International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

F.746.4
(03/2017)

SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Multimedia services

Requirements for deployment of information-centric networks

Recommendation ITU-T F.746.4

ITU-T F-SERIES RECOMMENDATIONS

NON-TELEPHONE TELECOMMUNICATION SERVICES

TELEGRAPH SERVICE	
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	
Mobile services and multidestination satellite services	F.110–F.159
TELEMATIC SERVICES	
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	
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.746.4

Requirements for deployment of information-centric networks

Summary

Recommendation ITU-T F.746.4 describes the scenarios and requirements for deployment of information-centric networks (ICNs). The deployment supports flexible methods for deploying various ICN instances on a single network service provider (NSP) network, deploying an ICN instance over multiple NSP networks, and interoperating between different ICN instances. The framework requires decoupling of the data plane and the control plane; in addition, one or more switches and controllers supporting such deployment are required. The software and hardware resources in the switches and controllers are required to be virtualized and to be used to create ICN instances. There exist appropriate inter-ICN service provider interfaces to facilitate interoperations of two ICN instances.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T F.746.4	2017-03-01	16	11.1002/1000/13179

Keywords

Deployment, information-centric networks, interoperation, software-defined networking.

---

* 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.

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, 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 TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T F.746.4

Requirements for deployment of information-centric networks

1 Scope

This Recommendation describes the scenarios and requirements for deployment of information-centric networks (ICNs). The deployment supports flexible methods for deploying various ICN instances on a single network service provider (NSP) network, deploying an ICN instance over multiple NSP networks, and interoperating between different ICN instances.

This Recommendation describes scenarios and common requirements for the deployment of ICNs. It also presents the framework for the deployment. This Recommendation covers the following:

– scenarios of the deployment of an ICN;

– requirements of the deployment of an ICN and its key components;

– framework for the deployment of an ICN.

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 Y.3001] Recommendation ITU-T Y.3001 (2011), *Future networks: Objectives and design goals.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 future network [ITU-T Y.3001]: A network able to provide services, capabilities, and facilities difficult to provide using existing network technologies. A future network is either:

a) A new component network or an enhanced version of an existing one, or

b) A heterogeneous collection of new component networks or of new and existing component networks that is operated as a single network.

3.2 Terms defined within this document

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API Application Programming Interface

CONET Content Networking

FN Future Network

ICN	Information-Centric Network
NDN	Named Data Networking
NetInf	Network of information
NSP	Network Service Provider
PURSUIT	Publish–Subscribe Internet Technology
SDN	Software-Defined Networking

5 Convention

In this Recommendation:

– The expression "**is required to**" indicates a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

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

6 Background

In recent years, future networks (FNs) as described in [ITU-T Y.3001] have attracted considerable attention from both academia and industry. One FN objective is data awareness, which enables retrieval of data regardless of their location. To achieve this objective, the concept of information-centric networks (ICNs) has been proposed together with various ICN architectures [b-ITU-T Y.3033], [b-Dannewitz], [b-Jacobson], [b-Särelä], [b-Seskar], [b-Detti]. The next major challenge is to convince network service providers (NSPs) around the globe to adopt the concept of ICN and to deploy ICN-enabled networks.

To achieve this goal, many prototypes and testbeds have been developed. In general, these proof-of-concept systems can be implemented by two approaches: overlay and non-overlay. With the first approach, some special overlay nodes are deployed to deal with ICN protocol-related operations on top of an existing physical network. For example, overlay-based systems have been developed for named data networking (NDN) [b-Jacobson] and network of information (NetInf) [b-Dannewitz].

In contrast, in the non-overlay approach, ICN functions are implemented in routers directly. For instance, the prototype of Publish–Subscribe Internet Technology (PURSUIT) [b-Särelä] has been developed based on the Click modular router [b-Kohler], which allows network designers to create their own routers based on general-purpose personal computer hardware. Besides that, some ICN projects, such as MobilityFirst [b-Seskar] and content networking (CONET) [b-Detti], developed their prototypes based on software-defined networking (SDN), which provides programmability to networks.

Despite the importance of these prototypes, the deployment of ICN is still an open question. One obvious reason is that there are too many ICN candidates, which have different design principles and various technical details in terms of naming, routing, and so on. Taking content access as an example, while most ICN architectures are based on the assumption that a user will initiate a request and expect to access the content object as soon as possible, the PURSUIT project is based on the publish–subscribe model, in which both publisher and subscriber register on the ICN, and the publisher can push content whenever it is generated. Clearly, these two approaches can be applied by different types of application to optimize their performance.

As each ICN architecture has its own pros and cons and is best suited to some particular application requirements, various ICN architectures will be adopted. On the other hand, different ICN service providers can also implement their own ICN instances to provide specific services for users. For instance, one ICN service provider provides streaming service and another ICN service provider provides instant message service. Thus, various ICN instances will coexist on top of the same physical network.

Nevertheless, existing ICN prototypes only focus on the implementation of individual ICN architectures. Neither the coexistence of multiple ICN instances in the same physical network nor the requirement for interoperation of different ICN instances is considered.

This Recommendation focuses on the issue of the deployment of ICNs, including the scenarios, requirements and framework.

7 Requirements for the deployment of ICNs

7.1 General requirements

GEN-01: The deployment framework is required to decouple the data plane and the control plane. One or multiple switches and controllers supporting such deployment are required.

GEN-02: The deployment framework is required to virtualize the resources of network infrastructure to facilitate ICN implementation and coexistence. That is, the software and hardware resources in switches and controllers are required to be virtualized and to be provided to ICN instances.

GEN-03: The deployment framework is required to define appropriate inter-ICN service provider interfaces to facilitate interoperations between two ICN instances.

GEN-04: The deployment framework is required to provide basic general functions, including name-based routing, in-network cache management and content-based security.

7.2 Requirements for the switch supporting the deployment

DS-01: A switch is required to support general ICN-related operations and to process received packets according to the defined rules configured by control programs (i.e., ICN instances). The general ICN-related operations include name-based routing, in-network caching and content-based security.

DS-02: A switch is required to provide the following primitive functions: forwarding packets and caching traversed content.

DS-03: A switch is required to support virtualization for the implementation and coexistence of multiple ICN instances in the data plane. That is, the forwarding table and storage of the switch require allocation to different ICN instances to guarantee the required service quality. Packets belonging to different ICN instances require delivery to the appropriate control program and forwarding to appropriate interfaces.

DS-04: A switch is required to provide interfaces for ICN instances to manipulate the allocated resources, including the forwarding table and storage.

DS-05: A switch is recommended to provide the general ICN-related functions as modules.

DS-06: A switch is recommended to support interoperation, including re-encapsulating packets and sending requests according to the rules configured by the control programs.

7.3 Requirements for the controller supporting the deployment

DC-01: A controller is required to provide interfaces for an ICN service provider to deploy their own ICN instances in the control plane with full control of the physical resources.

DC-02: A controller is required to support virtualization for the coexistence of multiple ICN instances.

DC-03: A controller is required to support the registration of an ICN service provider.

DC-04: A controller is required to support the registration of switches which support the deployment.

DC-05: A controller is required to provide interfaces between different ICN instances to mutually exchange control information.

DC-06: A controller is recommended to provide general ICN-related functions as modules, including routing manager, content manager, storage manager, security manager and interoperation manager.

8 A framework for deployment of an ICN

This clause addresses the capabilities of the switch and controller.

Figure 8-1 shows the details of the switch and controller framework supporting the deployment.

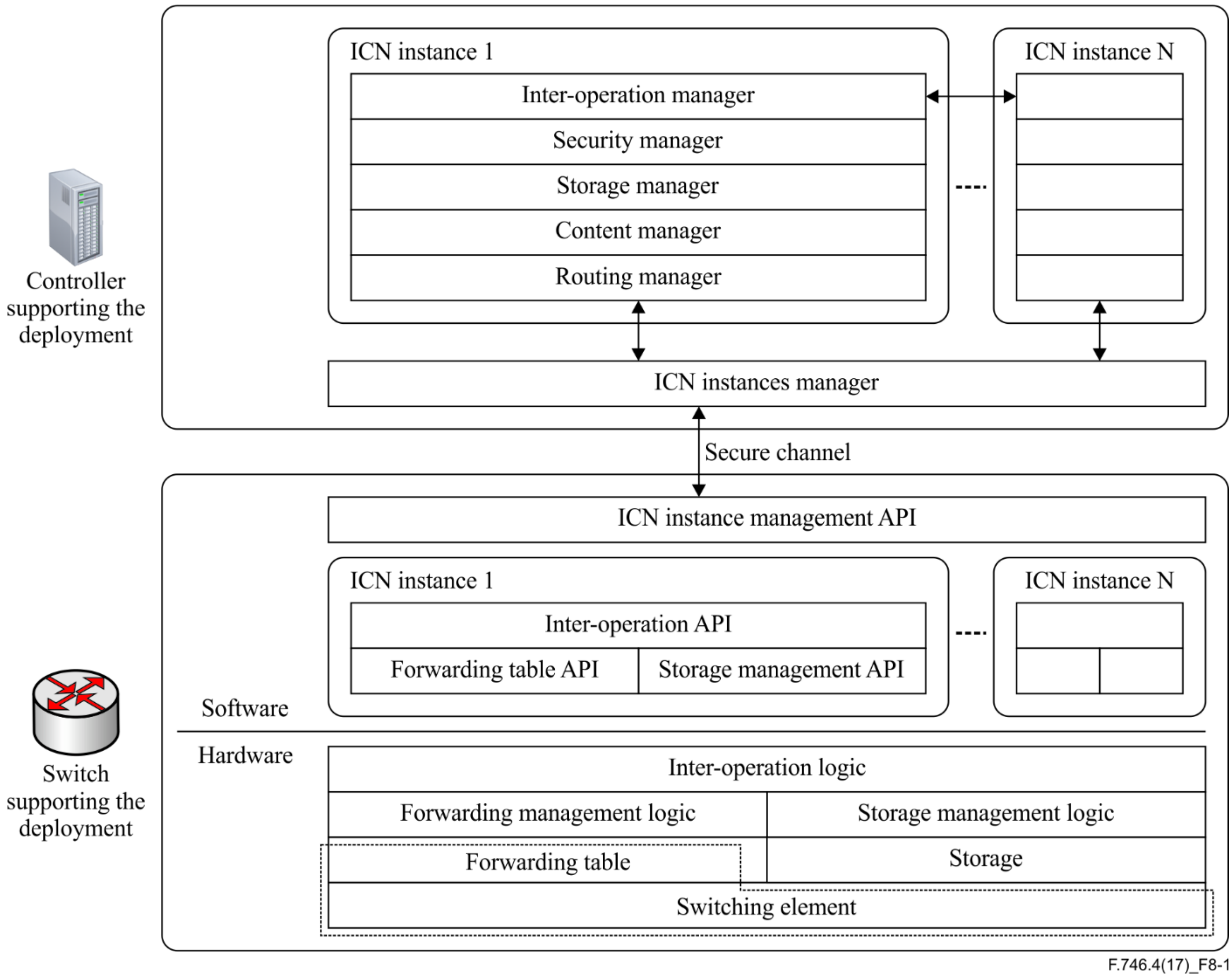

Figure 8-1 – A switch and controller framework supporting the deployment

8.1 Switch supporting the deployment

The switch, consisting of the hardware and software systems, is responsible for forwarding packets belonging to different ICN instances. To support various ICN-related operations, including local caching decision and name recognition, there are six hardware elements in the hardware system: switching element, forwarding table, storage, forwarding management logic, storage management logic and interoperation logic. These hardware resources are shared by different ICN instances. Such hardware resources are virtualized into different slices, each of which is dedicated to a particular ICN instance.

The switch provides interfaces, including forwarding table application programming interfaces (APIs), storage management APIs and interoperation APIs, to ICN instances to manage the resources allocated to them. The forwarding table API is used to instruct the forwarding management logic to manipulate one or more forwarding tables for a particular ICN instance. The storage management API is responsible for managing local caching policy in storage management logic or caching content in the content storage under the control of the controller. The interoperation API is designed to guide the interoperation logic to encapsulate packets or perform protocol translation received from an incompatible user.

8.2 Controller supporting the deployment

The controller is responsible for managing virtualized physical network resources for each ICN instance. The controller provides five functions for ICN service providers, as shown in Figure 8-1. The content manager is responsible for maintaining information about content sources and destinations. The routing manager is used to maintain the topology of this ICN instance and perform ICN-related routing algorithms. The storage manager is used to set the policies for managing physical content storage. The security manager is responsible for providing secure service. The interoperation manager is used to guide the interoperation with other ICN instances. Each ICN service provider can deploy its own ICN instance according to the specification of a particular ICN architecture by selecting appropriate modules to instantiate.

9 Security considerations

This Recommendation has some security considerations similar to those pertinent to data aware networking and aligns with the security requirements specified in [b-ITU-T Y.3033]. The channels between controller and switch and that among controllers are required to be secured and also have good privacy protection.

Annex A

Scenarios of ICN deployment

(This annex forms an integral part of this Recommendation.)

A general scenario for the deployment of an ICN is shown in Figure A.1.

Each NSP network supporting the deployment consists of two types of networking elements, i.e., switch and controller. For example, in Figure A.1 there are two NSP networks (i.e., NSP1 and NSP2).

Multiple ICN instances can coexist and each of them is owned by a particular operator, which is defined as an ICN service provider. Different ICN instances may adopt different ICN architectures.

Each ICN instance has its own group of users. A user of one ICN service provider may move to a geographical area that their ICN service provider does not cover. For example, a user of ICN service provider 1 may move to a place covered only by ICN service provider 4.

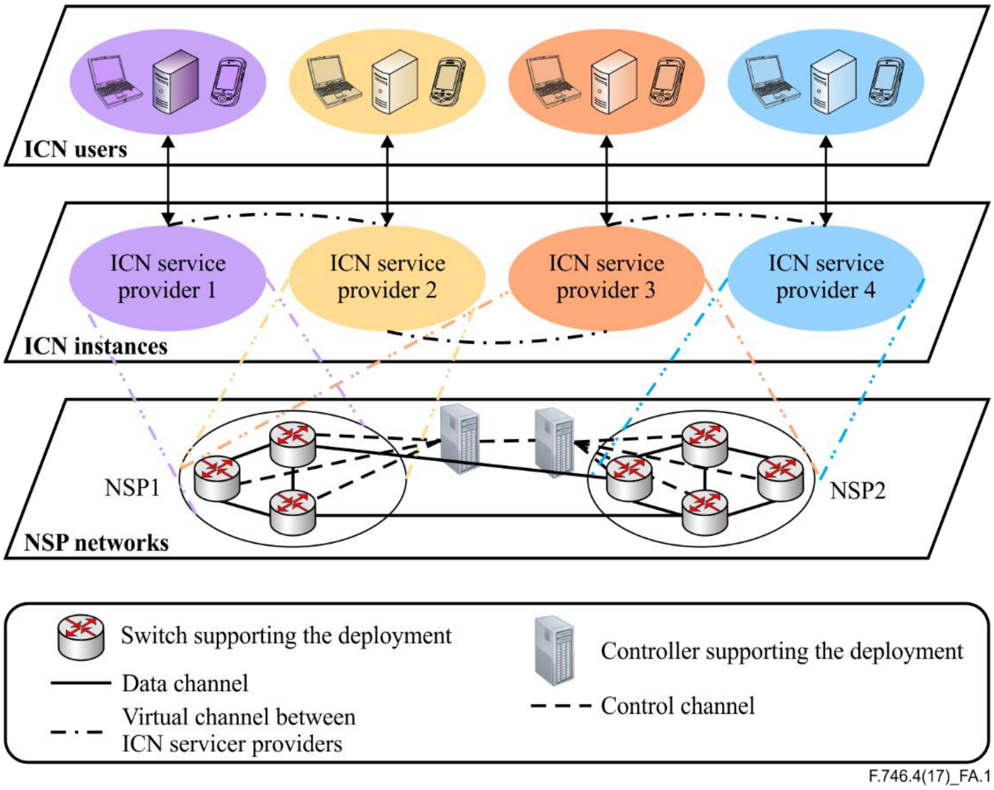

Figure A.1 – An overview of ICN deployment

A.1 Scenario of a single ICN instance over multiple NSP networks

As ICN instances are implemented on top of NSP networks to provide content delivery service, one common implementation scenario for the deployment is when one ICN instance is implemented over multiple NSP networks. To guarantee service quality, one ICN service provider can rent resources from multiple NSP networks to deploy its own ICN and to optimize content delivery efficiency.

For instance, ICN service provider 3 in Figure A.2 is built on the networks of both NSP1 and NSP2. A user associated with ICN service provider 3 needs not be aware of the underlying NSP networks. When the user moves from one location on the NSP1 network to another in NSP2, it gets uninterrupted service from ICN Service Provider 3.

To facilitate an ICN instance across multiple NSP networks, both the data channels and control channels to allow the interconnection are provided.

The data channel is used for data transmission. The control channel is used to exchange control information, e.g., routing and interconnection information. With such information, ICN service provider 3 sets up communications across multiple NSP networks and provides unified service to its users.

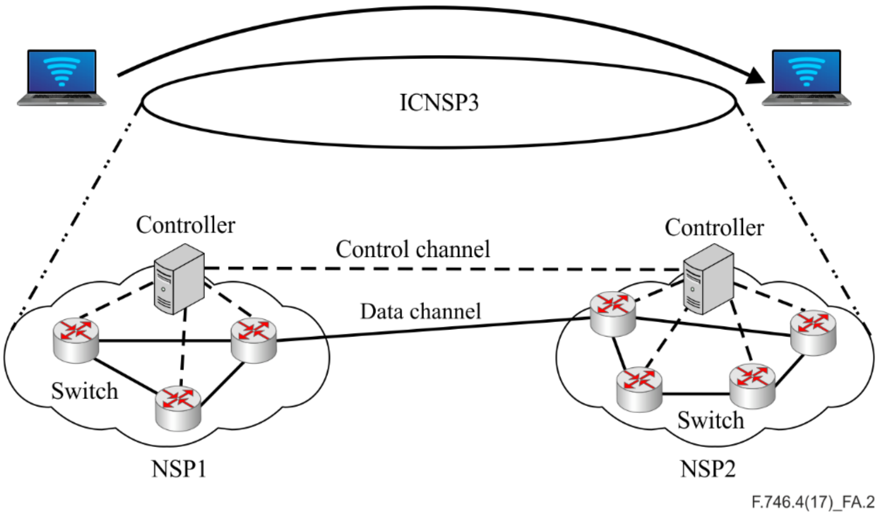

Figure A.2 – A single ICN instance deployed over multiple NSP networks

A.2 Scenario of multiple ICN instances on a single NSP network

Since different ICN architectures have their own pros and cons, multiple ICN instances employing different ICN architectures can coexist on the same NSP network.

One NSP network supports multiple ICN service providers. Each of them creates its own ICN instance to provide optimized services to its own users. For example, as shown in Figure A.3, ICN service provider 1 may choose NDN to provide services with the aim of optimizing video streaming, while ICN service provider 2 may adopt PURSUIT to provide services to efficiently facilitate online social networking.

To allow the creation of multiple ICN instances on a single NSP network, a set of interfaces is provided such that ICN service providers can perform ICN architecture-related operations (name-based routing, in-network caching, etc.). The traffic belonging to different ICN instances is processed independently.

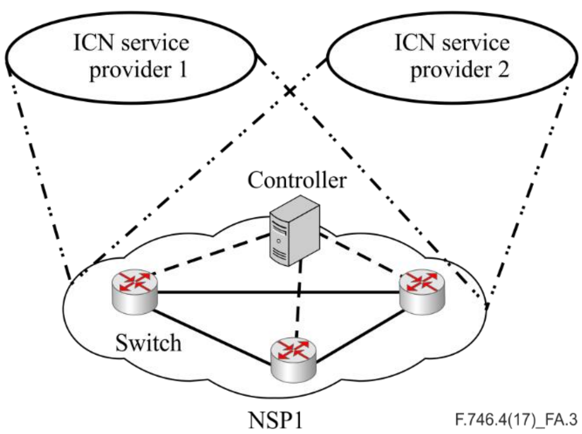

Figure A.3 – Multiple ICN instances deployed on a single NSP network

A.3 Scenario of interoperation between ICN instances

A user of one ICN service provider may need to access services from another ICN service provider, where the two ICN service providers adopt different ICN architectures as shown in Figure A.4.

One example is that a user in ICN service provider 1 needs a content object which is owned by a server in ICN service provider 2 as shown in Figure A.4 a). Another example is that a user of ICN service provider 1 moves to a geographical area that is not covered by the underlying NSP1 of ICN service provider 1 as shown in Figure A.4 b).

There are two ways to support interoperation. The first is tunnelling, with which a user of one ICN service provider can connect to its ICN instance via tunnels established in another ICN instance. The second is to perform protocol translation in the border switch.

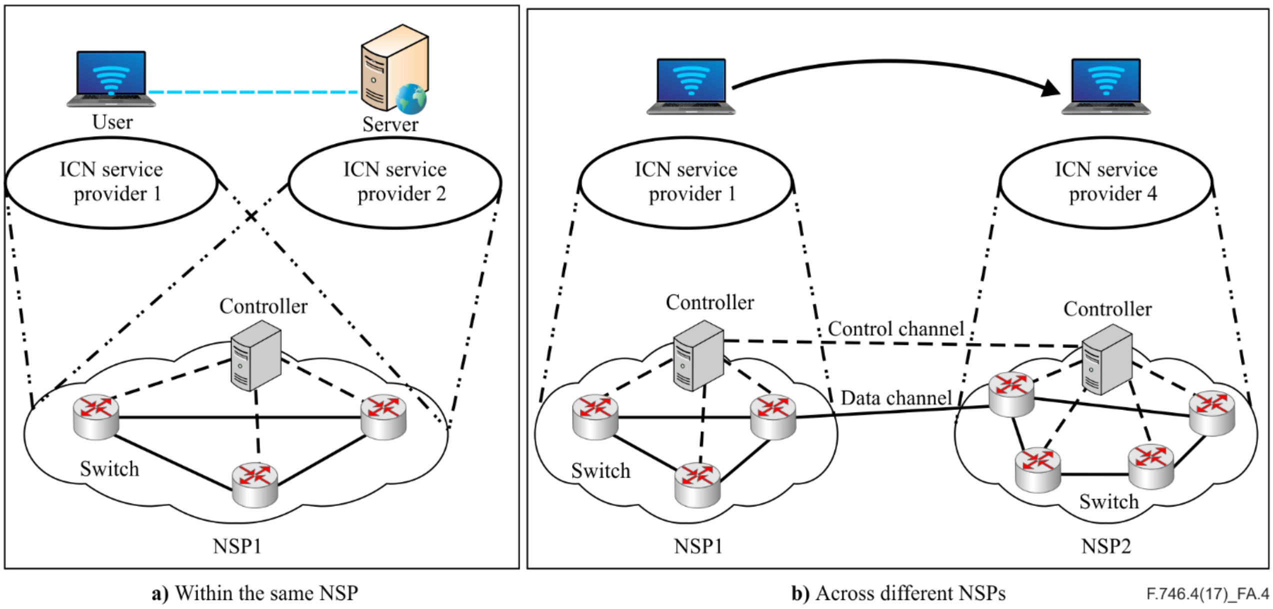

Figure A.4 – Interoperation of two ICN instances

Bibliography

[b-ITU-T Y.3033] Recommendation ITU-T Y.3033 (2014), *Framework of data aware networking for future networks*.

[b-Dannewitz] Dannewitz, C. (2009). NetInf: An information-centric design for the future Internet, In: *Proceedings of the 3rd GI/ITG KuVS Workshop on The Future Internet*.

[b-Detti] Detti A, Blefari-Melazzi N, Salsano S, Pomposini M (2011). CONET: A content centric inter-networking architecture. In: *ICN 11 Proceedings of the ACM SIGCOMM Workshop on Information-centric Networking*, Toronto, ON, 2011-08-19, pp. 50–55. New York, NY: ACM.

[b-Jacobson] Jacobson V, Smetters DK, Thornton JD, Plass MF, Briggs NH, Braynard RL (2009). Networking named content. In: *CoNEXT '09 Proceedings of the 5th International Conference on Emerging Networking Experiments and Technologies*, Rome, 2009-12-01/04, pp. 1–12. New York, NY: ACM.

[b-Kohler] Kohler E, Morris R, Chen B, Jannotti J, Kaashoek MF (2000). The Click modular router. *ACM Transactions on Computer Systems*, **18**(3), pp. 263–297.

[b-Särelä] Särelä M, Rinta-aho T, Tarkoma S (2008). RTFM: Publish/subscribe internetworking architecture, In: Cunningham P, Cunningham M, eds. *ICT-Mobile Summit 2008 Conference Proceedings*, 8 pp. Dublin: IIMC International Information Management Corporation Ltd.

[b-Seskar] Seskar I, Nagaraja K, Nelson S, Raychaudhuri D (2011). MobilityFirst future internet architecture project. In: *AINTEC '11 Proceedings of the 7th Asian Internet Engineering Conference*, Bangkok, Thailand, 2011-09-09/11, pp. 1–3. New York, NY: ACM.

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

Printed in Switzerland
Geneva, 2017