10-05-2010

Deliverable DS2.1.1: Multi-Domain Service Architecture

Deliverable DS2.1.1

Contractual Date:	31-03-2010
Actual Date:	10-05-2010
Grant Agreement No.:	238875
Activity:	SA2>
Task Item:	T1
Nature of Deliverable:	R (Report)
Dissemination Level:	PU (Public)
Lead Partner:	NORDUnet
Document Code:	GN3-10-126
Authors:	B. Bach Mortensen (NORDUnet), A. Harding (SWITCH), B. Belter (PSNC), R. Corn (DANTE), T. Coulouarn (FSKnet), A. Hanemann (DFN), A. Polyrakis (GRnet), T. Szewczyk (PSNC), J. Sobieski (NORDUnet)

Abstract

This deliverable provides an overview of the considerations and practices involved in creating a multi-domain service architecture.

Table of Contents

Table of Figures

Executive Summary

For the joint offer of multi-domain connectivity services by the GÉANT community, a common approach and procedure needs to be specified and agreed upon. In order to address this issue, this document presents a service architecture for multi-domain connectivity services.

This service architecture aims to be flexible and adaptable to be able to serve connectivity services developed in collaboration with partners outside the GÉANT community, and to be adaptable to new technological developments. It shows how these services are built, and some important terms and requirements are defined.

To put the architecture in place and to maintain it over time, the services are defined by focusing on different aspects (see *Designing Multi-Domain Connectivity Services within the GN 3 Project* on page 6). In addition, a framework is presented to prepare a clear technical specification of each service (see *Service Design Specifications* on page 19). The concrete service specifications and precise technical specifications are not contained in this deliverable, but in additional service specification documents, which will be produced over the lifetime of the project.

1 Introduction

This document presents the service architecture for multi-domain connectivity services to be developed and implemented primarily within the GÉANT service area. These services comprise any user-accessible network capability that directly or indirectly supports digital data transport among GÉANT service area users and towards the service architecture's external interface to international collaborators. The service architecture is also intended to scale to support cooperation in service delivery with GÉANT external partners, where appropriate.

While the definition and architecture of the service offerings must consider the technical capabilities of the participating networks as well as the available hardware and software product capabilities, this document does not intend to provide a detailed engineering plan for the implementation of these services. Instead, it specifies a set of requirements and processes in order to define a flexible and adaptable framework that can serve as a set of guidelines for future transport services in GÉANT, as well as services developed in collaboration with domains outside GÉANT.

This document is organised in two main parts:

- Designing Multi-Domain Connectivity Services within the GN 3 Project.

  In this chapter, the service architecture for the services offered jointly by DANTE and the NRENs in the GÉANT service area is developed as an adaptation of the ITIL [ITIL] framework for service development. The management of the service catalogue (i.e. the set of services which currently offered) is also described.

- Service Design Specifications.

  This chapter specifies the questions that need to be addressed to allow multi-domain connectivity services to be delivered. It is intended to be used as a framework or check-list for the service specification of the different services.

1.1 Terminology

The following key terminology is used throughout this document.

- GÉANT service area

  The maximum potential area to which services can be delivered by the collaboration of participating interconnecting networks in the GÉANT community. The actual service footprint of individual services within this area does not have to be identical or comprehensive. However, the shared concepts for delivery of multi-domain services outlined in this document are designed to apply to the full service area, so that the criteria for participating in delivery of individual services are clear.

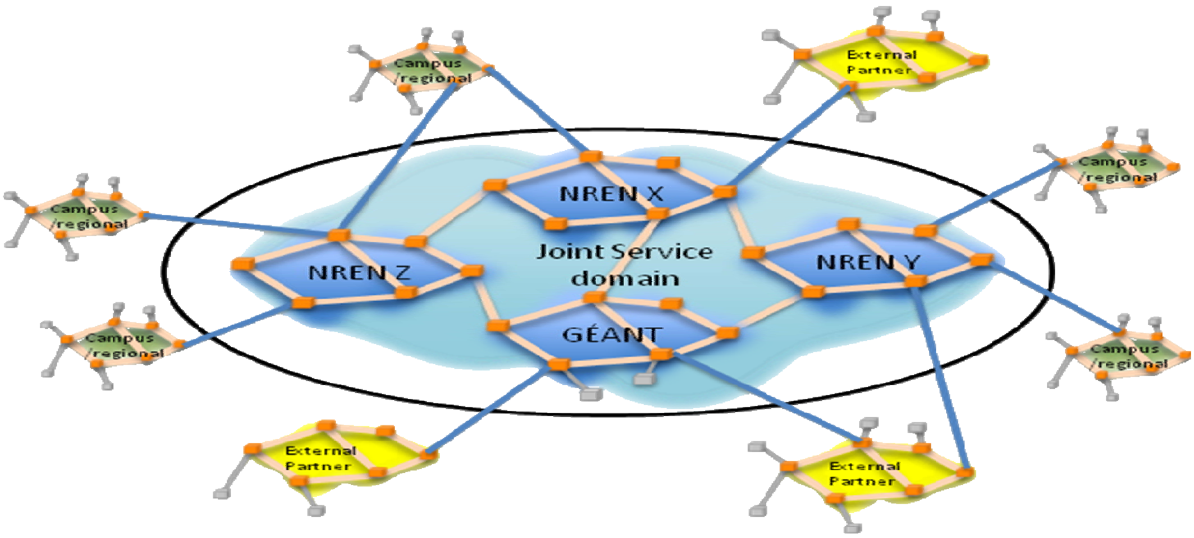

Figure 1.1: GÉANT service area offering joint services.

- End users:

  Primarily users of the GÉANT service area. In general, even though the service is intended to serve end user researchers or members of the higher education community, actual users of network connectivity services are expected to be network managers, mainly at the level of campuses. They are the target users when these services are, for example, presented to the public.

  In practice, a user is anyone who requests these services (e.g. network operators at other levels such as regional network managers) from the service area.

- Service definition:

  The description of services that is presented to end users. This includes a description of the offered connectivity type, usage details and the service level specification.

- Participating domains:

  Primarily synonymous with GÉANT and the domains managed by NRENs who are GN3 partners.

  Participating domains can be considered as administrative autonomous networks, even though they can encompass multiple sub-domains such as campus or regional networks where end users are located.

- Intra-domain transport services

  Participating domains operate intra-domain transport services. They are connectivity services which are offered within a single NREN and either provide the final segment where the service is delivered to the user, or segments that connect two edges of an NREN within a multi-domain connection

- Multi-domain connectivity services

  Services that are offered across different NRENs and connect these different intra-domain services in participating domains. This is illustrated for the simple case of connectivity in Figure 1.2.

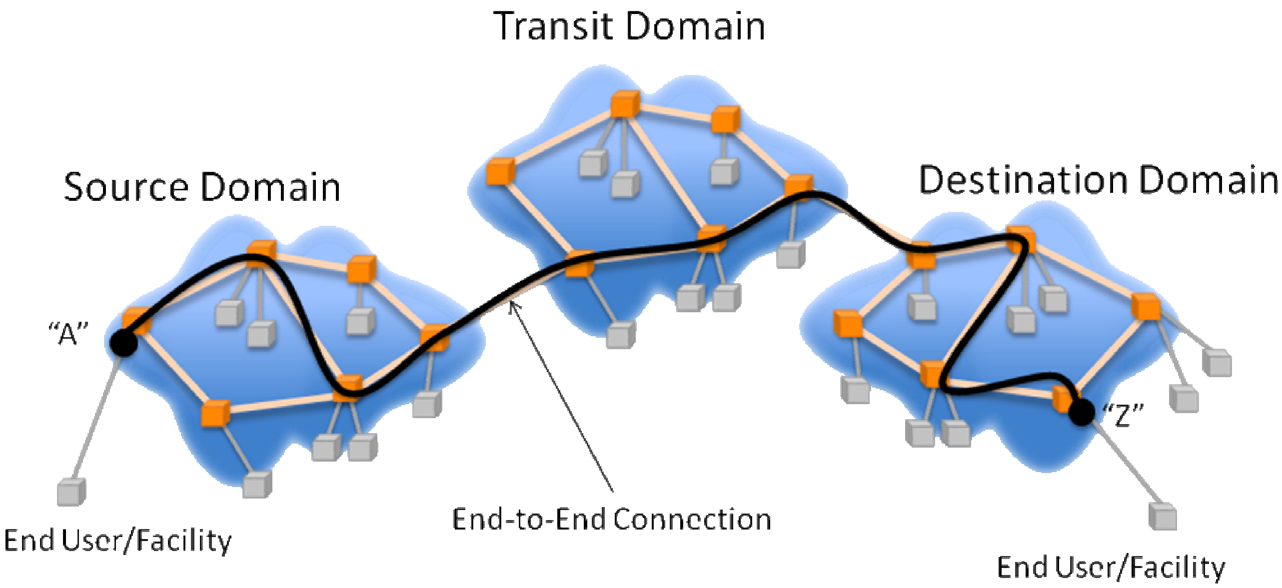

Figure 1.2: Network domain types.

- Multi-domain services & supporting services:

  By definition, multi-domain connectivity services are co-provided within the GÉANT service area. Therefore, in order to implement GN3 multi-domain connectivity services, a combination of selected intra-domain transport services of the participating domains will be used. These intra-domain transport services are formed from pieces of infrastructure and the resources and supporting elements that keep them running. They are referred to as supporting services.

For the selection of intra-domain transport services to take place, all domains must provide a catalogue of the transport services that can be used to provide the end-to-end service. This document distinguishes between services as they are presented to end users and supporting services (see *Designing Multi-Domain Connectivity Services within the GN 3 Project* on page 6).

Other supporting services may include multi-domain performance monitoring services, information services or topology services. The participating domains may also operate per-domain supporting services such as AAI or security response, depending on the concrete specification of a given service.

In short, any definable, supported piece of infrastructure or tool that facilitates the creation and management of the end-to-end service may be defined as a supporting service.

- Service demarcation points (SDPs)

  A location in the physical topology where the service can be delivered. SDPs are typically at an edge port and/or sub-interface. SDPs should be referenced through symbolic names or numeric addresses (see the black dots in Figure 1.3).

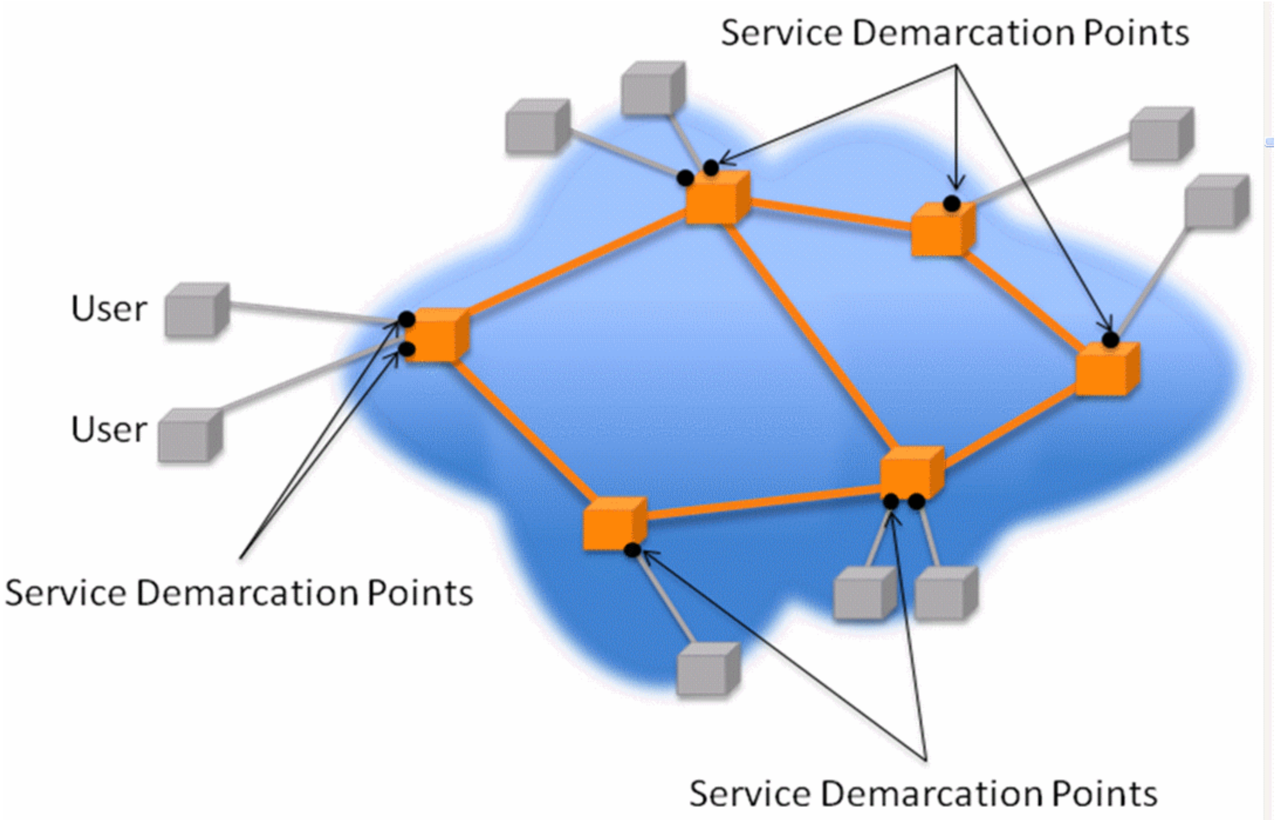

Figure 1.3: Service Demarcation Points.

2 Designing Multi-Domain Connectivity Services within the GN 3 Project

This chapter describes the overall approach to be adopted for the design and management of connectivity services within the GÉANT service area.

2.1 Multi-Domain Connectivity Services in Standard Network Management Frameworks

Before adopting a network management approach within the GÉANT service area, it is helpful to consider existing best practices and standards. Therefore, the position of multi-domain connectivity services in two network management frameworks, the Tele Management Forum (TMF) and International Telecommunication Union (ITU-T) was explored.

Multi-domain connectivity services encompass the minimal set of business processes needed for the provision of e2e connectivity in the GÉANT environment. These business processes can be most accurately mapped to the Service Management and Operations and Resource Management and Operations processes under the Operations area in TMF's eTOM business process framework [eTOM]. Due to the non-profit and multi-legal entity nature of the GÉANT network, other Operations area processes are not present or only partially present in the multi-domain connectivity services (e.g. Strategy, Infrastructure and Product Area, Enterprise Area, Billing and Revenue Management processes, Customer Relationship Management processes, etc).

eTOM Resource Management and Operations processes are typically performed in the Transport stratum of the ITU-T NGN model while Service Management and Operations processes are typically performed in the Service stratum of the ITU-T NGN model [M.3060]. Therefore, multi-domain connectivity services include the functionalities of both strata. The ITU-T network management model defined in Principles of the Management of the Next Generation Networks [M.3060] allows for recursive Service stratum replications in order to provide complex services composed of other services. In such a recursive service model (shown in Figure 2.1) multi-domain connectivity services encompass Transport and the lowest Service stratum, while upper Service strata are used to describe the position of other services typically oriented towards end users in end institutions that use multi-domain connectivity service functionalities. These services are outside the scope of this document.

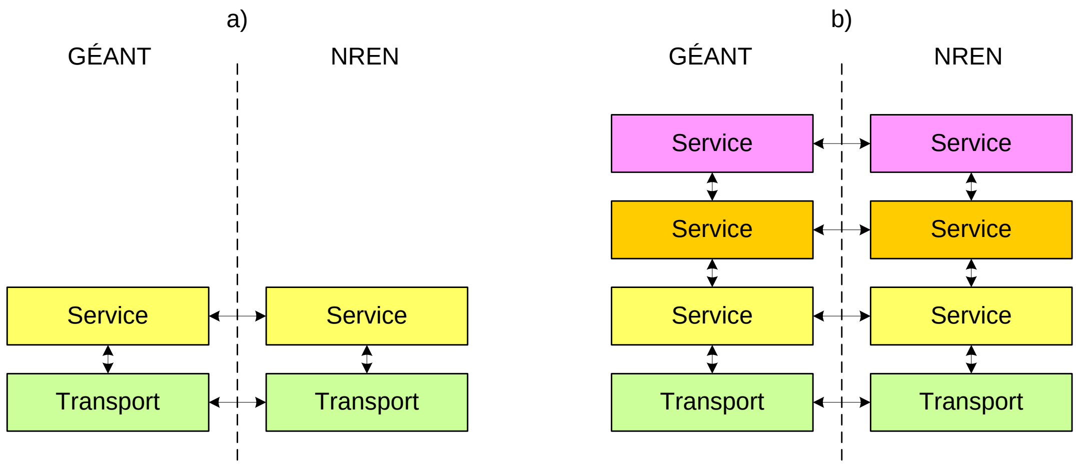

Figure 2.1: Service Strata models: a) basic, b) recursive [MJ2.1.1].

2.2 Offering Services

To present the different aspects of services offerings, a distinction is made between the notions of service portfolio and service catalogue (for further information on these concepts, see ITIL [ITIL]):

- A service portfolio refers to all services that are planned, designed, built, run or retired by a provider. It focuses on the life time of all services, including past, present and the potential future (see *Service User Perspective* on page 8).

- A service catalogue refers only to the services which are currently designed, built, or run. Only the services in the service catalogue are offered to users. The service catalogue comprises:
  - The business service catalogue.

    A catalogue that is directly offered to users, describing what service is available.
  - The technical service catalogue.

    Building blocks for the business services. In the case of multi-domain connectivity services, these building blocks refer, for example, to path finding, the determination of service termination points, topology discovering and distribution, authorisation, etc. They are only relevant for a co-provider internally and are not visible to the end users.

In the GN3 project the networks contributing to the joint service portfolio should be seen by the user as a single service provider. The user should perceive the service as an end-to-end service, and not be required to deal with internal details. The business service catalogue offered within the GN3 project should contain services that can be defined to be interoperable with similar services outside the GN3 service area.

In the following, four main aspects are therefore distinguished and presented:

- The service as seen by the user (see *Service User Perspective* on page 8).
- The service delivery process (see *Service Delivery Process and Parameters Affecting the User* on page 11).
- The organisational aspects of the service delivery (see *Multi-Domain Connectivity Service Architecture* on page 13).
- The management of the service seen as a process (see *Service Management Processes* on page 15).

2.3 Service User Perspective

2.3.1 Service Access Hierarchy

Although multi-domain network connectivity services are by definition co-provided by a number of domains, it is expected in the GÉANT service area that end users connect to and access them through their respective NREN and have a single point of contact (as for other national services). End users should not be able to request multi-domain connectivity services through other NRENs with whom they have no national relationship. Instead, requests for multi-domain connectivity services should be collated and managed at the NREN level.

In practice, a researcher who needs a specific connectivity service can, for example, communicate with a single point of contact situated at their campus who then transmits the request to the NREN. It is not required that another user at the remote end of the path also makes a service request, only that the participating domain at the remote end is willing and able to deliver, for which they may seek a confirmation from the remote user. At this point, the appropriate multi-domain connectivity service to deliver is decided. How the NRENs provide their users with access to the GN3 services is up to them. This relationship must be emphasised since language and procedural differences between NRENs may require local knowledge.

The service access hierarchy is shown in Figure 2.2. This deliverable addresses the connectivity services which will be jointly offered by GÉANT and the NRENs. Additional connectivity services can still be offered by NRENs or GÉANT to their respective direct user base independently of the multi-domain services developed within the GN3 project.

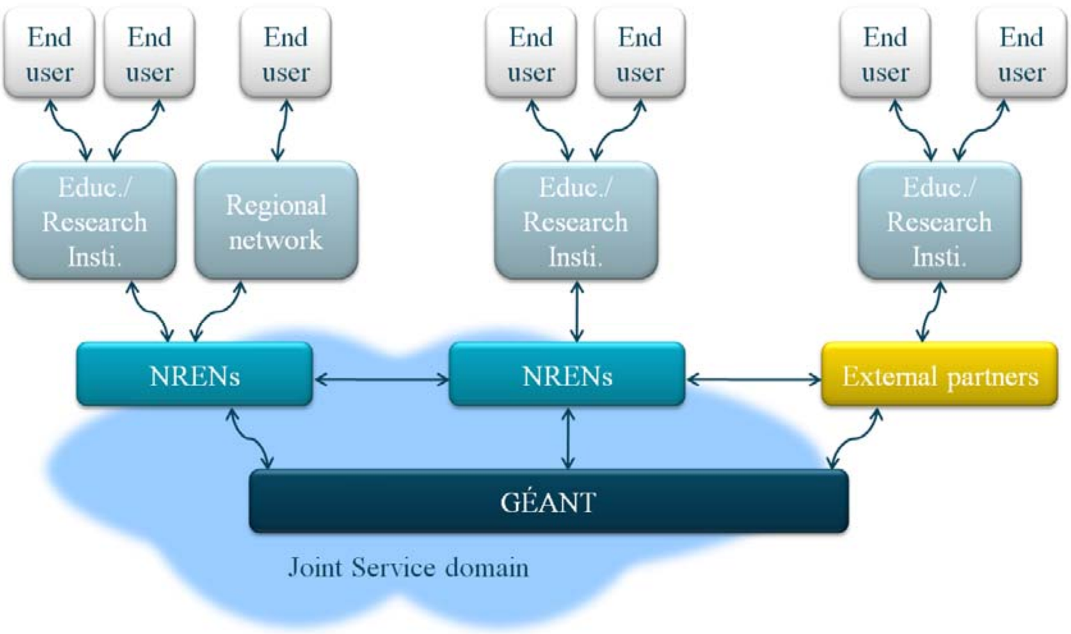

Figure 2.2: Service access hierarchy.

Figure 2.2 illustrates the business aspect rather than the technical aspect of the access to the service. From a business point of view, the requester has a single point of contact to broker for them over the service area. For example, the end user makes their request via campus IT who acts as the actual requester to the NREN. In this way local procedures are preserved in every NREN.

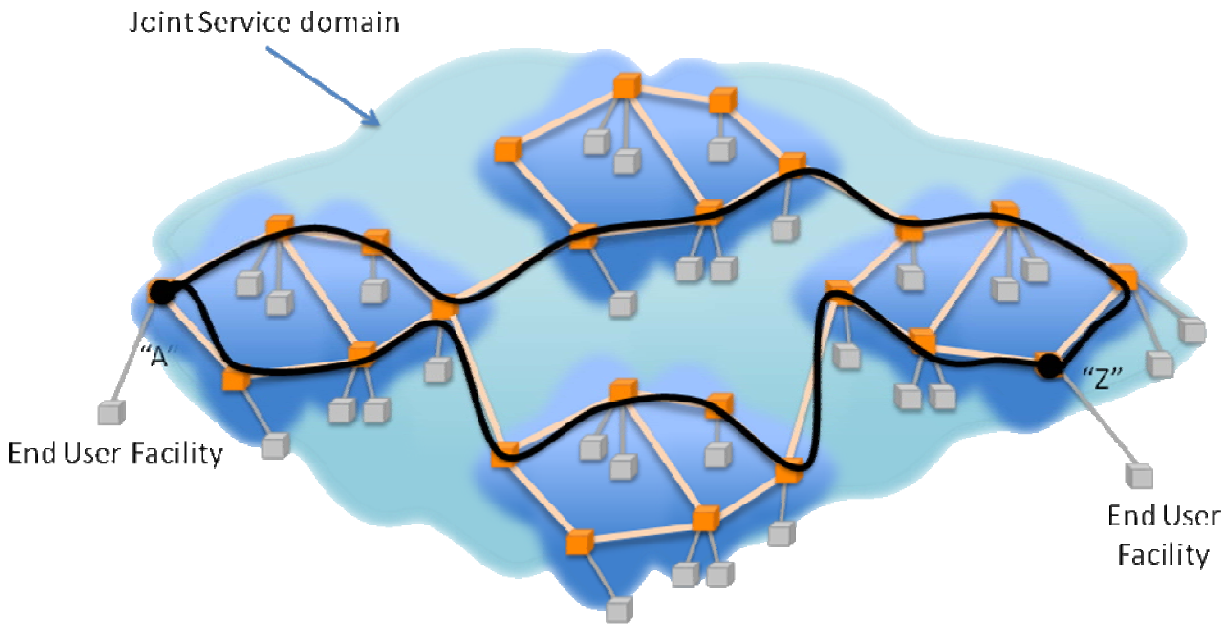

Figure 2.3: End-to-end connection via different networks.

Figure 2.3 shows how an end to end connection can be formed using two different paths that use two different internal domains inside the service domain without affecting the end user's connectivity service. The networks delivering the end-to-end connection hide the internal complexity and end users are still using their ordinary NREN to access the connectivity services. Although there will be differences in the technical parameters of two different paths, the end user should not be concerned with this, provided they are within the specifications that have been given for a particular service.

From a technical point of view, the demarcation point of the service located where the NREN delivers the service and which forms the edge of the multi-domain service area, is in most cases not located where the end user uses the service.

However, it is important to specify the end point of the multi-domain connectivity service within the service domain that is controlled by the NRENS offering the service. The handover of services to local networks is not covered in this deliverable, but NRENs can decide with their local users how the services area can be enlarged and still offer well specified services.

Besides delivering services to the NREN's end users (directly or through regional education and research networks), services may be offered to external partners through any of the participating networks. However, such service offerings to external partners should be in line with an Acceptable Use Policy (AUP). This should be specified for all multi-domain connectivity services offered within the GN3 service area.

2.3.2 Offered Services

The business service catalogue consists of a set of service definitions that detail the offered service. The service definition for end-to-end connectivity services offered to the end user are described by three main components:

- General service description (GSD)

  The GSD provides a high level explanation of the service for users who have little or no knowledge of networks. This description can be forwarded by the NRENs to any customer they may wish to announce the service to or included in marketing and promotional material.

  Example: A GSD explains that the service Y connects institution A and institution B permanently by providing a conduit for moving data from institution A to institution B and vice versa. High level technical parameters from the service level specification (SLS) may be included to give non-technical users an idea how much connectivity they can achieve. Specifying the possible bandwidths and uptimes of a connectivity service is a minimum requirement.

- Service functionality description (SFD)

  The SFD explains what the service offering is. This information is typically needed by the NOC managers and operational people at the institutions that need the service.

  Example: An SFD explains that the service is delivered using e.g. tagged Ethernet frames at the specified service demarcation A and B. The tagged Ethernet frames entering at service demarcation point A must be tagged with a specific VLAN ID value, and are delivered at service demarcation point B with a specific VLAN ID value. While the VLAN Id value must be specified by the end user, limitations may exist on the specific service demarcation points, thereby limiting the number of VLAN IDs available.

- Service level specification (SLS)

  The SLS specifies the boundaries of the service's technical parameters. This information is important to NOC managers, operational staff and institutions that need the service. High level parameters of the SLS that are likely to be of interest to users may also be described in the GSD.

  Example: An SLS explains that the Ethernet frames delivered at service demarcation point A are delivered at service demarcation B with a delay less that 100ms, and with a maximum delay jitter of 10ms. The up time of the service is 95% and the bandwidth allocated to the connection is not over-subscribed anywhere along the path.

The services offered within the service architecture described in this document should be of consistent quality, regardless of where the service is accessed. This does not imply that technical parameters are exactly the same (e.g. delay and delay jitter or response time may be different), but rather that the minimum limits on these are well described. The general service description, the service functionality description and the service level specification will be mandatory parts of a business service catalogue which will be offered jointly by the participating networks.

The service catalogue should be clear enough to indicate which user needs can be met by a particular service. For example, only specific types of users may wish to use a particular service (e.g. a wavelength-based service may only be designed for users with very high data volume transfer needs, or a dynamic service for short-term use). This will help NRENs to offer appropriately dimensioned multi-domain services to users.

2.4 Service Delivery Process and Parameters Affecting the User

As previously described, end users must contact their local NREN when asking for multi-domain connectivity services. The definition of this process is not within the scope of this deliverable. However, when it comes to delivering services within the participating networks of particular multi-domain connectivity services, understanding the process and expectations for service delivery is extremely important. Without processes to initiate and control service delivery, and specified delivery times within participating networks, it is difficult to specify important service parameters. The user experience of the service area will not be deterministic. Therefore, from a service point of view, delivery times and processes need to be considered for at least three phases of any concrete multi-domain connectivity service. These are:

- Service initiation

  Information about how to request and establish a multi-domain connectivity service.

- Service operation

  Information regarding changes to multi-domain connectivity services in operation, e.g. change of service profile, service type etc.

- Service removal
  Information about how to remove a multi-domain connectivity service.

For each phase, information must be made available about the necessary steps that need to be taken in order to deliver service effectively. This must include information about who to contact, how to contact them, and the maximum response time associated with the individual steps. Although some of these steps may be automated in a concrete service description, they must still exist.

For example, if an NREN wants to initiate a multi-domain connectivity service, information about whom to contact must be made available and easy to find. The contact point may of course depend on the type of multi-domain connectivity service requested (an automated system may broker all these issues). Additionally, the NREN must have information about the correct contact point and the correct contact media (phone/mail/web service/web page/etc). After contacting the appropriate contact point using the correct media, the NREN should have a reply within a given time span (e.g. 5 business days, 4 hours etc.) and there should be a restricted period of time within which the NREN must reply to the answer. If the requested multi-domain connectivity service is accepted, the NREN should have a restricted period of time to specify the maximum service delivery time.

The above example may not be applicable to all types of multi-domain connectivity services. However, each multi-domain connectivity service specification should be analysed and potential participating domains consulted to find reasonable service delivery parameters. The above service delivery process and parameters should not be seen as operational procedures and processes. However, operational procedures and processes in the participating networks may require changes to deliver the specified service delivery parameters. How this is achieved is up to the individual network.

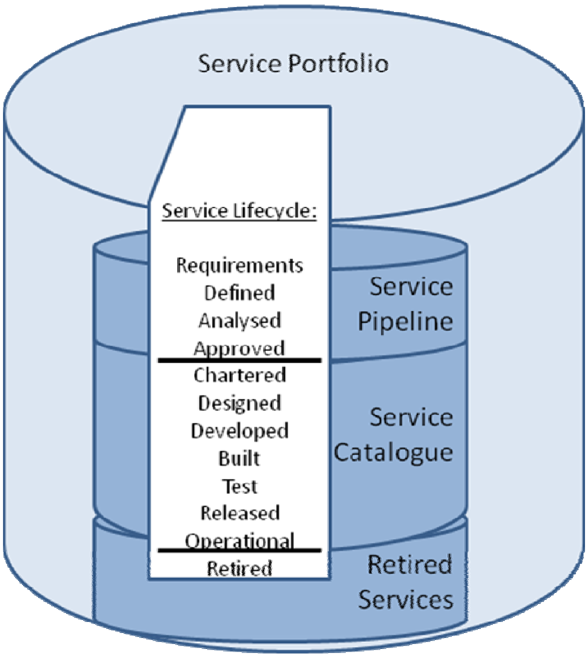

Figure 2.4: Service portfolio and service catalogue terminology.

Figure 2.4 shows the difference between service portfolio and service catalogue. The service portfolio includes services at all stages of their lifecycle, i.e. being under development in the service pipeline, being active in the service catalogue, and being retired in the retired services. ITIL has introduced additional differentiations for the service lifecycle which are also shown in the figure.

2.5 Multi-Domain Connectivity Service Architecture

From a management and organisational point of view, delivering guaranteed service parameters requires that the relationship between support services, infrastructure tools and resources as well as services offered by participating networks and operational teams are well described and documented. This section describes this relationship in general for any potential multi-domain connectivity services provided by the GN3 partners.

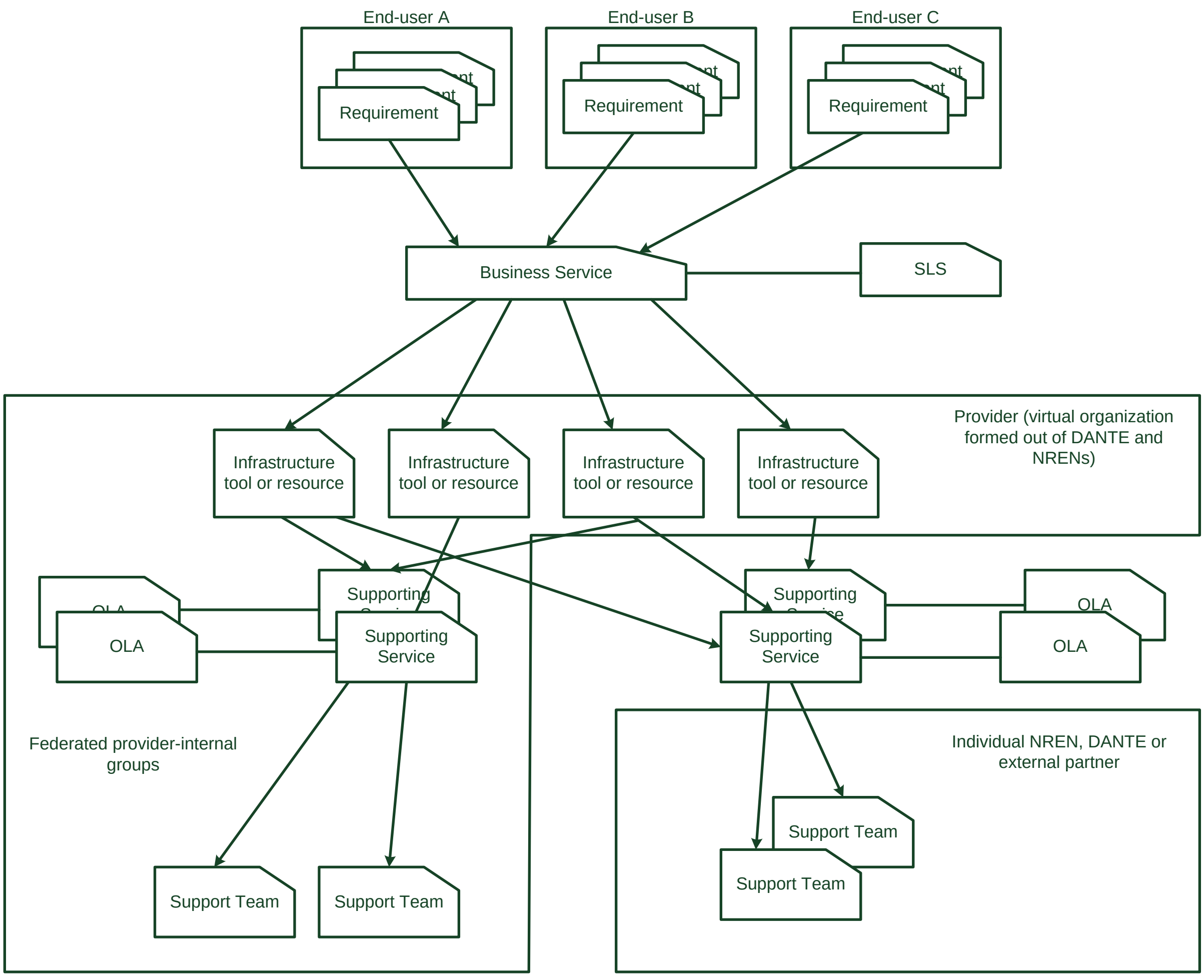

Figure 2.5: Generic service architecture model.

Considered from top to bottom, the different levels in Figure 2.5 can be explained as follows:

- End users:

  Multiple end users that may have different requirements for different connectivity services.

- Services:

  The services are described in a business service catalogue which details what is delivered to the user (relationship to end users) and in a technical service catalogue which specifies how the services are constructed.

- Infrastructure:

  To deliver connectivity services, infrastructure is required. This may be, for example, hardware, software (databases, applications, etc) or information. Infrastructure comprises all concrete elements that make service delivery possible. It includes the network segments but also the interconnections between the different domains. This ensures that the individual smaller elements (such as per-NREN connectivity) that form the end-to-end service are deployable. Some of the infrastructure operates at the Transport stratum and primarily within domains, and some at the Service stratum in controlling the delivery of end–to-end service, and primarily across multiple domains.

- Supporting services:

  The supporting services keep the infrastructure running and have specified Operational Level Agreements (OLAs) that define the boundaries the supporting service should stay within in order to meet end user expectations. The OLA is a service-internal document supporting delivery of the service and has no penalties associated. It is important to stress that there is a strong relationship between the OLAs of the supporting services and the SLS of a multi-domain connectivity service. If for example a connectivity service SLS specifies a particular availability, the minimum of all of the supporting service OLAs should not be below that limit. Domains have the ability to freely choose their own internal network technologies, underpinning provider SLAs and processes and still be able to take part in the joint service offer, guided by the SLS to deliver a compatible supporting service and OLA.

Figure 2.6 illustrates how these basic principles and relationships can be applied to multiple services with multiple users.

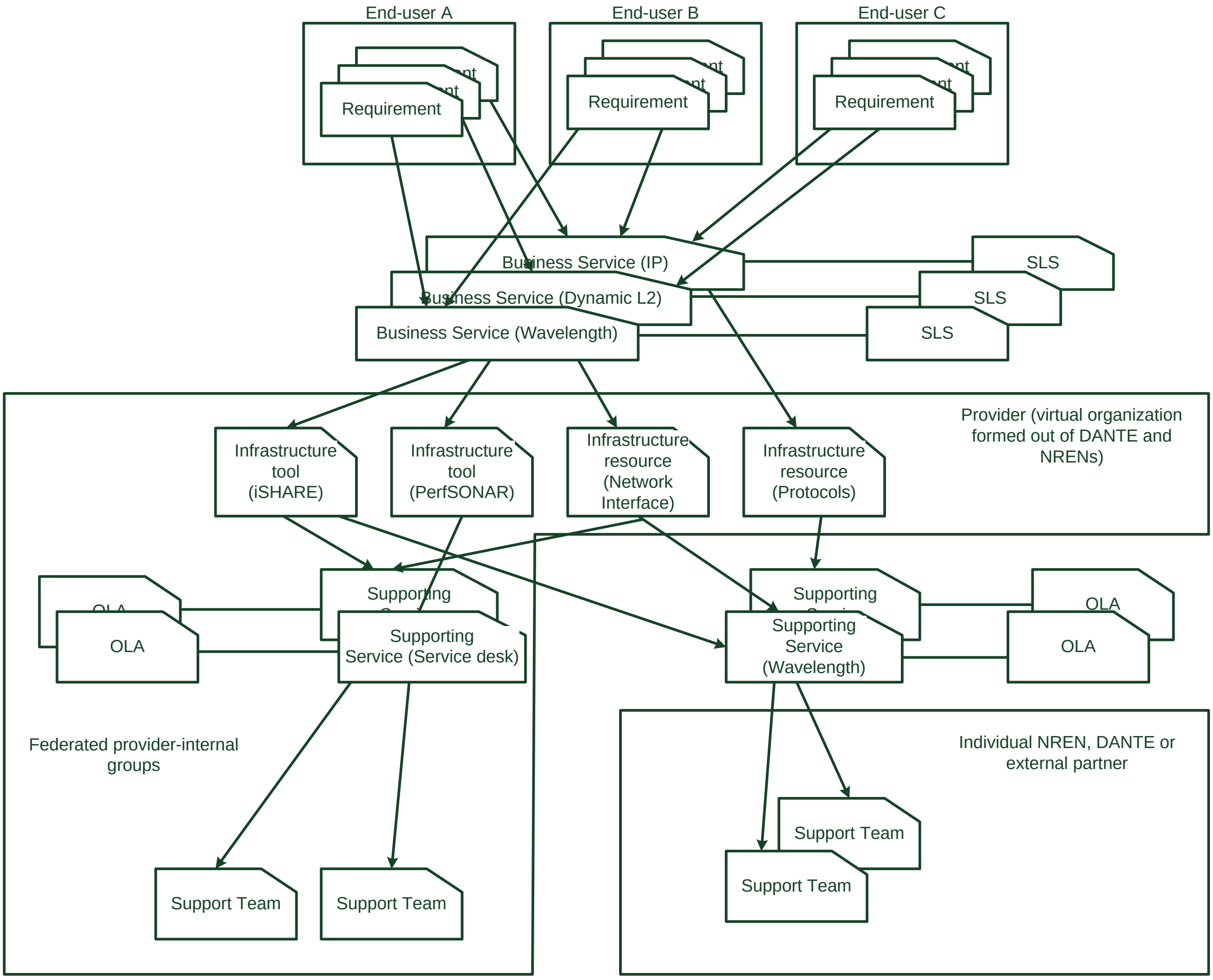

Figure 2.6: Example of three business services mapped to the generic model.

2.6 Service Management Processes

The GN3 project defines a set of shared mechanisms for determining which services will be provided and how they will be provided. Determining these processes is outside the scope of this document but the general principles and phases are detailed below.

2.6.1 Business Cases

A business case needs to be defined for each service. ITIL defines a business case as a "justification for a significant item of expenditure which includes information about costs, benefits, options, issues, risks and potential problems." [BC]

For the cost, a list of factors should be listed, including service design costs, service setup costs and service operation costs. An evaluation of contingency costs should also be made.

2.6.1.1 *Benefits*

The benefits of the service are considered from the user perspective. For the end users the value of a service is the combination of utility and warranty. Utility means that the service functionality is fit for the end users purpose. Warranty ensures that the end user can benefit from the service during operation because certain levels of availability, capacity, continuity, and security are guaranteed.

2.6.1.2 *Options, Issues, Risks and Potential Problems*

The service offer can often be realised or detailed in different ways, so that the major options can be given. In the event that there are multiple supported options for delivering or implementing a service, these options must be detailed (e.g. protected or unprotected paths). In addition, issues, risks and potential problems must be identified.

2.6.1.3 *Analysis of Service Requirements*

After the overview of services in the definition phase, it is necessary to perform a deeper analysis of the service requirements. In the analysis phase, the services to be selected for the service catalogue should also be looked at in context because commonalities between the services are relevant to the service operation. In particular, this involves:

- Identifying the potential end users of the service. Which prerequisites on the user side are necessary to access the service?
- Specifying the functionality of the service. Is there a set of functionalities or is it mainly one functionality with a set of parameters?
- Identifying quality requirements. What quality expectations do users have (related to availability, performance, security)? How can they be met (e.g. what kind of monitoring and service desk is required)?
- Identifying the usage pattern of the service. Is it used only temporarily and, if so, what is the duration? Are the times predictable? Which service setup time is acceptable?
- Identifying the service pricing/cost sharing options.
- Determining how the service be realised. What kinds of (external) supporting services and what resources are needed? How can these building blocks be composed, in particular when involving different domains? Identify technical infrastructure components and describe their organisation with the supporting services.

- Specifying how the service operation be realised (monitoring, service desk, security issues). What kinds of protections mechanisms (restoration/protection or security?) are needed, and how does the fallback work in order to assure the warrantees?
- Specifying how capacity should be planned in relation to the current and expected future service use. How will capacity planning between the participating networks work?
- Identifying costs that are related to the service. Do they have to be distributed within the provider (federation of NRENs and DANTE)?
- Identifying the risks and uncertainties related to the service.
- Identifying which legal aspects apply to a service.
- Specifying how the service is to be promoted.

2.6.2 Common Service Management of Centralisation, Decentralisation and the Federation of Operations

The service architecture and management processes do not mandate a particular operational model. For each service, and for appropriate supporting services, the relations and potential synergies between the services have to be analysed and an appropriate model proposed.

For example, it should be investigated whether two services are related in such a way that a service desk can serve as a common centralised service desk. Such a service desk may be virtual or in a single location. For other services it may be preferable to establish a common federation structure of their service desks.

A matrix structure of the services with their features can help to do this determination.

2.6.3 Critical Success Factors

Criteria that need to be met must be documented to mark a service as active/commissioned. This includes setting goals for how to move the service from design into operation and verify that the operation works (e.g. that it has sufficient users or particular performance characteristics).

2.6.4 Propose New Service Catalogue Entry

A proposal for a new service catalogue should be made which considers the individual service’s benefits, costs, and risks, but also the overall picture. Even though some services may not be seen as cost-effective on their own, they may be offered if some prerequisites are necessary anyway for other services.

2.6.5 Approve Services

The new service catalogue proposal has to be agreed by the GN3 management, as per the project procedures. After that the service catalogue needs to be made available to potential users, and the necessary delivery elements need to be put in place.

3 Service Design Specifications

This section guides service designers through the key consideration in defining a multi-domain connectivity service specification, providing an insight into the end–to-end requirements for designing a multi-domain connectivity service. It does not provide a concrete specification for domains to engineer to, but rather sets out a framework for designers to create such a specification in a multi-domain environment.

Multi-domain services transit other NREN-owned domains, may transit third-party-operated domains, may transit domain inter-connection points, and deliver a service to end users in a remote domain. The multi-domain connectivity service design relies upon particular functionalities delivered by a Transport stratum. This may include the transit of a specific transport technology, a set of transport technologies, a combination of technologies (implicit but not specified), or an explicitly defined transport technology.

An example of an implicit set of technologies is the delivery of 100GE serial transmission connectivity, as the ITU-T determined that SDH capacity will not extend STM256 (39.8Gbps). An example of an explicit technology is the requirement for an optical transport technology such as an OTN OCh (which is a 'wavelength service'), an MPLS VPN, or a PBB-TE transport path. In either case, it is not within the scope of this deliverable to provide technological specifications, but instead to ensure that during service design appropriate reference is made to Transport stratum constraints that may be required for service delivery.

The specification of operations and management procedures includes inter-domain elements and intra-domain elements. Similarly, service introduction specifications include inter-domain and intra-domain elements, both assumed and specified. Installation and commissioning stages require end-to-end cooperation. Provisioning and configuration stages include either coordinated manual procedures or pre-organised automated mechanisms. Each point of this process should be considered to ensure the particular service is covered by the agreed assumptions. If any aspects of the service are found that are not covered by the agreed assumptions, a specification is required. Existing intra-domain procedures should not be altered.

Dependencies on procedures and informational facilities may also be identified. For example, transport service delivery may rely upon the existence of transport technology topology and network topology mining tools.

As this section is intended as a guide through the process of combining (and ensuring the existence of) existing procedures, organisational practices and standards, and the creation of particular specifications, terminology from several different terminology models needs to be referenced or adapted (e.g. terminology used by NREN organisations, international standards bodies etc). Recommendations by the project on the most appropriate models to use will be adopted during service design and specification.

The service definition aims to specify the service in a way that underpins the SFD and SLS between service provider and end users. Therefore, the service description has to include its functionality and the quality guarantees given with the management functionality. The management functionality gives constraints for operational procedures carried out by the provider. It is also necessary to clearly specify how a service can be accessed (i.e. the service demarcation points have to be given).

3.1 Service Definition Concepts

3.1.1 Service Functionality Description

This part of the service design framework addresses the service functionality description in the business service catalogue and the end-to-end service offered to users. It is a detailed, technical document. For each service the end-to-end functionality needs to be specified. Both technical and service management functionality must be described.

The service functionality must be given in a textual description. Ambiguities should be avoided by explicitly defining important terms and outlining key assumptions. Any elements of standards adhered to should be specifically identified, not just broadly referenced. This description should explicitly identify and define any and all relevant aspects of the service as offered to the requester/user. It should detail which functionalities are provided at the Service and at the Transport stratum (through the Network Management Architecture), ensure a consistent interface between them and note any constraints that apply.

For example, it is possible that described functionalities are specified to be usable for a set of technologies (e.g. a service that allows data transport over a dedicated optical infrastructure, but without an explicit guarantee which technologies are used for the transport has a reasonably clear separation of Service and Transport stratum) or that a service is tied explicitly to a specific technology (e.g. EoMPLS, where the service cannot be offered without explicit transport requirements).

The service functionality has to contain constraints that apply to the users' application of the service (e.g. maximum burst sizes, maximum MTU sizes, or hours of support cover). Related to that, policies in case of off-specification use of the service must be specified.

It is also necessary to indicate whether the service is a point-to-point or point-to-multipoint service.

3.1.2 Service Level Specification

In addition to service functionality, quality parameters have to be defined. These parameters can be handled in different ways. Values, for example, may be predefined by the provider, so that they cannot be negotiated. Alternatively, the provider may offer ranges or certain classes of service levels.

For example, bandwidth can be offered at a minimum of 50 Mbps and then in increments of additional 50 Mbps. The availability of a service can be defined as best effort or with predefined classes such as e.g. 95% during regular business hours for a certain time period (e.g. per month). It is not the purpose of the service level specification to describe how the service capabilities are accomplished within the network service domain. This is left to the Transport stratum functions and/or engineering staff tasked with designing and implementing the service. In some exceptional cases, it is recommended to specify this explicitly, if this is important for the service acceptance by users (e.g. that an optical 1+1 protection is applied).

For connection-oriented services, each service instance (i.e. each connection request) should allow the specification of scheduling parameters (a start time and end time or duration). While the end date may be left open in the actual agreement, an explicitly defined service availability timeframe is necessary to support scheduling and efficient resource planning.

It is important to note that the service levels are not only relevant to the service as delivered to the user, but also to the service management functionality. For example, service desk hours and the time it may take to solve a performance problem need to be defined. Service levels can also comprise security levels related to unauthorised service access, integrity and the protection of transmitted data.

When the service is finally used, an individual SLS has to be communicated and accepted between the local domain acting as broker and the user/requester to fix parameter values and meet service quality expectations. It is not foreseen that these individual SLS also lead to per-user OLAs. The possibilities to support individual users should be sufficiently defined in the OLAs of the individual services.

3.1.3 Service Demarcation Point

The service demarcation point (SDP) defines a point to which the connectivity service can be delivered. Different services may have different service demarcation points. The service demarcation points will be used as a part of the service functionality description that is intended to be used for NOC managers and operational engineers in the regional and campus networks (see *Offered Services* on page 10). For each multi-domain connectivity service offered, a mechanism must be available that allows the association between the multi-domain connectivity service type and the possible service demarcation points. Such a mechanism may vary between multi-domain connectivity services. E.g. the SDP for a connectivity service could be constructed from an equipment identifier, a port identifier, and a service ID identifier (e.g. <S/P/I> tuple).

The management of the SDPs is likely to be maintained by the individual networks participating in a multi-domain connectivity service, as the SDP may change frequently, based on the underlying Transport stratums at the inter-domain level.

3.1.4 Service Management Functionality

The functional service specification must describe any feature of the service that the user can measure. The user should be able verify whether a service instance established at the user's request meets the agreed performance constraints. The service management functionality allows the user to take an appropriately detailed look into the providers' management of the service, to be able to determine that the service is delivered as agreed.

Service management functionality may allow the user to make certain changes (e.g. the migration to a higher service level). It should take account of whether the service is targeted at individual end users or strives to support a consortium of users who require a complete network solution.

User-centric service management functionalities should indicate which operator-level functionalities should support this. The user-level service management functionalities generally operate at the Service stratum, whereas the operator-level information may go deeper.

The service management functionality should address the following areas:

- Service readiness:

  Functionalities that indicate that systems and processes for services are in place. This is supported by systems and processes which indicate that resources are available and ready.

- Service orders:

  Configuration, activation, decommissioning tracking, managing service orders, service implementation and recovery. It should be indicated how this is supported by functionalities that enable resource allocation/recovery, provisioning, configuration and testing to be implemented at a lower stratum.

- Service problem management:

  Functionalities include how faults can be discovered by service management tools and/or reported by users, how the issue is tracked and managed and how the user is informed about the fault-handling progress and what happens after problem resolution. This is supported by functionalities at the individual resource level that track these stages.

- Service accounting:

  Gathering and making information about service usage available, and guiding the user in the interpretation of the delivered service's performance and quality. This is supported by functionalities that provide information about resource usage.

- Service quality management:

  Functionalities that allow the user to compare performance against the SLS, get information about the performance as monitored by the provider, report performance issues and get a resolution. These are supported by functionalities that track the same issues per resource.

Policy and tools should be in place that address and enforce the appropriate level of user and operator access to these functionalities.

It is possible that service management interactions are carried out by automated or manual agents which act on behalf of the user and provider. If this is supported by the service, they way they exchange information must be specified.

For every service a projected start date and end date should be part of the service rollout plan.

3.1.5 Service Pricing and Conditions of Use

The service description has to contain the terms by which the pricing or cost of the service use can be calculated. In addition, it needs to define how service usage is monitored. The offering partner does not have to calculate or present the pricing directly to the user if they have different procedures, but the service pricing implications must nonetheless be understood, so that NRENs can have a picture of the value of the service against costs, that is relevant to their own situation

DANTE and the NRENs in general provide services for the benefit of research and education networking. An additional statement must be added to ensure that the participation of users (in particular from a commercial research background, if agreed) does not affect the recognition of these networks or their sponsor as non-profit organisations.

3.2 Service Delivery Concepts

3.2.1 Service Trust Model

For each service participating in service delivery a trust model must be specified. As a default, the preferred approach is for the trust relationship formed by the acceptance of the user request by the contact NREN to be accepted by all domains on the path. Provisions can be made for the participating domains to reject a service request on other grounds (e.g. resource availability), but the identity and associated trust should be consistently accepted and this principle facilitated by a clear AUP.

3.2.2 Service Stitching

The provision of services to end users requires that these services are consistently and efficiently built. As indicated earlier, the processes making this possible are not visible to the end user but underpin the service as offered to them. In other words, they are part of the technical service catalogue, not the business service catalogue even if they are not technological processes.

In practice, the multi-domain service is stitched together from smaller segments of network connectivity between the participating domains. This approach is illustrated in Figure 3.1, using an example end-to-end (E2E) path. The E2E path can be realised using different technologies in the domains, such as native Ethernet, Ethernet over SDH, Ethernet over MPLS or any other appropriate transport technology.

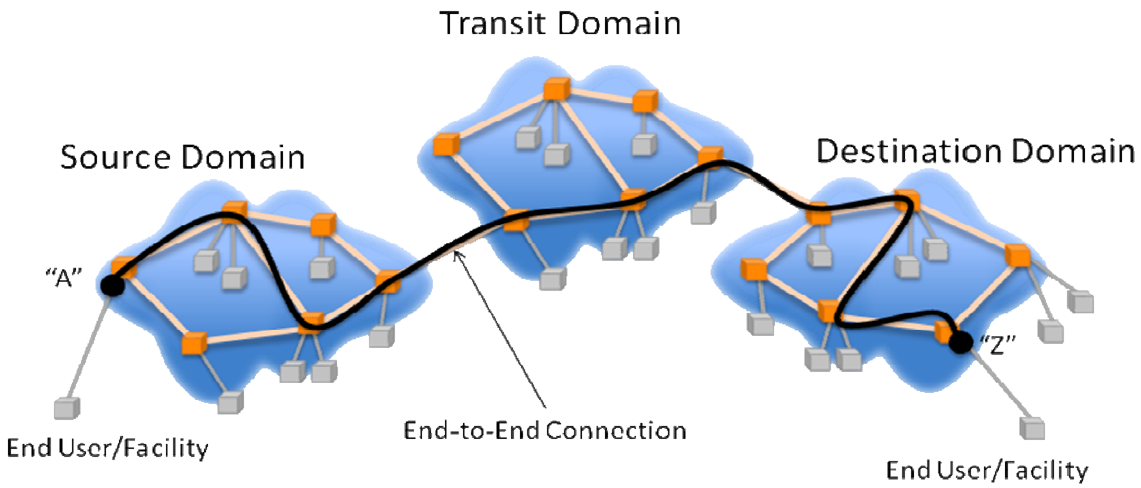

Figure 3.1: End-to-end connection.

To deliver a joint service catalogue to end-users that contains both a service description (what the service does for the end user) and an SLS, a similar specification is needed for each of the network segments that participating domains contribute for the delivery of the joint service. It is not possible to provide any predictable service parameters across multiple networks if some of the participating networks are not providing known minimum service parameters. This chapter presents a framework for the technical parameters that need to be specified for the different connectivity services, so that they can be fully specified in the individual service specifications. The levels for each of these parameters are agreed in OLAs.

3.2.3 Supporting the SLS through Operating Level Agreements

The service functionalities and SLS which are defined in the Business Service Catalogue are delivered jointly by the domains on the service path i.e. both DANTE and NRENs. It is therefore necessary to define sufficiently detailed OLAs between these organisations, so that a common service of high quality is delivered and cooperation is efficient and predictable.

Although the delivery of service functionality and service quality is dependent on both intra- and inter-domain components, the independence of the organisations that collaborate has to be considered. It is, therefore, necessary to aim to define domain-internal operations and infrastructure in the OLA only in terms of the input and output interfaces and agreed arrangements for the collaboration between organisations. Where this is not possible due to explicit technology constraints, these must be clearly highlighted as applying to the intra-domain environment.

In the context of the Network Management Architecture, the OLA should consider the relationship between Transport and Service stratum, and must be described in a manner that allows the Service stratum to be aware of capabilities. This way a service request can be accepted or rejected, and the Transport stratum can implement the necessary configuration to actually deliver it, if it is accepted.

The following points serve as a checklist for design of OLAs:

- An OLA always has to be regarded in context of the SFD and SLS for which it serves as basis. The structure of the OLA mirrors the structure of the SFD SLS and underpins the delivery of the appropriate end-to-end service.

- The OLAs serve as basis for the collaboration inside the service area. For the collaboration with external partners, whether SLS or OLAs should apply can be decided on a case-by-case basis. For example, in a collaboration with an external partner like Internet2 to offer a Bandwidth-on-Demand service, Internet2 may be regarded as participating in the architecture (OLA) or, if the service architecture compatibility is not that tight, an SLS may be appropriate.

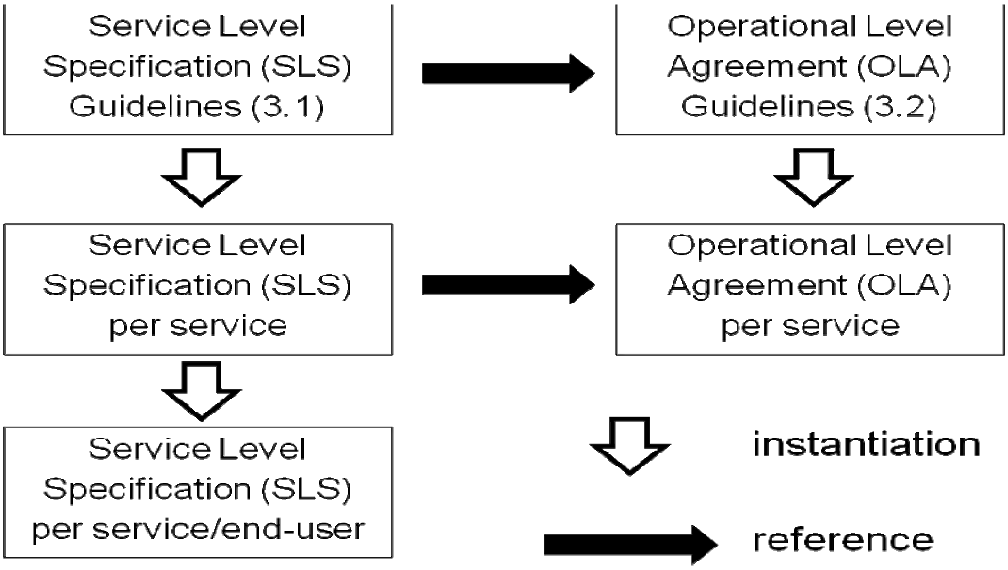

Figure 3.2: SLS and OLA organisation.

Figure 3.2 shows the relation of the SLS and OLAs. Each OLA only makes sense in relation to an SLS (indicated by black arrows). When doing a specification per service, the OLA document has to reference the concrete service specification.

3.2.4 Transport Stratum Inter-Domain Functionality Realisation

Based on the level of description required in the Service and Transport stratum, which the SLS and service functionality descriptions provide, implicit and explicit requirements may apply to the technologies that have to be used to realise the service.

Explicit technology requirements constrain the Transport stratum. For example, if the SFD includes an MPLS VPN and Optical PVC, these also need to be complied with in the OLAs and intra-domain operations have to be carried out accordingly.

Implicit technology requirements are governed by the service choice, but are not specifically set out as technology requirements. However, they still pose constraints on the functionalities of the Transport stratum. For example:

- If the service is 100Gbps, the transport cannot be SDH serial, because the maximum SDH capacity is STM256.
- If the service is constant bit rate, a transport technology with GFP-transparent bit-by-bit mapping must be chosen. If a transport service with GFP-frame mapping is chosen, this will cause problems.
- If the service is offered as resilient, an associated protection scheme must exist.

For Transport stratum technologies that are involved in service realisation, specific references to standards documents should be given to avoid ambiguities (it is more useful to refer to specific sections rather than entire documents). If the standards allow different options to be followed, it is also necessary to state which options have been chosen. Furthermore, additional technical agreements may be necessary (e.g. that 10GE will be delivered as native Ethernet). The detailed technical specifications must be provided in additional specification documents, and references to these documents must be given.

The SLS includes restrictions that apply to the user (such as a maximum MTU or burst size). The ingress domain must consider technical measures to make sure that these restrictions are observed, so that the service operation is not put at risk.

Sufficient detail must be given to determine engineering requirements within participating domains and to allow participating domains to identify any implicit local technology requirements that could affect their participation in the service.

3.2.5 Transport Stratum Inter-Domain Demarcation Points

The agreement on this level is very much dependent on functionality of the Transport stratum. In the example of a wavelength service, the physical interface, the wavelength, the input power and many other parameters have to be given. Sufficient detail must be given to determine engineering requirements within participating domains and for participating domains to identify any implicit local technology requirements that could affect their participation in the service. Specifically, from the level of detail provided by the functionality requirements and demarcation points, participating domains should be able to identify any specialist hardware (e.g. functionality requirements such as a 100G interface, or timing source), software (e.g. particular OS or applications) or logistical requirements (e.g. PoP space, power) that apply to their intra-domain network to be able to deliver the required quality to demarcation points.

3.2.6 Transport Stratum Inter-Domain Service Quality Realisation

In addition to the agreement on the functionality, compliance with service quality parameters needs to be ensured. This means that agreements have to be made about the service quality that each participating domain has to deliver. For example, if the service specifies a maximum delay of 1ms per 100 km, then each domain should also individually support such a specification. If an optical path with alternative paths is to be delivered, information has to be exchanged about the path configurations.

Capacity planning is important to ensure compliance to any current and future service quality level. This planning for the service has to be based on assumptions about the service use and the growth rate. Agreements have to be made about how the participating domains manage the capacities that are dedicated to support the service.

3.2.7 Service Stratum OLA Requirements

Where service delivery relies on software modules or compliance to particular standards in each participating domain, the OLA should detail which functionalities these modules and standards expose to ensure the running of the service. It should outline quality metrics and responsibilities for the availability of the software elements that support the SLS and SFD. This allows the participating domains to understand the requirements for and reasons for operating such software elements.

The service quality also has to relate to the service management functionalities. E.g. for a federated service desk to react in time, all participating domains have to commit themselves to answer questions within a specific time frame.

3.2.8 Service Management Functionality

3.2.8.1 *Inter-Domain Service Management Interaction Points*

To allow the service management functions to be accessed, additional service management access points have to be clearly defined to support multi-domain management processes. These points must be aligned with the service management functions as defined for the end-to-end service (e.g. to support a fault management process, troubleshooting interaction points are required).

Management information exchange points have to be defined for all the service functionalities and OLA terms at both service and transport levels to demonstrate that the service is handed over to the next domain in the path as expected. Control plane interaction points must be defined for relevant services. Where possible, interaction points should be automated, but for all cases the information exchange method must be specified. Quality expectations must be agreed for the availability of these interaction points.

For each management functionality that is set up, it is recommended to create process diagrams. Each step should be identified as inter-organisational or intra-organisational. An inter-organisational step has to be described in detail, but due to the organisational independence it does not make sense to describe domain-internal procedures. These are defined by input and output artifacts. It is proposed to use UML activity diagrams, as outlined in DS3.16.1 [DS3.16.1] or in the eTOM Process Flow examples [eTOM process]. Such diagrams can then be used to identify possibilities for automation and more efficient service delivery over time.

An example of a process to be defined among the domains is the installation of a service instance. When a domain declares that it has completed a certain step, there must be clear handover criteria to determine whether the step has been performed correctly. For this situation and the acceptance of the overall service tests, procedures must be agreed. The documented process may be completely automated, completely manual or a combination of the two.

3.2.8.2 *Intra-Domain Service Management Interaction Points*

Depending on the agreed supporting service model, the definition of some intra-domain service management interaction points may be required. These allow participating domains to report relevant service quality and functionality along their parts of the multi-domain path. Where possible, such points should be automated, but for all cases, the way they exchange information must be specified. Quality expectations regarding the availability of these interaction points must be agreed. E.g. a domain participating in a managed private network service could be asked to make link status information available in a defined format with a defined availability of information.

3.2.8.3 *Supporting Service Functionality*

For support functionalities ITIL recommendations should be taken into account. This means that agreements concerning a service desk model (e.g. centralised, virtual, federated, decentralised) and functions (incident management, problem management, change management, configuration management) to support the infrastructure elements have to be made and documented.

3.2.9 Cost Recovery and Conditions of Use

The end-to-end service description has to contain terms by which the pricing of the service use can be calculated. To support efficient cost recovery, it should be defined how participating domains will manage usage or other relevant accounting and reporting.

Participating domains must undertake measures to ensure usage of the service is compliant with conditions of use. Where necessary, the OLA may detail these measures.

4 Conclusions

The concepts outlined throughout this document provide a charter or framework around which the GÉANT community can design, build and implement collaboratively delivered multi-domain connectivity services. The purpose is to identify and define necessary common ground between different management domains that facilitate the efficient and consistent delivery of services to the edge of the common service area.

Priority has been given to identifying standards-based approaches to service management. Therefore an important partner document to this architecture is MJ2.1.1 [MJ2.1.1]. Concrete service specifications will be created, adhering to the service architecture and supported by the concepts in the control and management architecture.

The relationship between supporting services and the end service is critical in ensuring consistent delivery, and the architecture clarifies different types of supporting service. The architecture and services built on it must respect the differing environments and operational models involved in co-delivering the service. This makes it possible to benefit from local knowledge, and ensures an efficient delivery of multi-domain services to the user and to the NREN community as operators. The collaborative development efforts that underpin common supporting services must be robust and supported themselves in order to function as supporting services.

The concepts presented in this document will be used and validated by the GÉANT community over the duration of GN3. This document is intended as a living document, to be reviewed and updated over the course of the project, as experience in co-delivery of services increases and underlying capabilities in technology and organisations change.

References

[BC]	http://www.itil.org/en/glossar/glossarkomplett.php?filter=B
[DS3.16.1]	E. De Marinis, M.K. Hamm, A. Hanemann, G. Vuagnin, M. Yampolskiy, G. Cesaroni, S. Thomas, "DS3.16.1: Use Cases and Requirements Analysis for I-SHARe" http://intranet.geant2.net/upload/pdf/GN2-08-095v2-DS3-16-1_Use_Case_Collection.pdf
[eTOM]	GB921 "Business Process Framework (eTOM) Concepts and Principles", Release 8.0, Version 8.1 http://www.tmforum.org/DocumentsBusiness/GB921BusinessProcess/36653/article.html
[eTOM process]	GB921 Addendum Files "eTOM Process Flow examples", Release 8.0, Version 7.6, July 2008. http://www.tmforum.org/DocumentsBusiness/GB921BusinessProcess/36653/article.html
[ITIL]	http://www.itil-officialsite.com/home/home.asp Office of Government Commerce: Service Strategy Book, The Stationary Office, Norwich, UK, ITIL v3 English Library, May 2007 Office of Government Commerce: Service Design Book, The Stationary Office, Norwich, UK, ITIL v3 English Library, May 2007 Office of Government Commerce: Service Transition Book, The Stationary Office, Norwich, UK, ITIL v3 English Library, May 2007 Office of Government Commerce: Service Operation Book, The Stationary Office, Norwich, UK, ITIL v3 English Library, May 2007 Office of Government Commerce: Continual Service Improvement Book, The Stationary Office, Norwich, UK, ITIL v3 English Library, May 2007
[M.3060]	ITU-T M.3060/Y.2401 Principles of the management of the Next Generation Networks, 03/2006 http://www.itu.int/itudoc/itu-t/aap/sg4aap/history/m3060/index.html
[MJ2.1.1]	Definition of a Multi-Domain Control and Management Architecture, GN3 JRA2T1 milestone document. https://intranet.geant.net/sites/Research/JRA2/T1/Documents/Forms/AllItems.aspx?RootFolder=%2fsites%2fResearch%2fJRA2%2fT1%2fDocuments%2fT1%20Sandbox&FolderCTID=0x01200002C4C1F937ECB544A14DF3C27A9B8C8F&View=%7b5E15E810%2d9FD4%2d406F%2d8FAB%2d46C67087AAA4%7d

Glossary

AAI	Authentication and Authorisation Infrastructure
AUP	Acceptable Use Policy
E2E	End-to-End
EoMPLS	Ethernet over Multi Protocol Label Switching
Gbps	Gigabit per second
GE	Gigabit Ethernet
GFP	Generic Framing Procedure
GSD	General service description
ID	Identity
IP	Internet protocol
IT	Information Technology
ITIL	Information Technology Infrastructure Library
ITU-T	International Telecommunication Union
L	Layer
Mbps	Megabits per second
MPLS	Multiprotocol Label Switching
ms	millisecond
MTU	Maximum Transmission Unit
NOC	Network Operations Centre
NGN	Next Generation Networking
NREN	National Research and Education Network
OCh	Optical Channel
OLA	Operational Level Agreement
OS	Operating System
OTN	Optical Transport Network
PBB-TE	Provider Backbone Bridge Traffic Engineering
PoP	Point of Presence
PVC	Permanent Virtual Circuit
SDH	Synchronous Digital Hierarchy
SDP	Service Demarcation Point
SFD	Service Functionality Description
SLA	Service Level Agreement
SLS	Service Level Specification
TMF	Tele Management Forum
UML	Unified Modeling Language
VLAN	Virtual Local Area Network

VPN Virtual Private Network