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ITU-T J.1600

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SERIES J: CABLE NETWORKS AND TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

Artificial intelligence (AI) assisted cable networks – General requirements for the AI-assisted cable network platform

Premium cable network platform – Framework

Recommendation ITU-T J.1600

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Premium cable network platform – Framework

Summary

Recommendation ITU-T J.1600 specifies the framework of the premium cable network platform (PCNP) for cable TV and broadband network that exploit cloud based artificial intelligence (AI) and network data to optimize network and TV services, thus enabling the high satisfaction of user's experience of perceptual aspects of services.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T J.1600	2019-10-07	9	11.1002/1000/13977

Keywords

AI, premium cable network platform, PCNP.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Premium cable network platform – Framework

1 Scope

This Recommendation supports the automation of the operation and maintenance for cable TV and broadband networks, typically the hybrid fibre coaxial (HFC), through the premium cable network platform (PCNP) embedded with intelligent analyser and controller (IAC).

It specifies the framework of the PCNP that exploits the cloud based artificial intelligence and network data to optimize network and television (TV) services, thus enabling the high satisfaction of user's experience of perceptual aspects of services.

This Recommendation also defines a number of functions and interfaces that may be supported by the platform to facilitate intelligent network operation and maintenance. The functions specified in this Recommendation provide the following key application features:

- Best aspect of rapidly providing basic network connection service;
- Best aspect of rapid troubleshooting for malfunction diagnostics in the network;
- Best aspects of optimizing configurations of the devices and services to meet customer satisfaction;
- Learning and prediction of customer requirements based on statistical network data;
- Carrying out the local or overall network migration plan, step by step, meeting customer requirements in an economical way.

The technologies specified in this Recommendation use the following key functionalities and capabilities:

- Network characteristics data collection and report from the integrated broadband cable network devices to the edge and centralized IACs;
- Configurable data analysis, inference and decision using network characteristics data inside IACs;
- Methods and associated data training and learning inside IACs;
- Characteristics database stored and maintained inside IACs;
- Application and adaptation of services management and operation to the results of the analyses.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI Artificial Intelligence
API Application Programming Interface
CD Characteristics Data
CDA CD Analyser
CDC CD Collector
CDDB CD Database
CM Cable Modem
CMTS Cable Modem Termination System
CPE Customer Premises Equipment
GDPR General Data Protection Regulation
HFC Hybrid Fibre Cable
IAC Intelligent Analyser and Controller
IMDB Intelligent Modelling Database
KPI Key Performance Indicator
MCE Management and Control Entity
OSS Operations Support System
PCNP Premium Cable Network Platform
STB Set-top Box
TCP Transmission Control Protocol
TV Television

5 Conventions

None.

6 Reference models

6.1 System reference model

This Recommendation covers the functions of the PCNP, the interfaces between the PCNP and integrated broadband cable network infrastructure (e.g., coaxial cable network, optical fibre network, HFC network, television (TV) network, etc.), and the corresponding functions of the devices deployed in the integrated broadband cable network infrastructure. These devices communicate with the PCNP

through the interfaces between the PCNP and integrated broadband cable network infrastructure. Figure 6-1 presents the functional reference model of PCNP.

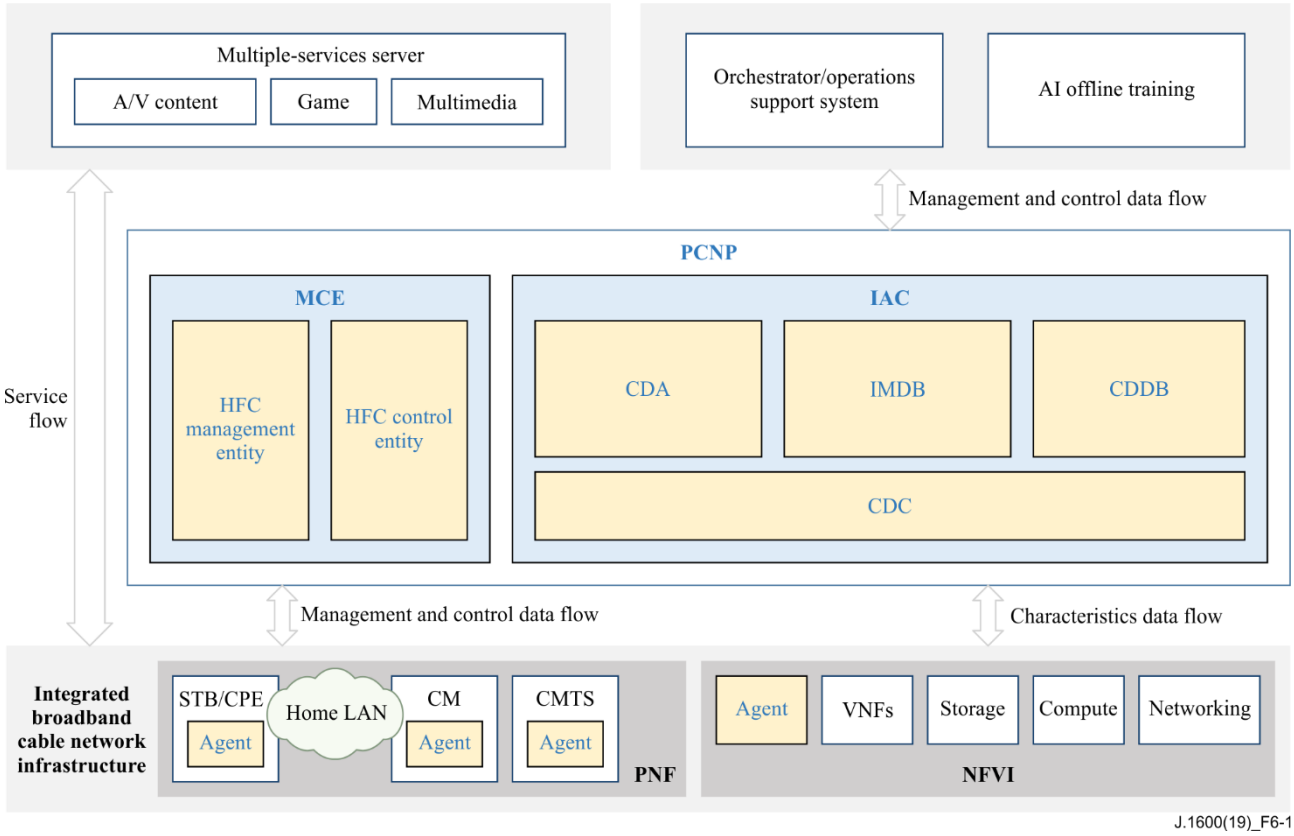

Figure 6-1 – PCNP reference model

The AI offline training may be implemented independently and is vendor or operator discretionary. The PCNP includes the management and control entity (MCE) and IAC. In the management and control plane, for basic broadband services and TV services, the MCE configures, controls, and operates the integrated broadband cable network and devices, including the cable modem termination system (CMTS), cable modem (CM), customer premises equipment (CPE), set-top box (STB) and other functional devices in the integrated broadband cable network infrastructure.

In addition to the basic services, the IAC is configured to perform advanced analyses to enable the integrated broadband operation and maintenance automation. The IAC operates based on the characteristics data (CD) generated in the integrated broadband cable network. The CD is the useful data representing the static or dynamic characteristics of entire networks, including devices and information stream. The IAC comprises characteristics data collector (CDC), characteristics data analyser (CDA), intelligent modelling database (IMDB) and the characteristics data database (CDDB) to implement efficient advanced analyses. Furthermore, the IAC may be divided into real-time and offline ones, where the real-time IAC may focus on normal and real-time analyses while the offline IAC may focus on complicated and offline analyses, respectively.

The PCNP operates with physical or virtualized network. To support the basic and advanced services, the integrated broadband cable network devices comprise agents to exchange requested or subscribed data with the IAC. The agent may further comprise local intelligent units to facilitate the network automation. The agent may be virtualized into the virtualized network to provide agent functionality.

6.2 Application reference models

Implementations can comply with this Recommendation using centralized IACs. In the centralized implementation, the PCNP (see Figure 6-1) is deployed in a single physical entity. Implementations

can also comply with this Recommendation using distributed IACs, especially distributed CDCs. The distributed CDCs may be further grouped with distributed MCEs to perform both management and collection functions.

6.2.1 Service specific distributed IAC

Figure 6-2 provides an overview of a distributed implementation of the PCNP from a service aspect.

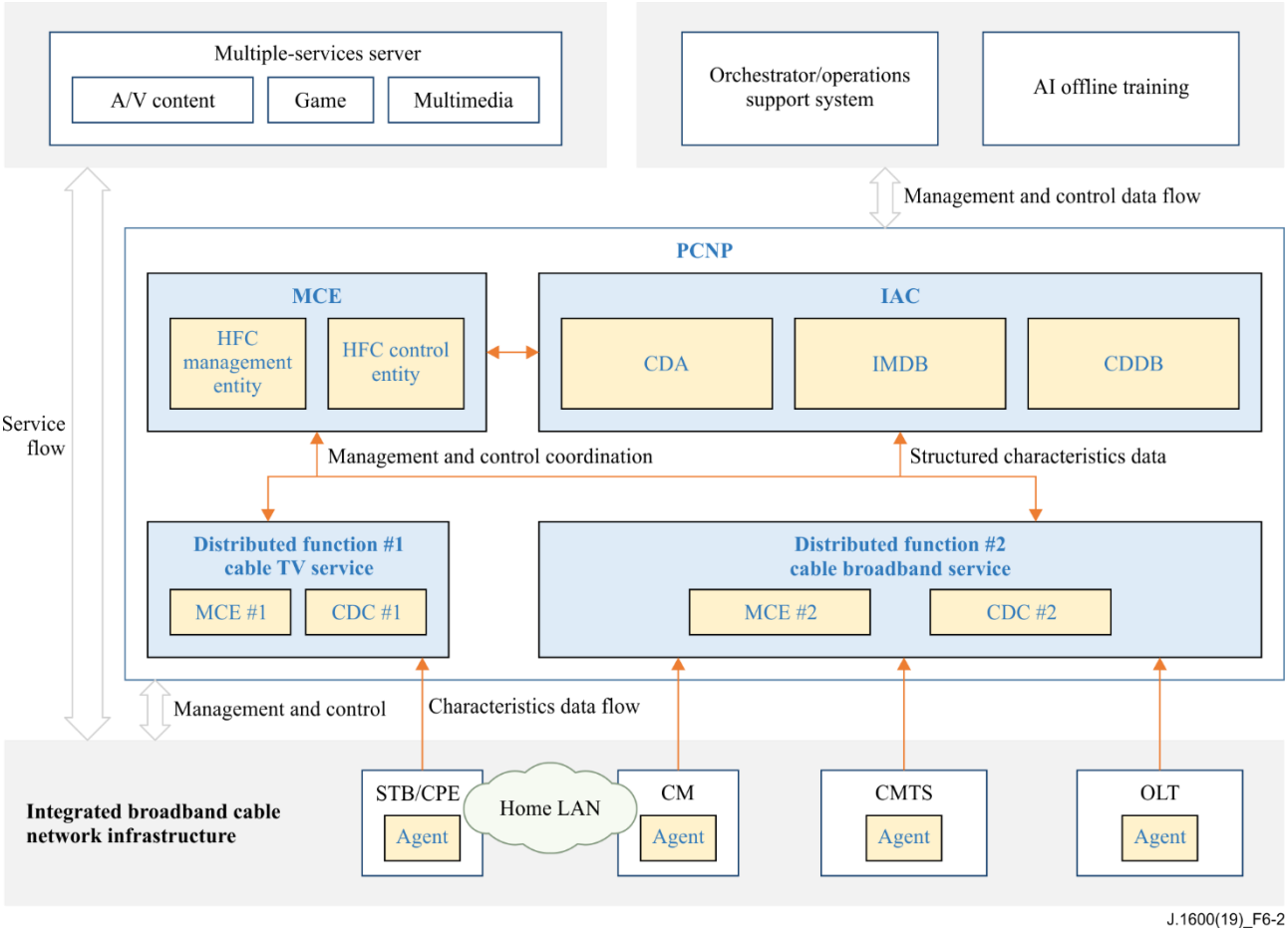

Figure 6-2 – Distributed PCNP

Distributed function 1 is for cable TV services, while distributed function 2 is for cable broadband services.

6.2.2 Network specific distributed IAC

Figure 6-3 provides an overview of a distributed implementation of the PCNP from a network aspect.

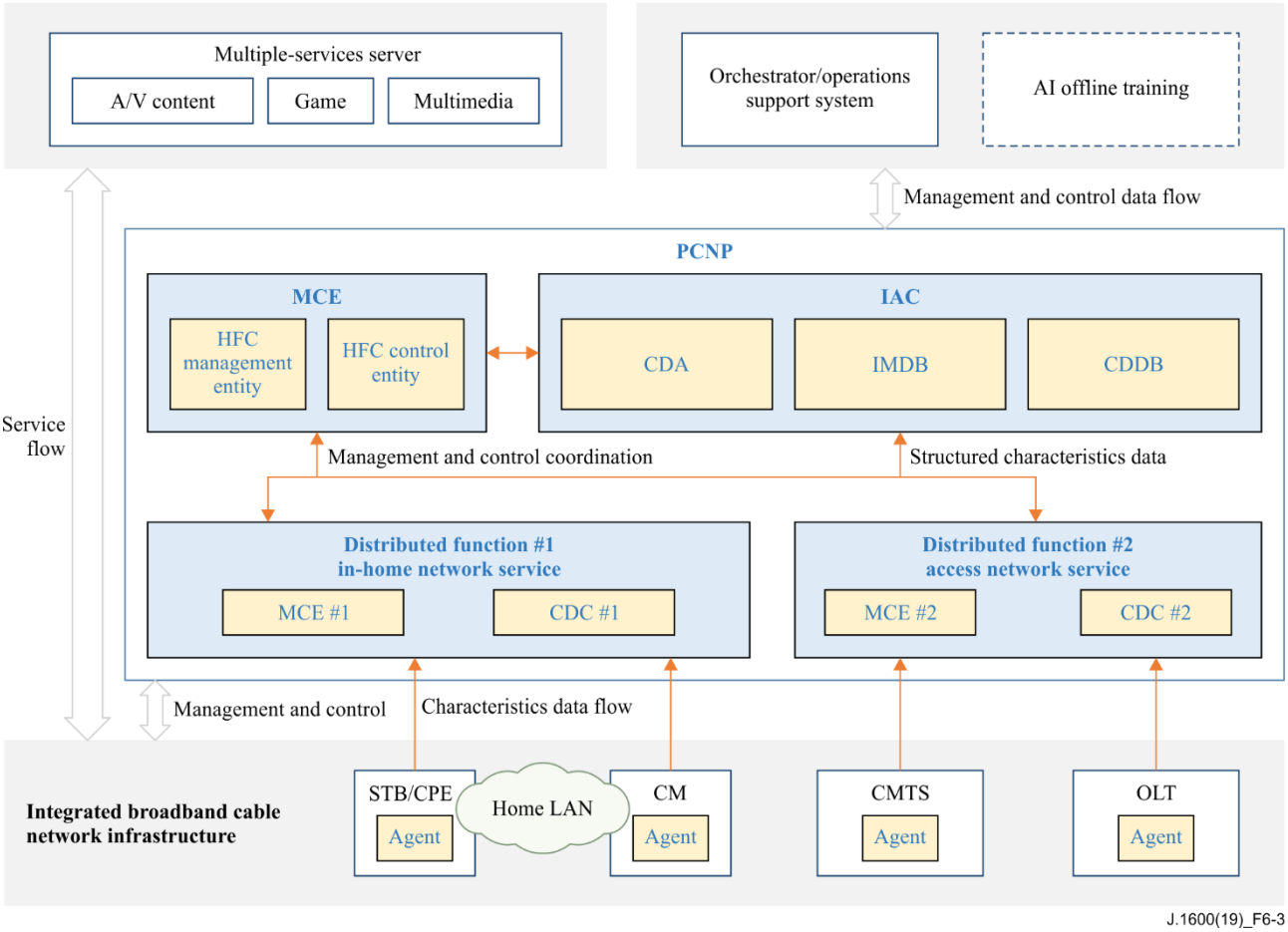

Figure 6-3 – Distributed PCNP

Distributed function 1 is for in-home network services, while distributed function 2 is for access network services.

7 Generic architecture

7.1 Management and control entity

The PCNP supports basic operation and management services by the MCE. The MCE can also collaborate with the IAC to enable a closed-loop automation system by sharing related information and instructions. Specifically, the MCE may share information such as network topology and configurations to the IAC to facilitate the analysis, and the IAC sends the optimization instructions to the MCE to reconfigure and optimize the integrated broadband cable network. Protocols, e.g., [b-BBF TR-069] are used for executing management and control. The MCE and the peer device shall support the same protocol to facilitate proper communication with each other.

Coordinated with the IAC, the MCE may instruct devices in the integrated broadband cable infrastructure to publish CD to the IAC, see clause 7.2.

7.2 Intelligent analyser and controller

The IACs are utilized to support advanced operation and management services. The IAC is typically deployed at the centralized cloud server. Additionally, some functional modules can be deployed at multiple network edge entities without impacting the logical integration of analyses functions. The central and distributed parts shall be capable of communicating and coordinating with each other to perform dynamical consecutive network optimization.

At the southbound interface, the IAC collects network characteristics data from integrated broadband cable network devices. Those characteristics data are monitored, measured, processed or packaged by the agent in the network devices. The IAC and the agent shall support the same communication protocol stack and data model for transmission of packaged characteristics data. The IAC shall trigger capability negotiation, exchange and selection with the agent to determine the specific protocol stack for the transmission of characteristics data.

Through the northbound interface of PNCP, the IAC communicates with the operations support system (OSS) or higher-level controller or orchestrator.

To fulfil the advanced operation and management services, the IAC shall support the data collection and analyses functionalities. The functional model of the IAC is shown in Figure 7-1.

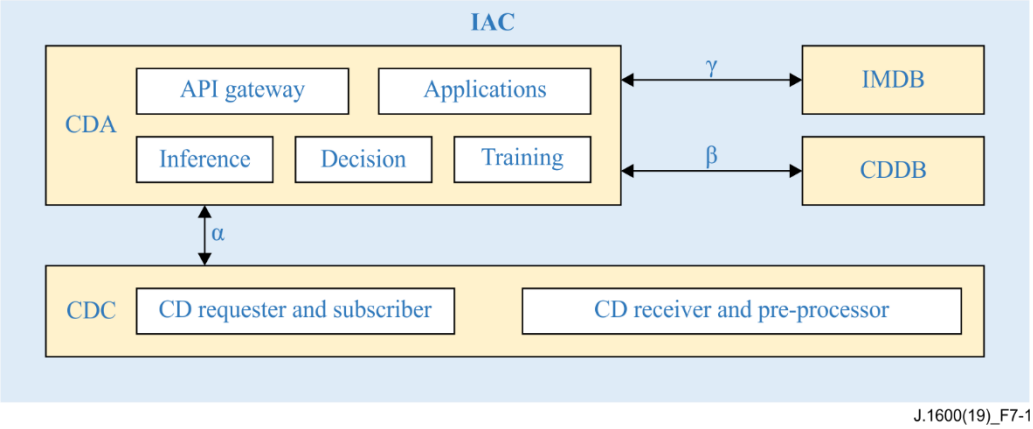

Figure 7-1 – IAC functional model

Inside the IAC, the CDA is used for data analyses and analytical results application, while the CDC is used for receiving and generating structured data. Besides, the CDDB and IMDB maintains corresponding parameters and methods for data analyses, respectively. Methods and parameters in IMDB and CDDB are vendor discretionary.

The CDA communicates with CDC, CDDB and IMDB via the α, β and γ interfaces, respectively. Those interfaces serve as logical functional descriptions, and are vendor discretionary. For a given analysis task, the CDA requests corresponding structured analytical data inputs, parameters and methods from the CDC, CDDB and IMDB via the α, β and γ interfaces, respectively.

The CDA implements analyses. During implementing data analyses, the training functional module may generate, update or remove parameters in the CDDB to improve the usage range and precision of those parameters. Besides, the training functional module may generate, update or remove methods in the IMDB. The CDA further generates analytical results and instructions of optimization policies. The instructions may be sent to the MCE for network configuration, enabling a close-loop automation system. In the cases where cross-domain decision making or end-to-end analysis is required, the CDA sends the analytical results or policies to the higher level decision system for further processing.

The IAC may be connected to one or more upper level orchestrators or OSSs via the application programming interface (API) gateway included in the CDA, to support the upper level management and orchestration. The API gateway provides the unified northbound interface for the provision of advanced services. The application module in the CDA, through the API gateway, provides multiple utilities to various OSS systems which subscribe services from the IAC. Other functions of the northbound interface are for further study.

NOTE 1 – For simplification management, the northbound interface may support the REST protocol.

NOTE 2 – The utilities may cover intelligent operation and management, user experience management, precise marketing and other advanced services.

Through the CD requester and subscriber, the CDC obtains CD from the integrated broadband cable network infrastructure. The CD receiver and pre-processor receives and processes the CD into the proper structure and forward the data to the CDA. In some cases, the devices may be directly assigned by the MCE for the CD subscription and publish to the CDC.

7.2.1 AI modelling

The IAC shall support the AI modelling functionality. It provides AI online training, AI model and algorithm management.

7.2.2 Offline training

In addition to the AI online training, the PCNP architecture also supports the AI offline training, especially if the AI online training is not implemented or the online training requires offline training results as a supplement.

NOTE – With the offline training, the IAC can further utilize services and knowledge from public cloud. It can therefore reduce the complexity of the IAC.

7.3 Agent

Throughout the entire integrated broadband cable network, each device and each link transmits information continuously. The amount of raw data used to extract the CD is huge. Transmission of that raw data to the CDC is not only unnecessary but also harmful to the user or the network because of the risk of leakage of private user data or congestion of the user data traffic. To achieve efficient and sufficient CD transmission, the agent inside the device in the integrated broadband cable network pre-processes the physical and logical information of the device (e.g., temperature, time, buffer utilization and power consumption) and the network information of the link (e.g., data rates, protocols and latency) including extracting, encoding, compacting and packaging. In order to further improve the data efficiency and reduce the complexity of the network and IAC, the agent should be capable of implementing pre-processing of the CD, which may include at least one or more of the following processes: data format converting, data masking, data complementing, data serialization, data compression, and data tailoring.

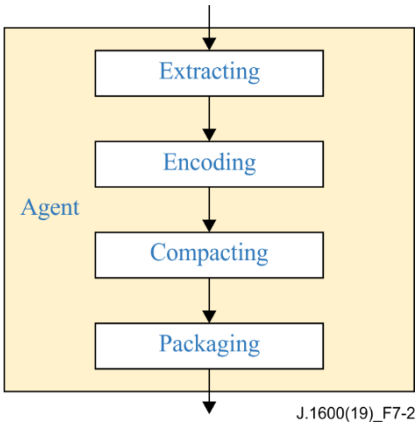

Figure 7-2 – Pre-processing inside the agent

8 Functional requirements

8.1 Network control and service configuration

The MCE shall be capable of managing, configuring, controlling, and monitoring tasks for the devices in the integrated broadband cable network infrastructure and shall also be capable of applying policy to the integrated broadband cable network.

8.2 Network characteristics data collection

The CDC shall be capable of implementing the pre-processing of the CD. The pre-processing shall support at least one of the following functions:

- **Data extracting and compacting**: In this function, the redundancies are removed to reduce the volume of data.
- **Data complementing**: The pre-processor completes the data in case there is a deficiency during the data collection.
- **Data serializing**: In this function, structured object data are mapped to the bytes stream for transmission and storage in the network.
- **Data aggregation**: For a given analysis, the CDC may collect CD from multiple devices. Those CD may have a correlation with each other, thus may be aggregated and transmitted. It further includes the sub-processes of searching, gathering and presenting data.
- **Privacy removing**: Based on the privacy policy, only the non-privacy part of the data are retained to protect the privacy information.
- **Data format converting**: The pre-processor may convert various data format to another specific format for use.

NOTE – For example, the pre-processor may convert the text format to binary format for automatic machine learning.

- **Service index computation**: The pre-processor may calculate key indexes of services, e.g., the key performance indicator (KPI) of the transmission control protocol (TCP) link.

The scope of the CDC includes devices and links in the integrated broadband cable network, and also virtual elements (e.g., computation, storage and networking) in the virtualized network. Collected data covers the characteristics from the physical layer to the application layer excluding any user privacy data.

For data collection, the CDC shall support the GRPC/GPB-based telemetry that is a subscribe-publish mechanism. The CDC may support other subscribe-publish mechanisms. The CDC may support other subscribe-publish mechanisms (e.g., SNMP, CLI, and sFLOW) according to the integrated broadband cable network capabilities. Furthermore, to enable efficient data collection and processing, the CDC shall be capable of adapting different request-acknowledge mechanisms to a unified mechanism preferably GRPC/GPB-based telemetry. If an integrated broadband cable network device does not support the unified mechanism, the adaption function shall translate subscription instructions under the unified mechanism received from the CDC to specific instructions under one or more mechanisms (e.g., SNMP) which are supported by the integrated broadband cable network device. Correspondingly, the adaption function also converts the format of data from integrated broadband cable network devices to the format under the unified mechanism before sending them to the CDC. This adaption function may be performed by the CDC or the agent addressed in clause 7.3.

NOTE – Compared to the traditional request-acknowledge mechanism (e.g., SNMP), the GRPC/GPB-based telemetry is a subscribe-publish mechanism and is capable of transmitting massive fine granularity real-time data with a shorter collection period.

8.3 Characteristics data analysis

The PCNP differs from other platform as it uses IAC to maximize the gain by means of artificial intelligence and machine learning for a variety of application spectrum. The IAC incorporates the structured data into the existing method with selected parameters and outputs the suggestions that may be further applied by the MCE. The IAC shall not use any user privacy data.

NOTE 1 – To facilitate the cable TV service provider to continuously monitor or even optimize the performance of the service, the IAC can, in a regulated way, figure out the peak time curve of a specific link during a day or month or year, understand how large the peak and average requirements is, learn how popular a particular TV show/series is, understand customers' video watching habits or behaviours (e.g., what kind of

services a customer is usually immersed in), and enable corresponding customized value-added services or precision marketing.

NOTE 2 – The IAC can also be used for analysing other broadband access and in-home services, e.g., uplink and downlink rates, delay, and packet loss rate. Analytical results are used for improving network configurations.

NOTE 3 –It is expected that, by long time CD collection, analyses and network optimization application, the user experience can be remarkably increased.

8.4 Synthesized function

Figure 8-1 provides the synthesized function of using the PCNP, including IAC and MCE to optimize the integrated broadband cable network.

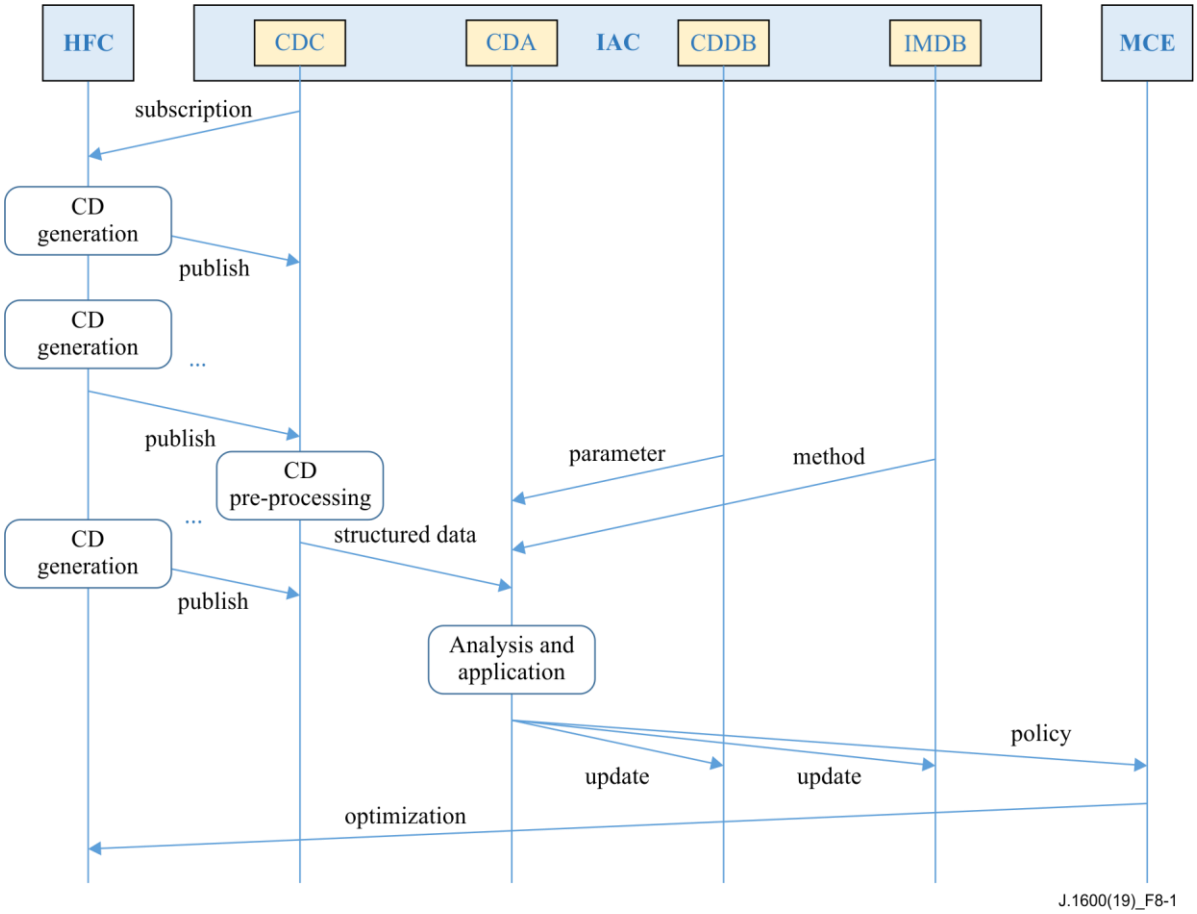

Figure 8-1 – The synthesized function for advanced services

The IAC subscribes data from integrated broadband cable network, and further processes the data via analytical tools. As an application, optimizations are addressed to the integrated broadband cable network.

Appendix I

Privacy data

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

I.1 Introduction

This appendix originates from the general data protection regulation (GDPR). The GDPR specifications are available on the European Commission website[b-EC].

I.2 Privacy data

In this Recommendation privacy data refers to personal data. A clear definition of what constitutes personal data is provided in the following extraction from the website of the European Commission:

Personal data is any information that relates to an identified or identifiable living individual. Different pieces of information, which collected together can lead to the identification of a particular person, also constitute personal data.

Personal data that has been de-identified, encrypted or pseudonymised but can be used to re-identify a person remains personal data and falls within the scope of the law.

Personal data that has been rendered anonymous in such a way that the individual is not or no longer identifiable is no longer considered personal data. For data to be truly anonymised, the anonymisation must be irreversible.

The law protects personal data regardless of the technology used for processing that data – it is technology neutral and applies to both automated and manual processing, provided the data is organised in accordance with pre-defined criteria (for example alphabetical order). It also does not matter how the data is stored – in an IT system, through video surveillance, or on paper; in all cases, personal data is subject to the protection requirements set out in the GDPR.

Examples of personal data:

– a name and surname;
– a home address;
– an email address such as name.surname@company.com;
– an identification card number;
– location data (for example the location data function on a mobile phone)*;
– an Internet Protocol (IP) address;
– a cookie ID*;
– the advertising identifier of your phone;
– data held by a hospital or doctor, which could be a symbol that uniquely identifies a person.

*Note that in some cases, there is a specific sectorial legislation regulating for instance the use of location data or the use of cookies – the ePrivacy Directive (Directive 2002/58/EC of the European Parliament and of the Council of 12 July 2002 (OJ L 201, 31.7.2002, p. 37) and Regulation (EC) No. 2006/2004) of the European Parliament and of the Council of 27 October 2004 (OJ L 364, 9.12.2004, p. 1).

Examples of data not considered personal data:

– a company registration number;
– an email address such as info@company.com;
– anonymised data.

Bibliography

[b-BBF] Broadband forum TR-069 (2007), *CPE WAN Management Protocol v1.1*.

[b-EC] European Commission, *What is personal Data?*
https://ec.europa.eu/info/law/law-topic/data-protection/reform/what-personal-data_en

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