the device form of the master node and a HM is the device form of the client nodes.

As shown in Figure I.1, the coaxial distribution network deployed in the building can be composed of tap(s), distributer(s) and coaxial cable, which are all passive components. A wide frequency band of up to the 1.2 GHz frequency band can be used. The attenuation is limited due to the short-range transmission within a building.

Another channel characteristic in the coaxial network is the multipath reflection caused by the open branches and impedance mismatching, which results in deep fading points in the frequency domain.

OFDM technology, which is employed in HiNoC systems, is suitable in this scenario because of its immunity to the multipath effects.

There are several interference sources in the coaxial network, such as narrow-band interference, impulse interference and consumer electrical device interference. These interference noises originate from the home electricity or wireless signal crosstalk. As a result, in addition to the additive white Gaussian noise (AWGN) and the impulse noise, it is necessary to take the test results in the real coaxial network into account while building the channel model.

Since the HiNoC services are multiplexed in the frequency domain with the existing TV broadcasting services and IP data transmission services in the coaxial network, the transmit power density of HiNoC should satisfy the adjacent channel protection requirement. Several sub-carriers in the high frequency bands of each OFDM symbol are assigned as null to get a better roll-off performance in the HiNoC technology. The out-band interference is therefore greatly reduced.

There are three types of triple-play services (video, voice and data), each of which has its own specific performance requirements. For the video service, both broad bandwidth and low bit error rate (BER) are needed. However, for the voice service, real-time service is more important, which means lower latency and jitter and therefore the access system should be carefully designed to guarantee different QoS elements, such as priority, latency and jitter.

Due to the diversity and uncertainty of the future service, the characteristics of the service flow and the requirements of the network supporting capability are hard to predict. It is necessary for an access technology to make a real-time response dynamically according to the downstream and upstream bandwidth allocation. Therefore, time division duplexing (TDD) is the recommended solution.

To meet the tough demands for dedicated network resources management and diversified service-specific transmission requirements, the MAC mechanisms such as DBA and flow classifier should be adopted to ensure the different QoS requirements. Multicast is needed to save bandwidth costs. IPv4, IPv6 or both forms of IP addressing should also be supported in the HiNoC system.

Appendix II

Use cases of HiNoC

(This appendix does not form an integral part of this Recommendation.)

HiNoC networking use cases are presented in Figure II.1. In use case 1, PON transmits TV signals and IP services in one physical channel and the HB connects only to PON and supports the multi-services. In use case 2, the analogue/digital TV signal is from one physical channel and IP services are from the other physical channel. In use case 2, the HB has two ports to access to the multi-services, one for analogue/digital TV and the other for IP services. HiNoC supports the point-to-point unicast service and point-to-multi-point multicast services.

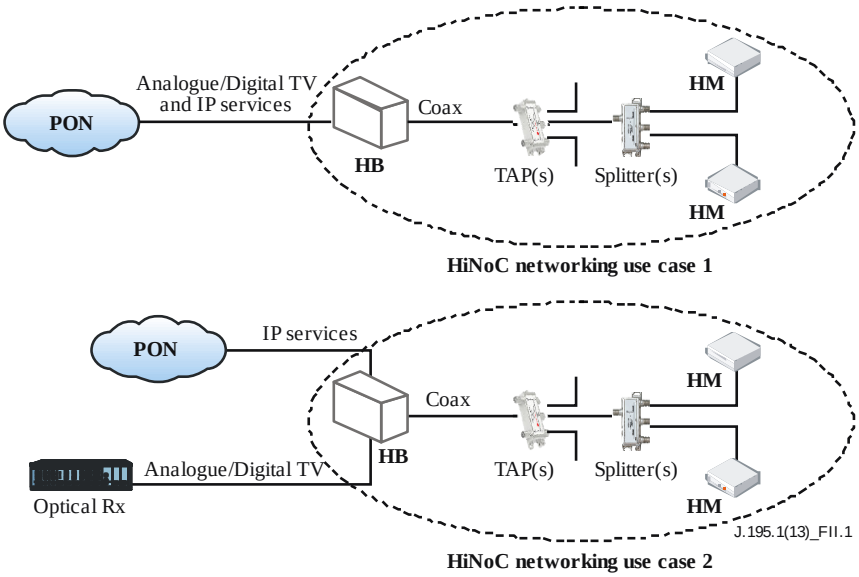

Figure II.1 – HiNoC networking use cases

HiNoC supports a 16 MHz bandwidth per channel and each channel can be deployed in any spectrum window below the 1.2 GHz frequency band and can be allocated beside or between the analogue TV, digital TV or data service channels. HiNoC signal transmission will not interfere with adjacent channels and supports channel bounding to provide a higher access rate. A HB supports up to 64 registered HMs.

HiNoC has several possible equipment models. For instance, the HB can be a single device and can be situated in an ONU of the PON as a module. The HM can also be a single transmission device and can be situated in a set-top box (STB) as a service terminal.

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