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Multimedia services

Functional requirements for virtual content delivery networks

Recommendation ITU-T F.743.4

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Recommendation ITU-T F.743.4

Functional requirements for virtual content delivery networks

Summary

Recommendation ITU-T F.743.4 gives an overview and the requirements for a virtual content delivery network (VCDN). Appendix I provides two use cases to show how to apply VCDN scenario.

Compared with the traditional content delivery network (CDN) service provisioning defined in Recommendations ITU-T Y.1901 and ITU-T Y.2019, VCDN is a new paradigm using cloud computing, network virtualization and software defined networking (SDN) technology for content delivery for various multimedia services, providing a CDN infrastructure according to vendors' needs. This Recommendation specifies the requirements for VCDN, including requirements on service provision, physical resource management, virtual resource management, VCDN logically isolated network partition (LINP) management, service management, backbone network and security consideration.

History

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Recommendation ITU-T F.743.4

Functional requirements for virtual content delivery networks

1 Scope

This Recommendation describes the functional requirements for a virtual content delivery network (VCDN). The scope of this Recommendation covers:

– An overview of VCDN concept and the objectives of VCDN.

– The requirements for applying VCDN on service provision, all kinds of resources of VCDN, and security considerations.

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.1901] Recommendation ITU-T Y.1901 (2009), *Requirements for the support of IPTV services.*

[ITU-T Y.2019] Recommendation ITU-T Y.2019 (2010), *Content delivery functional architecture in NGN*.

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

[ITU-T Y.3300] Recommendation ITU-T Y.3300 (2014), *Framework of software-defined networking*.

[ITU-T Y.3500] Recommendation ITU-T Y.3500 (2014) *Information technology – Cloud computing – Overview and vocabulary*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

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

3.1.2 network virtualization [ITU-T Y.3011]: A technology that enables the creation of logically isolated network partitions over shared physical networks so that heterogeneous collection 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.

3.1.3 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.

3.1.4 software-defined networking [ITU-T Y.3300]: A set of techniques that enables to directly program, orchestrate, control and manage network resources, which facilitates the design, delivery and operation of network services in a dynamic and scalable manner.

3.1.5 cloud computing [ITU-T Y.3500]: Paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand.

3.2 Terms defined within this Recommendation

This Recommendation defines the following term:

3.2.1 virtual content delivery network: A content delivery network using virtualisation technology that enables the allocation of virtual storage, virtual machines, and network resources according to vendors' requirements in a dynamic and scalable manner.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAA Authentication, Authorization, and Accounting

ACL Access Control List

CPU Central Processing Unit

I/O Input/Output

LINP Logically Isolated Network Partition

OS Operating System

QoS Quality of Service

SDN Software Defined Networking

SLA Service Level Agreement

VCDN Virtual Content Delivery Network

VLAN Virtual Local Area Network

5 Conventions

In this Recommendation, the following conventions are used:

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

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

6 Background

With the development of Internet technology, the network traffic resulting from audio and video services grows exponentially. In the future Internet, video services will be mainstream. A content delivery network (CDN) is technically a comprehensive solution to handle the increased demand for

services. Existing CDN architectures face the challenges of a dramatic increase in video service traffic, as well as additional construction and maintenance costs provided to various multi-vendor services. How to sufficiently take advantage of the resource of CDN to provide flexible and superior service is an important issue to be resolved.

The essential character of virtualisation technology is the elastic allocation of resources. A virtual content distribution network (VCDN) uses virtualization technology to make a unified resource pool, to provide the infrastructure of CDN according to the vendors' need. VCDN uses the management interface to monitor CDNs' load.

VCDN can realize accurate infrastructure distribution and elastic resource scheduling. VCDN can integrate the resources of CDN, reduce construction cost and improve the scalability.

7 Overview of VCDN

Virtual CDN provides content delivery service to multiple vendors. VCDN utilizes a set of techniques including cloud computing, network virtualization and software defined networking (SDN) to dynamically control and manage the computing and network resources, which improves scalability, flexibility and availability.

Figure 1 illustrates the basic concept of VCDN.

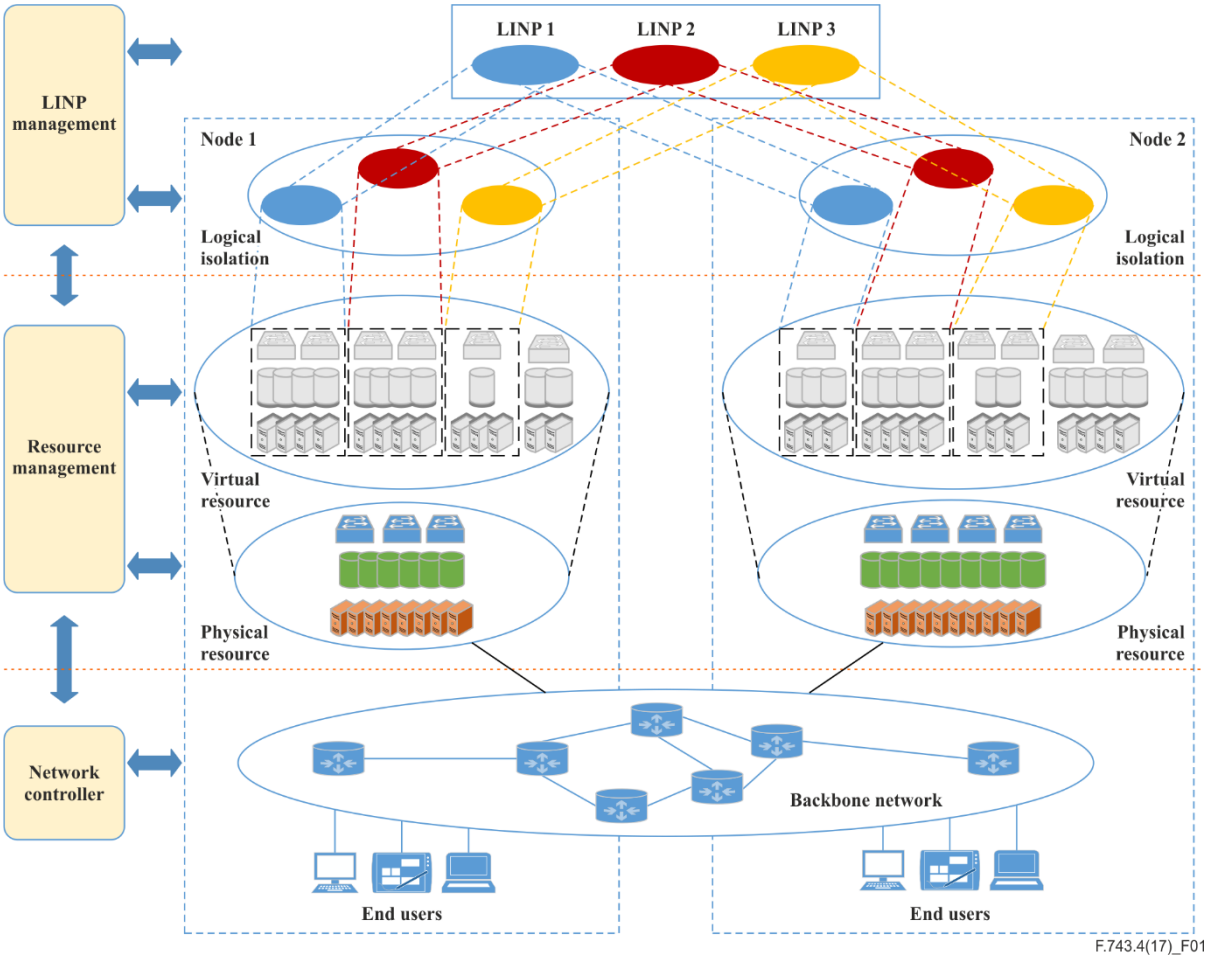

Figure 1 – VCDN concept

A typical CDN providing good performance content delivery service generally consists of many nodes which are located in different areas close to the end user. The nodes are deployed as physical resources such as servers, storage and switches. The physical resources are converted into virtual

resources such as virtual machines, virtual storage and virtual switches, which form a virtual resources pool utilizing virtualization technology. In order to provide service to multiple vendors in a single physical CDN, virtual resources are aggregated and isolated according to vendors' service requirements. Every logically isolated network partition allocated to a specific customer is called a logically isolated network partition (LINP). A VCDN LINP is an aggregation of virtual resources in all the nodes.

The LINP is managed by LINP management which controls and configures the LINP in terms of VCDN vendors' requirement. The virtual resources and physical resources are managed by resources management. When the requirements of a LINP are changing, the LINP management requires resource management to perform functions such as adding or diminishing the virtual resources to the LINP, moving virtual resources from one node to the other node. When resource management is required to adjust backbone network performance, the resource management requires that network controller performs functions such as optimize routing, expanding bandwidth, etc. Note that the backbone network may support software defined networking (SDN) functions.

8 Objectives

Virtual CDN is a paradigm using cloud computing, network virtualization and SDN technology for content delivery for various multimedia services. VCDN provides a scalable and elastic CDN function pool of shareable physical or virtual resources to multiple vendors with self-service provisioning and administration on demand. See [b-ETSI-GS-NFV001].

The following are the advantages of applying VCDN:

– Suitable for providing service to multiple vendors.

  VCDN provides on-demand CDN resource provisioning, which dynamically provides resources according to VCDN vendors' needs. So it is more suitable for providing service multiple vendors.

– Rapid and flexible adaptation to the requirement of vendors.

  VCDN provides rapid provisioning of service to adapt to vendors' demands by dynamically changing its configurations and re-allocating virtual resources.

– Increased availability and usage efficiency.

  VCDN increases the availability and efficiency in the usage of resources by assigning resources to vendors from a large pool of virtual resources.

– Reduced investment of CDN provider.

  VCDN is capable of expanding or reducing its virtual resources to accommodate heavier or lighter workloads. All the resources located in different areas are shared, instead of the physical resources in a certain area which can only be used by the service distributed in that area. Allocating virtual resources increases capability with lower cost than adding physical resources.

– Increased resiliency and robustness.

  VCDN is totally deployed in virtualization of network and computing resources, it can implement service chaining without limitation of physical networks.

9 Requirements

This clause addresses the requirements for VCDN.

9.1 Service provision requirements

VCDN service provision requirements include basic content delivery service provision requirements and special requirements for implementation of virtual CDN. Basic content delivery service provision

requirements are provided in [ITU-T Y.1901], [ITU-T Y.2019] and [b-ETSI-TS-182019]. The related requirements are detailed in clause 6.6.4.1 "Content delivery" of [ITU-T Y.1901] and clause 8 "Content delivery requirements" of [ITU-T Y.2019].

The special requirements for implementation of virtual CDN are as follows:

– The virtual CDN is required to support providing various multi-vendor services.

– The virtual CDN is required to support legacy CDN service provision, including content downloading, delivery of multiple audio streams, accelerating web page presenting and so on.

– The virtual CDN is required to support that multiple virtual resources of multiple VCDN vendors be logically isolated from each other.

– The virtual CDN optionally provides different priority levels for different VCDN vendors according to their service level agreement (SLA).

– The virtual CDN is required to support dynamic change of its configuration and re-allocation of virtual resources according to VCDN vendors' requirements.

9.2 Physical resource management requirements

Physical resource management enables the configuration of all physical resources used in the VCDN, such as storage, servers and networks used by different VCDN vendors. The requirements for the physical resource management are as follows:

– The physical resource management is recommended to provide the capabilities of managing, configuring, controlling, and monitoring all physical resources for virtual resource management.

– The physical resource management is recommended to provide diagnostic mechanisms for trouble-shooting to help identify the causes of physical resources failures.

– The physical resource management is recommended to provide information obtained through the diagnostic mechanisms (e.g., expected recovery time) to virtual resource management.

– The physical resource management is recommended to detect new physical resources automatically as they are added to the network.

– The physical resource management is recommended to provide authentication, authorization, and accounting (AAA) mechanisms.

9.3 Virtual resource requirements

9.3.1 Virtual machine requirements

Physical servers can be abstracted into virtual machines (VMs) in VCDN. Virtual machines provide service functions of CDN, such as media service, load balance service, statistical service and network management. A virtual machine pool is composed of many single virtual machines, the VCDN LINP can utilize the VM in a virtual machine pool according to the requirements of VCDN vendors. The requirements for the virtual machine are as follows.

– The virtual machine is required to provide a virtualized and isolated computing environment for each operating system (OS).

– The virtual machine is required to support migration of virtual machines between different physical computing machines.

– The virtual machine's central processing unit (CPU) is required to support virtualization, which allows running multiple virtual CPUs (vCPU) on a single physical CPU.

– The virtual machine's vCPUs' computing capability can optionally be specified as a fraction of a physical CPU.

– The virtual machine's memory is required to support virtualization, which allows memory allocation and memory release when the virtual machine actives and shutdowns.
– The virtual machine is required for the hypervisor to support input/output (I/O) virtualization capabilities.
– The virtual machine is required to be capable of using virtual I/O devices abstracted from the physical I/O devices.
– The virtual machine's physical network interface is required to support virtualization, where the physical network interface can be virtualized into multiple virtual network interfaces.
– The virtual machine's physical network interface is required to support virtualization; different virtual machines can be grouped into one virtual local network.
– The virtual machine can optionally be duplicated to create a new virtual machine with the same configuration.
– The virtual machine is recommended to support the static and dynamic migration of a virtual machine.

9.3.2 Virtual storage requirements

Physical storage devices can be converted into virtual storage in VCDN. Virtual storage provides the storage function of CDN, such as storing media files and databases. The VCDN LINP can utilize the virtual storage according to the requirements of VCDN vendors. The requirements for the virtual storage are as follows:

– Virtual storage is recommended to provide the capability for the VCDN application to store content by ignoring the difference of storage resources at the physical level, such as storage network architecture, storage (read/write) protocols, physical storage medium, etc.
– Virtual storage is recommended to provide the capability for the VCDN to dynamically adjust its virtual storage resources according to application requirements. For example to change its storage space, file migration, etc.
– Virtual storage is required to provide storage interfaces, such as structured data-sharing access interfaces, block storage interfaces or file system interfaces as well as access data path interfaces.
– Virtual storage is required to provide the capabilities for user authentication and authorization.
– Virtual storage is required to provide basic configuration capabilities, including storage domain configuration, file system namespace configuration, storage resources configuration and local file system configuration.
– Virtual storage is recommended to provide performance monitoring and statistics (e.g., disk I/O speed, disk space usage, CPU utilization, memory utilization, job completion).
– Virtual storage is recommended to provide storage migration functions. Based on migration policies, data can be migrated between different storage devices, which can be local storage or shared storage.
– Virtual storage is recommended to provide storage backup functions. Backup can be applied at block level and file level storage.

9.3.3 Virtual CDN network requirements

A virtual CDN network provides network functions in one CDN node. Virtual CDN network functions are the functions of the specified intranet network which is applied to access and interconnect servers in one CDN node, instead of backbone network which is connected to other CDN nodes. A virtual CDN network provides network functions such as IP address allocation, virtual local

area network (VLAN) allocation, and virtual switching, among other functions. The requirements for virtual CDN network are as follows:

– A virtual CDN network is recommended to support the dynamic migration of virtual machines. The related resources of virtual machines can be migrated with virtual machines migration. The service cannot be interrupted during virtual machine migration.

– A virtual CDN network is recommended to provide elastic addressing for different virtual machines. It is recommended to support public IP address and private IP address mapping.

– A virtual CDN network is recommended to support the isolation of the logical network among virtual machines, such as establishment of a VLAN network.

– A virtual CDN network is recommended to support different security policies for particular virtual machines, such as access control list (ACL) and firewalls, etc.

– A virtual CDN network is recommended to support different quality of service (QoS) and bandwidth policies for different virtual machines.

– A virtual CDN network is recommended to support traffic monitoring and traffic statistics among virtual machines and network ports.

9.3.4 Software resource provisioning requirements

The software resources include the software for deploying virtual resource, and the software in support of service implementation. The requirements for the software resource are as follows:

– The software resource provisioning is recommended to provide a functionality to configure all virtual resources to support operations automated provisioning and deployment.

– The software resource provisioning is recommended to support automated deployment according to the service requirement, which can promote provisioning efficiency.

– The software resource provisioning is recommended to be easy to be programmed and understood.

– The software resource management is recommended to be unified, including capabilities for licence information registration, allocation, recovery, expiration notification and metering.

9.3.5 Virtual resource management

The virtual resources management enables VCDN LINP operators to apply management policies to a VCDN LINP. The requirements for the LINP management are as follows:

– The virtual resource management is recommended to provide physical-to-physical resources mapping and physical-to-virtual resources mapping management.

– The virtual resource management is recommended to provide the secure isolation in addition to conventional control plane and data plane isolation among LINPs.

– The virtual resource management is recommended to support topology awareness to allow the virtual resources to effectively interact with each other during the construction of LINPs.

– The virtual resource management is recommended to adjust the capability of LINPs according to the changes of requirements and the reconfiguration.

– The virtual resources management is recommended to build cloud infrastructure resource pools, and to support service implementation.

9.4 VCDN LINP requirements

9.4.1 VCDN LINP function requirements

The VCDN LINP is an aggregation of virtual resources in all the nodes. A VCDN LINP is created by the LINP manager and generated by using virtualized resources. The requirements for the VCDN LINPs are as follows:

– The VCDN LINP is recommended to be created and that it inherits appropriate control rights from the virtual resources manager controlling all virtual resources.
– The VCDN LINP is recommended to consist of a set of virtual resources that are independently manageable partition of physical resources.
– The VCDN LINP is recommended to abstract specific physical resources. The vendors can access the capabilities of virtual resources by using abstracted interfaces to deliver content.
– The VCDN LINP is recommended to be isolated from each other. LINPs may not mutually interfere with each other in terms of performance, security, and namespace. Any single LINP may not cause disruptions to other LINPs or physical networks.
– The VCDN LINP is recommended to be flexibly allocated, reclaimed and released according to the requirement of VCDN. It can automatically maximize the accommodation of multiple LINPs on physical resources and optimize the usage of the physical resources.

9.4.2 VCDN LINP management requirements

The VCDN LINP management enables VCDN LINP operators to apply management policies to a VCDN LINP. The requirements for the LINP management are as follows:

– The VCDN LINP management is recommended to align the allocation of virtual and physical resources in a LINP.
– The VCDN LINP management is recommended to reconfigure a LINP by reallocating virtual resources to the LINP so that the LINP operator can adapt the LINP profile to changes in service properties.
– The VCDN LINP management is recommended to terminate a LINP and release all the virtual resources that are no longer needed.
– The VCDN LINP management is recommended to provide independently managing LINP which is isolated from others.
– The VCDN LINP management is recommended to provide visible management operations such as monitoring, fault detection, topology awareness and reconfiguration, resource discovery/allocation/scheduling and customized control.
– The VCDN LINP management is recommended to provide abstracting the information of physical resources and supporting the simplified or the higher level interfaces for resource control.
– The VCDN LINP management is recommended to provide constructing or reconfiguring a LINP.
– The VCDN LINP management is recommended to optimize a LINP so that the LINP can be controlled and managed efficiently to adapt to all kinds of changes, such as traffic fluctuation and network congestion.
– The VCDN LINP management is recommended to provide authentication and authorization to achieve safe and secure operations of VCDN LINPs.

9.5 Service management requirements

VCDN service management enables a VCDN provider to support service provisioning to VCDN vendors:

– The virtual CDN is required to support providing a VCDN customer management system. The VCDN provider can add or remove vendors, clarify vendors group, customer's credit management and contract management, etc.
– The virtual CDN is required to support customer self-service portal. VCDN vendors can manage and operate VCDN service by themselves through customer self-service portal.

– The virtual CDN is required to support authentication, authorization, and accounting (AAA) mechanism. The mechanism is recommended to be executed before a VCDN provider or a VCDN customer entity accesses the management entity.
– The virtual CDN optionally provides vendors with the possibility to submit VCDN service requirement, such as storage and server capacity, content delivery areas, terminal client condition.
– The virtual CDN optionally provides vendors with the possibility to manage content, including ingest contents to the LINP, remove contents, updated contents, etc.
– The virtual CDN optionally provides vendors with the possibility to query VCDN service statistics, such as the usage of storage, number of times that the contents have been downloaded, number of online clients, etc.
– The virtual CDN optionally provides system statistics. It supports various statistics mode, such as usage of storage, total flow, number of nodes.

10 Backbone network requirements

VCDN resource management communicates with the backbone network in accordance with VCDN customer requirements, including traffic changes, node migrations and SLA changes. As opposed to the VCDN network, the backbone network is defined as the network that inter-connects all nodes of the VCDN, instead of the intra network of a specific VCDN node. The backbone network is required to transfer content data from VCDN nodes to end users. The backbone network is required to support the software defined networking (SDN) function. The network controller can adjust performance according to resource management requirements. Resource management requires the network controller to perform functions such as routing optimization and expansion of bandwidth, among others. The requirements for a virtual CDN network are as follows:

– Backbone network is required to provide a functionality to discover the underlying network topology to see how the network devices (e.g., SDN-enabled switches and routers) connect to each other.
– Backbone network is required to provide functionalities for programmability, abstraction, and the orchestration of the SDN devices.
– Backbone network is required to provide a functionality to collect network information about the capability of the network devices and network information including status of forwarding tables, routing policies, and network topologies.
– Backbone network is required to provide a functionality to monitor status (e.g., failure, overload) of network devices.
– Backbone network is required to provide a connectivity between VCDN nodes. By means of this connectivity, a superior node can interwork with the subordinate VCDN nodes to request contents that the nodes do not have, including transfer of virtual machines between connected nodes.
– Backbone network is required to provide the service level agreement capability according to the requirement of VCDN vendors. The SLA requirements (including QoS) of a VCDN customer for a given content delivery service are expected to be met by appropriate interworking with selected VCDN nodes, even in the event of service performance degradation or a disaster.

11 Security considerations

Since a VCDN consists of virtual resources that are available to multiple vendors, security issues regarding network virtualization can be raised. Every customer can administer their own LINP. LINP has some network virtualization properties, such as flexibility, configurability, network abstraction and so on. So those kind of properties can cause unexpected security and privacy issues.

Therefore, the following security issues should be considered to mitigate potential security problems. Security and privacy issues should be considered during planning and designing network virtualization solutions. The issues can include security and privacy requirements of VCDN vendors, VCDN providers and end users. In order to prevent malicious access, the AAA functions are essential to operate LINPs. In addition, it is necessary to keep monitoring the security and privacy of data and applications that are implemented and deployed in VCDN LINPs.

Appendix I

Use cases for VCDN

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

The traditional CDN model for distributing content is based on cache servers located at the edge of the network (those closest to the end users) for delivering content to end users in a reliable and timely manner. Generally, the capacity and service function of physical devices are deployed according to the requirement of the users in that area.

There are some disadvantages that come with this model. When service demand is dramatically and tentatively raised in area A, the CDN operator only adds physical cache servers to meet the requirement, while the workload of cache servers in the B area are very low, but they could not be shared with the cache servers in area A. However, when the service demand is decreased in area A, the load of cache servers becomes low. In that case, it comes at a higher operational cost for CDN operators..

Virtual CDN can deal with the issues mentioned above. VCDN uses virtualization technology to virtualize cache servers in any area. VCDN service provider ensures service sustainability and flexibly to manage their networks according to service demands without complexity. Distribution resources are not limited in its own local area of users, if the resource of virtual machine overloads in area A, while the load of virtual machine in area B is low. The central controller gets the message and logically distributes some of area B's virtual machine resources to area A to service users in area A. In addition, the central controller also distributes some network capacity to area A, such as bandwidth or superior QoS.

I.1 Use case 1: the number of users is rapidly rising in one area

This use case is illustrated in Figure I.1. A VCDN vendor provides a popular service, so the number of users is dramatically rising. However, the storage and distribution resources of the node of that area are insufficient. Hence, VCDN allocates some virtual resources to the node from another node. At the same time, the VCDN informs the SDN enabled network controller to allocate the network resource via the content delivery paths, which can guarantee quality of delivery contents service.

1) The number of users is dramatically rising when some new services which are popular are provided to the area.
2) The customer of the VCDN notices this issue and needs more content delivery resources. The VCDN resource management and LINP management find there is no more resources in node 1 which is the best node to provide service in the area.
3) But more resources are unused in node 2. So some virtual resources identified as N2V3 are allocated to provide service to the area.
4) At the same time, SDN enabled network controller is required to provide a better network path for providing delivery content service from node 2 to the users in the area.
5) The network controller allocates a best path to the service according to the topology information to guarantee the quality of service. Users can also receive best service from node 2.

NOTE – The identification in the node ellipse, which is described as NxVx in Figures I.1 and I.2, represents the virtual resources allocated by LINP management. This means that it is located in the specific node and the number of virtual resource. Letter "N" represents the node and letter "V" represents the virtual resource. The numbers after letters "N" and "V" represents the resource number. For example, N2V3 indicates that it belongs to node 2, and that it is the third virtual resource.

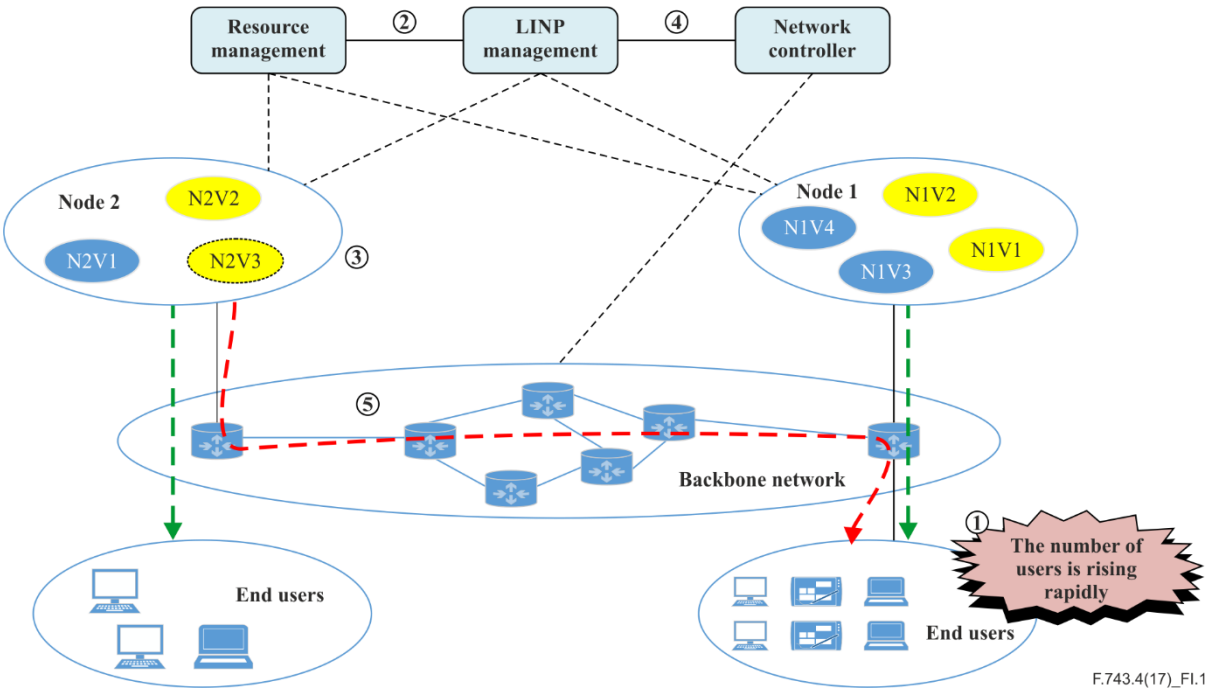

Figure I.1 – Use case 1: The number of users is rapidly rising in one area

I.2 Use case 2: one node is broken

This use case is illustrated in Figure I.2.

When the hardware, software and network of a certain node fails, this leads to content delivery service disruption. VCDN then allocates the service of the node to another node. At the same time, the VCDN informs the SDN enabled network controller to allocate the network resource via the content delivery paths, which can guarantee quality of delivery contents service.

1) Node 1 is broken for some reason.
2) The VCDN resource management and LINP management detect it.
3) Virtual resources identified as N2V3 and N2V4 in node 2 are allocated to provide service taking place node 1.
4) At the same time, SDN enabled network controller is required to provide a better network path for providing delivery content service from node 2 to the users in the area.
5) Network controller allocates a best path to the service according to topology information to guarantee the quality of service. Users can also receive best service from node 2.

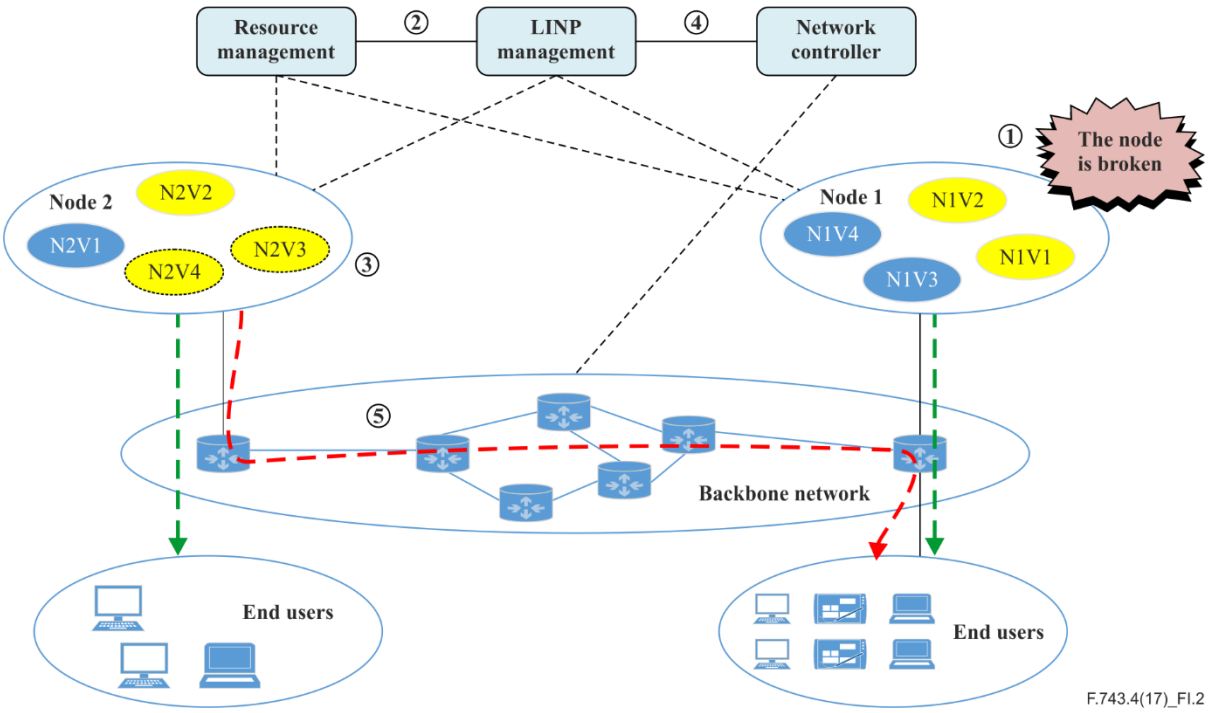

Figure I.2 – Use case 2: One node is broken

Bibliography

[b-ETSI-GS-NFV001] ETSI GS NFV 001 V1.1.1 (2013), *Network Functions Virtualisation (NFV); Use Cases.* <http://www.etsi.org/deliver/etsi_gs/NFV/001_099/001/01.01.01_60/gs_NFV001v010101p.pdf>

[b-ETSI-TS-182019] ETSI TS 182 019 V.3.12 (2011), *Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Content Delivery Network (CDN) Architecture.* <http://www.etsi.org/deliver/etsi_ts/182000_182099/182019/03.01.02_60/ts_182019v030102p.pdf>

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