ITUPublications
Recommendations

International Telecommunication Union
Standardization Sector

Recommendation

ITU-T F.748.22 (09/2023)

SERIES F: Non-telephone telecommunication services

Multimedia services

Functional architecture for feature-based distributed intelligent systems

ITU-T F-SERIES RECOMMENDATIONS

Non-telephone telecommunication services

TELEGRAPH SERVICE	F.1-F.109
Operating methods for the international public telegram service	F.1-F.19
The gentex network	F.20-F.29
Message switching	F.30-F.39
The international telemessage service	F.40-F.58
The international telex service	F.59-F.89
Statistics and publications on international telegraph services	F.90-F.99
Scheduled and leased communication services	F.100-F.104
Phototelegraph service	F.105-F.109
MOBILE SERVICE	F.110-F.159
Mobile services and multidestination satellite services	F.110-F.159
TELEMATIC SERVICES	F.160-F.399
Public facsimile service	F.160-F.199
Teletex service	F.200-F.299
Videotex service	F.300-F.349
General provisions for telematic services	F.350-F.399
MESSAGE HANDLING SERVICES	F.400-F.499
DIRECTORY SERVICES	F.500-F.549
DOCUMENT COMMUNICATION	F.550-F.599
Document communication	F.550-F.579
Programming communication interfaces	F.580-F.599
DATA TRANSMISSION SERVICES	F.600-F.699
MULTIMEDIA SERVICES	**F.700-F.799**
ISDN SERVICES	F.800-F.849
UNIVERSAL PERSONAL TELECOMMUNICATION	F.850-F.899
ACCESSIBILITY AND HUMAN FACTORS	F.900-F.999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T F.748.22

Functional architecture for feature-based distributed intelligent systems

Summary

Recommendation ITU-T F.748.22 defines the architecture, the functional entities, and the reference points for feature-based distributed intelligent systems.

History*

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T F.748.22	2023-09-13	16	11.1002/1000/15621

Keywords

Feature, functional architecture, functional entity, intelligent system, reference point.

* To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents/software copyrights, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the appropriate ITU-T databases available via the ITU-T website at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T F.748.22

Functional architecture for feature-based distributed intelligent systems

1 Scope

This Recommendation defines the architecture, the reference points and the functional entities and their relationships in feature-based distributed intelligent systems (FDIS).

The scope of this Recommendation includes:

– The architecture for feature-based distributed intelligent systems.

– The functional entities and their relationships with feature-based distributed intelligent systems.

– The reference points in feature-based distributed intelligent systems.

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.

[ITU-T F.748.11] Recommendation ITU-T F.748.11 (2020), *Metrics and evaluation methods for a deep neural network processor benchmark*.

[ITU-T F.748.21] Recommendation ITU-T F.748.21 (2022), *Requirements and framework for feature-based distributed intelligent systems*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 front-end equipment [b-ITU-T K.142]: Outdoor camera and associated ancillary equipment.

3.1.2 premises unit [b-ITU-T F.743]: A device located at the remote part of a video surveillance system and used to capture multimedia information (such as audio, video, image, alarm signal, etc.) from a surveilled object.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API Application Programming Interface

ASF Audio Sensor Function

DPF Data Preparation Function

DPPF Data Preprocessing Function

DSF Data Storage Function

FCF Feature Compression Function

FDF Feature Decoding Function

FDIS Feature-based Distributed Intelligent Systems

FEF Feature Encoding Function

FXF Feature Extraction Function

IAAF Intelligent Audio Algorithm Function

ITS Intelligent Traffic Systems

IVAF Intelligent Video Algorithm Function

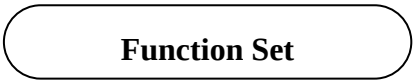
NLP Natural Language Processing

VSF Video Sensor Function

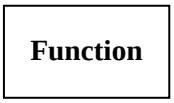
5 Conventions

In this Recommendation:

Function set: In the context of FDIS architecture, "function set" are defined as a collection of functionalities. It is represented by the following symbol:



Function: In the context of FDIS architecture, a "function" is defined as a group of functionalities that has not been further subdivided at the level of detail described in this Recommendation. It is represented by the following symbol:



6 Overview of feature-based intelligent applications

Feature-based distributed intelligent systems (FDIS) extract and transmit features instead of original data, i.e., video, audio, text, point cloud, etc. Compared to intelligent systems that are based on original multimedia data, which require a large amount of storage and transmission bandwidth and offer limited technological solutions that use multimedia coding to reduce data volume, FDIS could save bandwidth by extracting only the effective information from multimedia data.

In some latency sensitive intelligent systems, i.e., autonomous driving and industrial detection and control, it is crucial to process the data in real-time. Using features in addition to original data might allow fast searching and other artificial intelligence (AI) tasks. FDIS is able to reduce the latency in some scenarios.

Feature-based intelligent applications are applications that utilize feature data extracted from real-world scenarios for machine learning and processing. FDIS is a type of distributed intelligence system.

7 A functional architecture for feature-based distributed intelligent systems

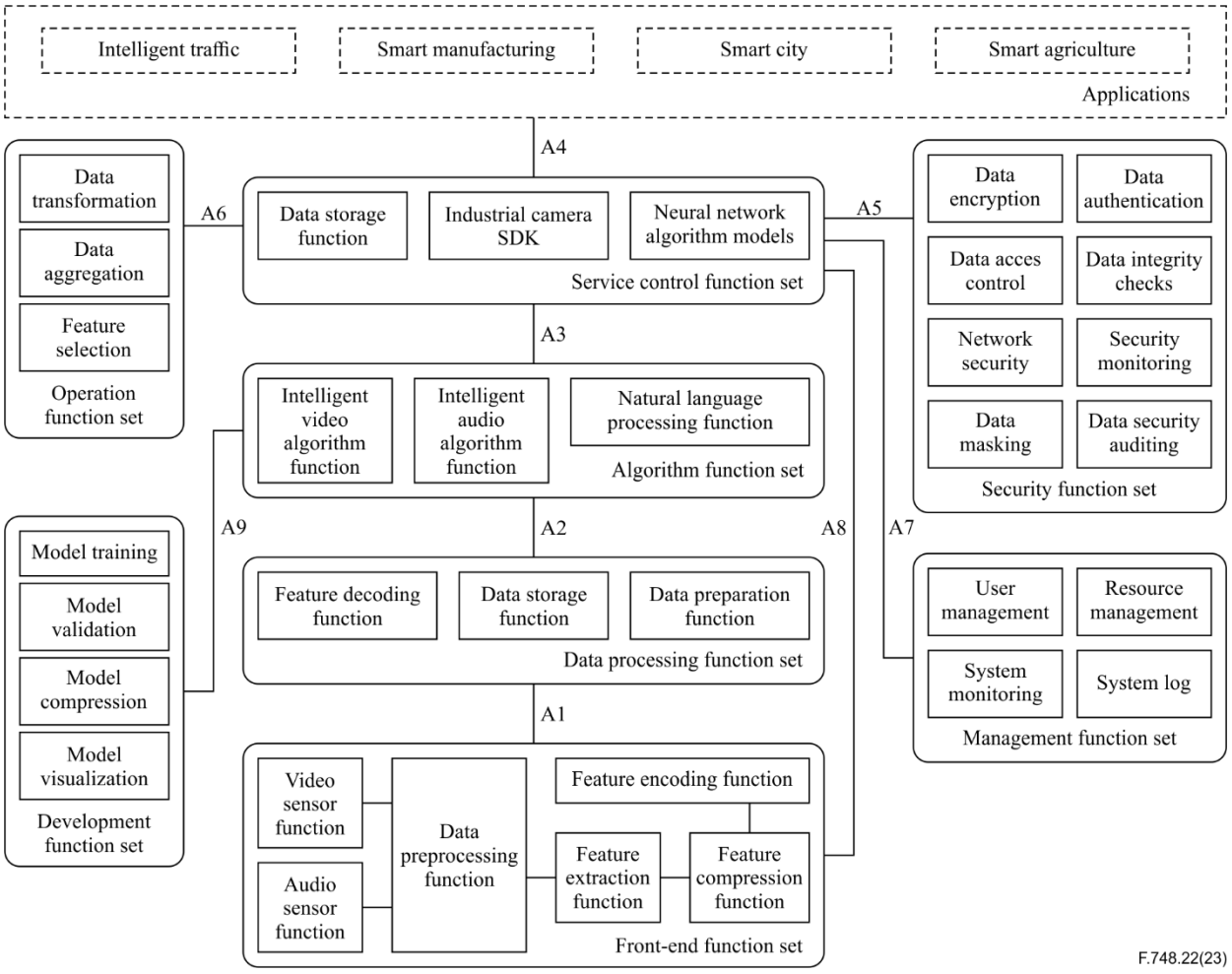


Figure 1 – A functional architecture for feature-based distributed intelligent systems

A functional architecture for FDIS, as shown in Figure 1, is composed of a front-end function set, a data processing function set, an algorithm function set, applications, a service control function set, an operation function set, a management function set, and a security function set.

The front-end function set (normally mapping to the front-end equipment) has the ability to capture, process, and compress the signal. The front-end function set also has the ability to pre-process, extract features, and encode data.

The data processing function set provides the ability to decode data, store data, and prepare data.

The algorithm function set provides algorithms for machine tasks, data storage, and data evaluation.

The development function set provides the ability of model training, model validation, model compression, and model visualization.

The applications provide the capability to implement machine tasks from the original data and/or from the feature data.

The service control function set provides abilities for users to control the service of the FDIS.

The operation function set provides the ability to manage and monitor the operation status of the system.

The management function set provides the ability to manage different parts of the feature-based distributed intelligent system.

The security function set provides capabilities for system security.

8 Functional entities

8.1 Front-end function set

The front-end function set (normally mapping to the front-end equipment) has the ability to capture, process, and compress the signal. Sensors capture and output the digital signals. Based on the target needs, users can choose which pre-processing methods and which kinds of features to be used for the captured signal. The features are then extracted accordingly and then encoded and sent to the application or service via a network by the front-end equipment. The front-end function set includes the video sensor function, audio sensor function, data preprocessing function, feature extraction function, feature compression function, and feature encoding function.

The video sensor function (VSF) captures the visual signal from the real world in raw format. The VSF could be a camera, camera system, or other imaging device that enables it to detect motion and capture it as a series of still images or video footage. Features could be extracted to detect motion of people or objects without detecting the identity of the people, alerting a user to potential security risks or allowing them to capture footage of an event. VSF could also be used to trigger an alarm or alert when motion is detected. Depending on the configuration, an alarm is triggered manually or automatically, with sensitivity and other settings that are adjusted to meet specific needs.

The audio sensor function (ASF) captures the audio signal from real-world scenarios and processes the signal in raw format. The ASF could be an audio sound transducer, a microphone, microphone systems, or other audio recording devices that detect sound and capture it as audio files. This module is used to detect sound from people or objects without detecting the identity of the people, alerting a user of potential security risks or allowing them to capture recordings of an event. ASF could also trigger an alarm or alert when sound is detected. Depending on the configuration, an alarm is triggered manually or automatically, with sensitivity and other settings that are adjusted to meet specific needs.

The data preprocessing function (DPPF) is responsible for transforming the captured video/audio data to a format that is suitable for subsequent processing required by users. This function supports multiple pre-processing methods, such as down/up-sampling, filtering, denoising, demosaicing, cropping, and format transformation. DPPF prepares data for analysis by cleaning, transforming, and organizing, and comprises auto functions that help deliver an enhanced signal.

The feature extraction function (FXF) is used to extract the relevant and informative features from preprocessed data. However the extracted features may be high dimensional and computationally expensive. Therefore, it can be beneficial to apply a feature compression function to reduce the number of features while maintaining as much information as possible.

The feature compression function (FCF) is used to reduce the data volume of the features by selecting a subset of the informative features, combining or transforming them, or using other techniques to reduce the redundancy in features. It improves the efficiency and performance of the system while maintaining the accuracy and quality of the results. FCF is a process of reducing the size of the extracted features while preserving the same level of accuracy or performance, making it more efficient for storage and analysis. There are a variety of methods for performing feature compression, including principal component analysis, singular value decomposition, and linear discriminant analysis.

The feature encoding function (FEF) consists of feature conversion and a video encoder. It encodes the extracted features into compact binary bitstreams then compresses the feature using a video codec. The feature conversion module transforms data into a format that a traditional video codec can process. When the input is video, the FEF is equal to the video encoder. It is designed to be compatible with the video coding system.

8.2 Data processing function set

The data domain provides the ability to process, store, and prepare data for applications or services.

The feature decoding function (FDF) corresponds to the feature compression function (FCF) in the front-end function set and is responsible for decoding/decompressing bitstreams to reconstructed features. These reconstructed features are then prepared and sent to the application or service to perform machine tasks. FDF is the process of converting encoded data back into its original form. This is typically done after the data has been encoded or transformed, such as with feature encoding, feature conversion. FDF restores the original format of the data, which is used for further analysation or display.

The data storage function (DSF) has two responsibilities: managing and storing the compressed bitstream of features in a well-managed file format, which enables random access, fast search, and reorganization of the compressed feature data, and storing the reconstructed features in their original formats suitable for implementing machine tasks. DSF is used to store data in a structured format. This includes storing data in a database or other data storage system. DSF helps to ensure that data is organized and protected, making it easier to access and analyse. DSF is also used to store data in multiple formats, such as text, images, and videos, allowing for more efficient analysis and management.

Lastly, the data preparation function (DPF) prepares the reconstructed feature data for transport to the application domain or service domain. DPF is used to clean, organize, and transform data before it is used for analysis. This module involves cleaning the data of errors or outliers, and transforming and organizing it in a way suitable for analysis. DPF is also used to combine data from different sources to create a dataset. After the data has been prepared, it is used for further analysis and to create predictive models.

8.3 Algorithm function set

An algorithm function set is a group of computer algorithms used to process and interpret data. These algorithms are used to create, predict, recognize, analyse or understand the content. Algorithm function sets include algorithms for video, image, audio, natural language processing, and data mining. The algorithms used in a function set will depend on the type of data being processed and the applications.

The intelligent video algorithm function (IVAF) comprises a set of algorithms targeting processing of video data and features extracted from video data. IVAF is a type of computer algorithm used to process and interpret video data. This algorithm is used to detect motion, analyse actions, or recognize objects in a video. The algorithm is also be used to create predictive models, such as predicting the outcome of a video or the likelihood of a certain event.

The intelligent audio algorithm function (IAAF) provides algorithms focusing on audio data and features extracted from audio data. IAAF is a type of computer algorithm used to process and interpret audio data. This algorithm is used to detect sound, analyse speech, or recognize words in a recording. The algorithm is also used to create predictive models, such as predicting the outcome of a recording or the likelihood of a certain event.

Natural language processing (NLP) is a field of artificial intelligence (AI) that focuses on enabling machines to understand, interpret, and respond to natural language, such as written or spoken language used by humans in everyday communication. In feature-based intelligent systems, NLP plays a role in identifying relevant features in natural language and using them to make intelligent guesses or decisions. For instance, NLP can help in sentiment analysis where it identifies the emotions that are expressed in a text to determine whether it is positive or negative.

8.4 Service control function set

The service control function set provides abilities for users to control the service of the FDIS, including activating services, deactivating services, requesting service access and managing service resources.

A service control function set in FDIS is a set of functions including access registration, access authentication, identification, authorization, location, presence, data flow control and clock synchronization.

8.5 Operation function set

The operation function set provides the ability to manage and monitor the operation status of the system, including service performance, resource usage, and operation log, etc.

Feature selection: The feature selection module has capabilities including feature categorization management, pre-processing selection, compression selection, feature extraction selection, analysis algorithm selection. It supports users choosing different data pre-processing algorithms, such as down/up-sampling, filtering, denoising, cropping, and different features, defined in [ITU-T F.748.11], to be extracted as well as related feature extraction algorithms, compression algorithms and analysis algorithms.

Data transformation: The data transformation module has capabilities including feature format transformation. It supports transforming of different features, defined in [ITU-T F.748.11], to be stored and transmitted for analysis and display.

Data aggregation: The data aggregation module has capabilities including feature concatenation, feature layering, feature splitting. It supports concatenate, layer and split features according to the configuration of feature selection, and thus applies to different feature decoding and analysis algorithms.

8.6 Management function set

The management function set provides the ability to manage different parts of the feature-based distributed intelligent system, including managing device configurations and resources. It also provides the capability for users to control or customize the system components in order to optimize the system performance or to meet specific requirements. The management functions in FDIS include:

– User management
– Resource management
– System monitoring: system configuration, system deployment, system optimization
– System log.

8.7 Security function set

The security function set provides capabilities for system security, such as encryption, data protection, access control, intrusion detection and response. It also provides capabilities to detect malicious behaviours and protect data stored within the system. The security functions in FDIS include:

– Data encryption
– Data authentication
– Data access control
– Data integrity checks
– Network security

– Security monitoring
– Data masking
– Data security auditing.

8.8 Development function set

The development function set involves the process of building a model that can predict outputs based on inputs. This process involves using a training dataset to train the model, which involves adjusting the model's parameters based on the data to improve its accuracy. The model is tested on a separate testing dataset to evaluate how well it performs on new, unseen data. The results of the testing are used to refine the model and improve its accuracy.

Some development functions in a feature-based distributed intelligent system are recommended to include:

– Model training
– Model validation
– Model compression
– Model visualization.

8.9 Applications

The applications implement machine tasks from the feature data. FDIS are employed across various industries and domains to perform complex tasks that require advanced computational capabilities and decision-making skills. Some application functions in a feature-based distributed intelligent system are recommended to include:

Intelligent traffic: FDIS can be used to extract features from traffic data such as vehicle speed, density, and volume, and use machine learning algorithms to optimize traffic flow, detect accidents or road closures, and improve safety. Applications of intelligent traffic include traffic management, urban planning, and logistics.

Smart manufacturing: FDIS can be used to extract features from manufacturing data such as machine performance, energy usage, and product quality, and use machine learning algorithms to optimize production processes, monitor equipment health, and predict equipment failures. Applications of smart manufacturing include predictive maintenance, quality control, and supply chain optimization.

Smart city: FDIS can be applied to analyse and process large amounts of data from various sources to optimize urban infrastructure and improve quality of life. FDIS can be used to extract features from data such as traffic, air quality, and energy consumption, and adopt machine learning algorithms to optimize transportation systems, reduce energy use, and improve public safety. Applications of smart city include traffic management, waste management, energy efficiency, and urban planning. FDIS can help city planners making decisions about infrastructure improvements, reducing energy consumption and greenhouse gas emissions, and improving the quality of life for residents.

Smart agriculture: FDIS can be applied to extract features from agricultural data such as soil moisture, temperature, and nutrient levels, and use machine learning algorithms to optimize crop yields, monitor plant health and predict crop diseases. Applications of smart agriculture include precision farming, crop management, and resource conservation. The use of feature-based intelligent systems in agriculture can help farmers make informed decisions about planting, fertilizing, watering and harvesting their crops, leading to increased productivity, cost savings and environmental sustainability.

9 Reference points

9.1 Reference point A1

Reference point A1 lies between the front-end function set and the data processing function set.

It is used to deliver a compressed feature stream from the front-end function set to the data processing function set for data processing and storage.

9.2 Reference point A2

Reference point A2 lies between the data processing function set and the algorithm function set.

It is used to deliver the pre-processed feature stream from data processing function set to the algorithm function set for intelligent analysis.

9.3 Reference point A3

Reference point A3 lies between the algorithm function set and the service control function set.

It is used by the service control function set to monitoring of the status of the algorithm function set, managing and configuring services within the system, enabling the algorithm function set to adjust its algorithms. Appropriate application programming interfaces (APIs) may be used to pass the parameters and configurations into algorithms, and receive the results from the algorithm function set.

9.4 Reference point A4

Reference point A4 lies between the applications and the service control function set.

It is used by the service control function set for providing specific services or applications to end-users through the applications. It is used by the applications to provide service delivery and quality to the service control function set.

9.5 Reference point A5

Reference point A5 lies between the service control function set and the security function set.

It is used by the service control function set for managing and enforcing service-related policies. It is used by the security function set for identifying and preventing security threats.

9.6 Reference point A6

Reference point A6 lies between the service control function set and the operation function set.

It is used by the operation function set for maintaining and diagnosing network components, management of network resources, and providing feedback to the service control function set regarding potential issues or performance degradation of the service control function set.

9.7 Reference point A7

Reference point A7 lies between the service control function set and the management function set.

It is used by the management function set for overseeing, directing the operation of the network, ensuring high-level network governance and effective service delivery, and for providing feedback to the service control function set. It is used by the service control function set to provide information to the management function set regarding current service policies or the status of network resources.

9.8 Reference point A8

Reference point A8 lies between the service control function set and the front-end function set.

It is used by the service control function set to control the access authentication, and authorization of the front-end function set, and to indicate the required types of features.

9.9 Reference point A9

Reference point A9 lies between the algorithm function set and the development function set.

It is used by the development function set to send the optimized model and updated hyper parameter to the algorithm function set.

Bibliography

[b-ITU-T F.700] Recommendation ITU-T F.700 (2000), *Framework Recommendation for multimedia services.*

[b-ITU-T F.743] Recommendation ITU-T F.743 (V2) (2019), *Requirements and service description for video surveillance*.

[b-ITU-T K.142] Recommendation ITU-T K.142 (2019), *Lightning protection and earthing of video surveillance systems*.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	**Non-telephone telecommunication services**
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities
Series Z	Languages and general software aspects for telecommunication systems

Published in Switzerland
Geneva, 2023