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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Future networks

Requirements of network virtualization for future networks

Recommendation ITU-T Y.3012

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Recommendation ITU-T Y.3012

Requirements of network virtualization for future networks

Summary

Recommendation ITU-T Y.3012 specifies the requirements of network virtualization in future networks, in particular requirements on physical resource management, virtual resource management, logically isolated network partition (LINP) management, service management, authentication, authorization and accounting of LINP, LINP federation and service mobility.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3012	2014-04-13	13	11.1002/1000/12166

Keywords

Future networks, logically isolated network partition, network virtualization, resource management.

* 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

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1 Scope

The scope of this Recommendation is to provide requirements of network virtualization for future networks.

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.*

[ITU-T Y.3011] Recommendation ITU-T Y.3011 (2012), *Framework of network virtualization for future networks.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 future network (FN) [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.

3.1.2 logically isolated network partition (LINP) [ITU-T Y.3011]: A network that is composed of multiple virtual resources which is isolated from other LINPs.

3.1.3 network virtualization [ITU-T Y.3011]: A technology that enables the creation of logically isolated network partitions over shared physical networks so that heterogeneous collections of multiple virtual networks can simultaneously coexist over the shared networks. This includes the aggregation of multiple resources in a provider and appearing as a single resource.

3.1.4 virtual resource [ITU-T Y.3011]: An abstraction of physical or logical resource, which may have different characteristics from the physical or logical resource and whose capability may be not bound to the capability of the physical or logical resource.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 LINP operator: A network operator that creates, programs, configures, manages and terminates network services on a given LINP.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAA Authentication, Authorization and Accounting

API Application Programming Interface

CPU Central Processing Unit

LINP Logically Isolated Network Partition

VLAN Virtual Local Area Network

5 Conventions

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

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

6 Overview of network virtualization

Network virtualization is a method that allows multiple virtual networks, called logically isolated network partitions (LINPs), to coexist in a single physical network [ITU-T Y.3011]. In order to provide LINPs, physical resources are partitioned and abstracted as virtual resources and the virtual resources are interconnected to create an LINP. These virtual resources can be created on physical resources such as routers, switches and hosts. As such, virtual resources are either allocated to each LINP or multiple virtual resources are aggregated into a single virtual resource.

Physical resources are composed of transport resources, computing resources and storage resources. A transport resource includes a physical node, link, router and switch, all of which are components of a transport network. A computing resource includes a central processing unit (CPU) and memory, which are components of a computing system. A storage resource includes a device holding a high volume of data.

7 Requirements

To operate LINPs and provide network services, both physical and virtual resources need to be controlled and managed effectively and efficiently. Since resources are managed by using different management functions in the entire cycle of service deployment, requirements for these functions are given in this clause. Realizing authentication, authorization, and accounting (AAA) of LINP, LINP federation and service mobility are also important issues from the viewpoint of flexible service deployment [b-Nakao].The requirements for these issues are also provided.

7.1 Physical resource management

Physical resource management enables effective and consistent use of physical resources which may include heterogeneous types of equipment such as routers and servers developed by different vendors.

The requirements for the physical resource management are as follows:

– The physical resource management is required to provide capabilities for managing, controlling, and monitoring heterogeneous types of physical resources for virtual resource management.

– The physical resource management is required to provide diagnosis mechanisms for troubleshooting to help identify the causes of physical resources failures.

– The physical resource management is recommended to provide information obtained through the diagnosis mechanisms (e.g., expected recovery time) to virtual resource management.
– The physical resource management is recommended to provide recovery mechanisms from physical network failures to improve reliability.
– The physical resource management is recommended to detect new physical resources automatically as they are added to the network.

7.2 Virtual resource management

Virtual resource management enables LINPs to bind physical resources and virtual resources.

The requirements for the virtual resource management are as follows:

– The virtual resource management is required to provide LINP identification means, such as LINP identifier (LINP ID), to differentiate LINPs.
– The virtual resource management is recommended to provide capability to collaborate with the physical resource management so that virtual resources can be allocated to an LINP effectively and efficiently.
– The virtual resource management is recommended to abstract an aggregated set of physical and virtual resources into a virtual resource in order to enable simplified control of virtual resources by LINP management.
– The virtual resource management is recommended to provide capabilities for monitoring or control of virtual resources to LINP management.
– The virtual resource management is recommended to change mapping between physical resources and virtual resources dynamically in the case of events like failures or performance degradations
– The virtual resource management is recommended to change mapping between physical resources and virtual resources according to requests for reconfiguration of LINPs from one or more LINP operators.
– The virtual resource management is recommended to allow LINP operators to configure LINPs quickly without imposing complexities of physical network operation including management of network addresses and domain names.
– The virtual resource management is recommended to allow LINP operators to reconfigure virtual resources to optimize performance and/or efficiency of LINPs through a simplified control interface. In this reconfiguration process, service interruption should be minimized to maintain quality of services on the LINPs.
– The virtual resource management is recommended to gather physical and virtual resource information, such as bandwidth consumption and CPU utilization.

7.3 LINP management

LINP management enables LINP operators to apply management policies to an LINP.

The requirements for the LINP management are as follows:

– The LINP management is recommended to reconfigure an LINP by reallocating virtual resources to the LINP so that the LINP operator can adapt the LINP profile to changes in service properties.
– The LINP management is recommended to terminate an LINP and release all the virtual resources that are no longer needed.
– The LINP management is recommended to monitor the status of a running LINP, such as traffic volume, energy consumption and utilization of virtual resources.

– The LINP management is recommended to optimize an LINP so that the LINP can be controlled and managed efficiently to adapt to environmental changes such as traffic fluctuations and equipment failures. In this optimization process, service interruption should be minimized to maintain quality of services on the LINP.

7.4 Service management

Service management enables an LINP operator to support service provisioning without complex interworking between the LINP operator and the network provider who provisions LINPs to the LINP operator, since the service can be composed of a large number of software components, that is, combinations of application programs and virtual resources.

The requirements for the service management are as follows:

– The service management is required to isolate applications or application-specific programs in order to execute them independently on different LINPs without interfering with each other.

– The service management is required to provide virtual resource related information to an LINP operator in order to assist the LINP operator for service provisioning procedures: installation, booting up, updating, termination and deletion of application programs or application processes over an LINP.

– The service management is recommended to provide programing capability regarding service provisioning procedures.

7.5 Authentication, authorization and accounting

To prevent malicious or unexpected access to physical and/or virtual resources, authentication, authorization and accounting (AAA) are essential.

The requirement for the AAA is as follows:

– Each management entity is recommended to provide an AAA mechanism. The mechanism is recommended to be executed before a physical and/or virtual and/or LINP management entity or LINP operator accesses another management entity.

7.6 LINP federation

LINP federation coordinates a single federated LINP from multiple LINPs built by individual distinct administrative domains. The federation should allow the LINP operator to build and to use the integrated LINP as a single LINP.

When a network service is provided to users, there are often two or more administrative domains among all users. In this case, a federated LINP is required to combine two or more LINPs for users to communicate with each other, while each LINP is individually managed by a different network service provider. Therefore, LINP operators should be able to build LINPs over the multiple administrative domains, regardless of the physical and/or virtual resources and/or management policies of these administrative domains.

The requirements for the LINP federation are as follows:

– The LINP federation is recommended to provide negotiation capability between different administrative domains for exchanging capability information about physical and virtual resources.

– The LINP federation is recommended to allow LINP operators to build LINPs over the different administrative domains, regardless of the physical resource types or management policies of these administrative domains.

– The LINP federation is recommended to avoid inconsistent use of resources and inconsistent configurations in an integrated LINP built over different administrative domains.
– An administrative domain is recommended to provide a set of standard interfaces for the other administrative domains in order to describe the different types of physical resources of each domain in a standard form.
– The standard interfaces between the administrative domains are recommended to allow for varying levels of resource abstraction.
– The standard interfaces are recommended to allow the administrative domains to coordinate the types of AAA procedures, such as, exchanging the LINPs operators' AAA information, delegating AAA procedures to the other administrative domain, etc.
– It is recommended that the identification of physical resources in one administrative domain is not restricted by the identification used in other domains.

7.7 Service mobility

In virtual networks, a significant number of services will be created by composing diverse software components. Some services may be provided within a single LINP and other services may employ multiple LINPs. As network virtualization enables LINP operators to easily acquire the virtual resources needed to compose the LINPs, LINP operators may require that the software components be dynamically moved when, due to end-user mobility, an attachment point to which the end-user connects in a single LINP is changed. An LINP operator may require that the software components be moved between multiple LINPs, depending on service status and end user demands.

In an additional fundamental requirement, network virtualization should provide service continuity. This allows the LINP operators to provide the services to end-users without service downtime regardless of whether the services are running in a single LINP or are moved to another LINP.

The requirements for the service mobility are as follows:

– The service mobility is recommended to allow the ongoing service to continue in a transparent manner regardless of where it is moved.
– The service mobility is recommended to allow an LINP operator to establish connectivity among multiple LINPs.
– The service mobility is recommended to allow an LINP operator to receive reports about service status including virtual resource usage.
– The service mobility is recommended to maintain the consistency of the software component's status during the mobility phase of the software components.
– The service mobility is recommended to provide LINP discovering capability which allows an LINP operator to find an appropriate LINP that satisfies the demands of the service.

8 Environmental considerations

Network virtualization technology changes the resource (e.g., metal or fibre) consumption and energy consumption of networks by changing the overall architecture of networks. Further details can be found in [ITU-T Y.3011].

9 Security considerations

Although network virtualization presents many benefits to both network operators and users, it also brings about security issues from different viewpoints than conventional ones. For example, it could be possible for a malicious user to monitor or control virtual resources even if these resources are not allocated to the malicious user. Thus, implementing malicious access identification and quarantine mechanisms, as well as AAA functions, is essential to the operation of LINPs. Coordinating relevant management functions so that they can effectively execute these mechanisms may address these issues.

Appendix I

Resource hierarchical model

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

Figure I.1 represents the hierarchical model of network virtualization. The physical resource management creates multiple logical resources which have the same characteristics as physical resources. In addition, it provides the virtual resource management with logical resources. The virtual resource management abstracts a logical resource to create a virtual resource. It can also build a virtual resource using multiple virtual resources. Therefore, a virtual resource has a nested structure. LINP management can build LINPs on multiple virtual resources which are provided by the virtual resource management. Once an LINP is created, the LINP management starts to manage its own LINP.

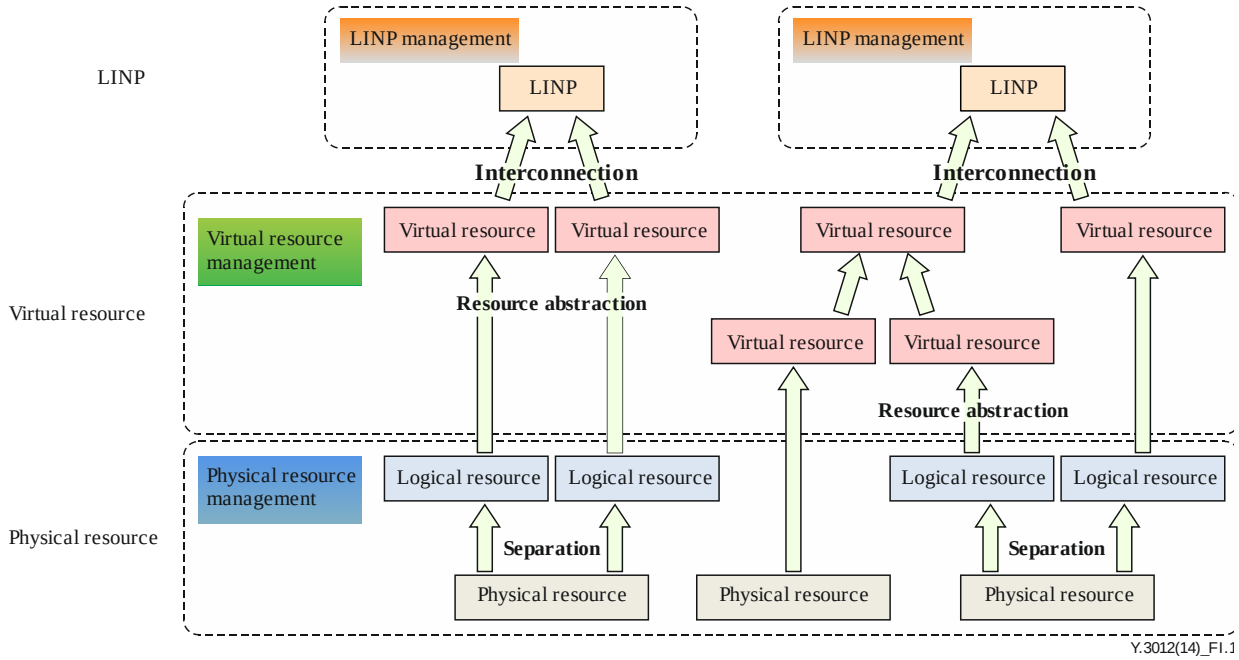

Figure I.1 – Resource hierarchical model

Bibliography

[b-Nakao] Nakao, *et al.* (2012), *Whitepaper – VNode: A Deeply Programmable Network Testbed Through Network Virtualization* https://nvlab.nakao-lab.org/vnode-white.paper.pdf

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