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Control of Interconectivity in the NGN Environment

Dissertation Thesis - Autoreferat

FEI-10849-55205

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Study programme: Telecommunications
Study branch: 5.2.15 Telecommunications
Organisation: Institute of Telecommunications

Bratislava, May 2013

Dizertačná práca bola vypracovaná v externej forme doktorandského štúdia na Ústave telekomunikácií FEI STU v Bratislave

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Autoreferát bol rozoslaný dňa: 30.5.2013

Obhajoba dizertačnej práce sa koná 22.8.2013 **o** 13:30 **h**.

na Fakulte elektrotechniky a informatiky STU, Ilkovičova 3, 812 19 Bratislava v miestnosti: zasadačka FEI STU, blok A, 1. posch.

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Abstract

Service and media related information exchange described in this thesis suggests an opportunity to enable dynamic service sharing. Subjects defined in standardisation boards from 3GPP, ETSI TISPAN and ITU-T have been considered by pointing the key aspects related to the proposed Service Discovery and Distribution System. Concurrently, the correspondent information model has been proposed representing the exchanged abstract network capabilities as allocatable resources. An outline is given, enabling current and prospective service access enabler technologies to be converged within the Service Discovery and Distribution System. Independent of the particularly used Core Network architecture or subsequent interworking issues, the system enables liberalisation and service variety as defined in functional and non-functional requirements. Transformation models between technical and business aspects according to the enhanced Telecom Operations Map have been specified with regulatory related framework requirements to prevent monopolisation. To strengthen the approach that a matrix of capability tuples logically describes a network, a composite service is originated of interdependent parts. Qualified solutions within comparable parts of the Service Discovery and Distribution System have been distinguished and compared in general and in detail. Open issues as a result of the analysis of advantages and disadvantages have been outlined, concretised and substantiated where possible. Possibilities presenting the deployment and achieving the introduction of the Service Discovery and Distribution System into standardisation boards are pointed. Finally, a stratum independent integration of 3rd party service providers is enabled by the proposed system to improve liberalisation, service variety and competition aspects as well as an enhanced utilisation of distributed network resources. The achievement of these objectives is considered by adaption of the regulation in respect of technical capabilities so far as possible.

Abstrakt

Výmena informácií vzťahujúcich sa na služby a médiá, ktorá je popísaná v tejto práci, umožňuje zavedenie dynamického zdieľania služieb. Subjekty definované v štandardizačných plénach organizácií 3GPP, ETSI TISPAN a ITU-T sú v práci posudzované z pohľadu kľúčových aspektov k navrhovanému Systému vyhľadávania a distribúcie služieb (Service Discovery and Distribution System). Súčasne bol navrhnutý zodpovedajúci informačný model, ktorý reprezentuje vymieňané abstraktné schopnosti siete ako prideliteľné prostriedky. V práci je dostupný aj prehľad o tom, ako budú súčasné i budúce technológie pre prístup k službám konvergované v rámci Systému vyhľadávania a distribúcie služieb. Nezávisle na tej-ktorej architektúre jadra siete (Core Network) alebo na ďalšie problémy prepájania sietí, systém umožňuje liberalizáciu a rozmanitosť služieb ako dôsledok technických požiadaviek. Transformačné modely medzi technickými a obchodnými aspektami boli špecifikované podľa rozšírenej Mapy telekomunikačných operácií (Telecom Operations Map) zahŕňajúc regulačný rámec zabraňujúci monipolizácii. S ohľadom na to, aby matica n-tíc technologických vlastností opisovala sieť, zložená služba je poskladaná z jednotlivých samostatných častí. Kvalifikované riešenia v rámci porovnateľných častí Systému vyhľadávania a distribúcie služieb boli porovnané vo všeobecnosti ako aj v detailoch. Práca obsahuje aj zoznam otvorených problémov systému ako výsledok analýzy jeho výhod a nevýhod, ich konkretizáciu a dôkaz tam, kde je možný. Možnosti prezentujúce nasadenie a zahrnutie Systému vyhľadávania a distribúcie služieb do štandardizačných plén sú tiež spomenuté. Nakoniec je predstavená vrstvovo nezávislá integrácia poskytovateľov služieb tretích strán s použitím navrhovaného systému s cieľom zlepšiť liberalizáciu, rôznorodosť služieb a súťaž ako aj využitie distribuovaných sieťových prostriedkov. Dosiahnutie týchto cieľov je posudzované s ohľadom na adaptáciu regulácie pri rešpektovaní technických možností pokiaľ je to len možné.

Contents

List of Tables

List of Figures

Nomenclature

3GPP	3^{rd} Generation Partnership Project
ALG	Application Layer Gateway
AS	Application Server
CDN	Content Delivery Network
CEIM	Capability Exchange Information Model
CEM	Capability Exchange Mechanism
CIC	Capability Information Collector
CIS	Capability Information Source
CIU	Capability Information User
CO	Consuming Operator
CSCF	Call Session Control Function
DC	Domain Controller
DHCP	Dynamic Host Configuration Protocol
DNS-SD	DNS - Service Discovery
ETSI	European Telecommunications Standards Institute
HSS	Home Subscriber Server
I-CSCF	Interrogating Call Session Control Function
IBCF	Interconnection Border Control Function
IBGF	Interconnection Border Gateway Function
II-NNI	Inter-IMS Network-to-Network Interconnection
IP	Internet Protocol
ISC	IMS Service Control
ISDN	Integrated Services Digital Network
IWF	InterWorking Function
NAPT	Network Address and Port Translation
NAT	Network Address Translation
NGN	Next Generation Network
P-CSCF	Proxy Call Session Control Function

PES .... PSTN/ISDN Emulation Subsystem
PPS .... Passive Presence Service
PS .... Presence Service
PSI .... Public Service Identity
PSTN .... Public Switched Telephone Network
QoE .... Quality of Experience
QoS .... Quality of Service
RACS .... Resource Admission Control Subsystem
S-CSCF .... Serving Call Session Control Function
SCL .... Session Control Layer
SCo .... Service Consumer
SCu .... Service Customer
SDD .... Service Discovery and Distribution
SDDS .... Service Distribution and Discovery System
SLA .... Service Level Agreement
SOAP .... Simple Object Access Protocol
SOF .... Service Offering Function
SRF .... Service Requesting Function
SRV-RR .... SeRVice Resource Record
SSP .... Service Sharing Provider
SSS .... Service Sharing System
SSS-AS .... Service Sharing System Application Server
THIP .... Topology HIding Procedure
TISPAN .... Telecommunications and Internet converged Services and Protocols for Advanced Networking
TrGW .... Transition Gateway
TRIM .... Topology and Resource Information Model
TRIS .... Topology and Resource Information Specification
TS .... Technical Specification
UPnP .... Universal Plug and Play
UPSF .... User Profile Server Function
WCF .... Windows Communication Foundation
WS-DP .... WebService-Discovery Protocol
WTO .... World Trade Organisation

1 Conception

Regarding the two main fields of telecommunication network technologies, Circuit Switched and Packet Switched, a trend towards the Packet Switched technology has been taken. Changes in architectures involved by this trend may be characterised by a transformation process, horizontal-oriented architectures are replacing vertical-oriented architectures.
By introducing the Next Generation Network (NGN) as a new approach for delivery of services guaranteeing a certain level of Quality of Service (QoS) has been proposed and defined in several standardisation boards.
Currently a suitable service sharing system enabling service offering, reselling as well as composition is still missing. It may extend the present proposals in terms of scalability, reliability, availability and flexibility towards the specified features of a NGN. Such a service sharing goes compete with Over-The-Top service providers and presents one way to keep the service provision and involved revenues on network operator's side, unaffecting services needless of QoS (best effort traffic).
Furthermore, a reduction of service enablers and resellers may prefer the constitution of service monopols, but considering the investment costs for launching new services, only a few services will be affected. From the customers view a large number of services won't be impacted by integrating a service sharing system, but the services will be still going improved, offering service selling depending on costs, QoS, reliability and further more to satisfy the customer needs.
An interconnection of these operator domains necessitates simplification in terms of service requirements and belonging QoS resources. In addition an identification of mapping procedures between technical and business parameters may improve the standardisation in terms of converging the interconnection of various network operators.
NGN as step towards a future-proof network, enabling the delivery of mul-

timedia and non-multimedia content similarly, allows the consideration of the required QoS per stream. With this an improvement of the Quality of Experience (QoE) can be achieved.
Considering the NGN as an agglomeration of independent network operators exchanging network traffic in compliance with the QoS requirements, a generalised model consisting of Internet Protocol (IP) Multimedia Networks as participated operator networks within the NGN does fit more the flat correlation between providers in an appropriate way.
Currently standardised IP Multimedia Networks (IMNs) are designed for operator preferences like home network located services and roaming. Opening the local domain for 3rd party services is considered, but a real service sharing is not marketable until limiting factors are not resolved. Such factors consists of service sharing models, distinguished into technical and business parts, mapped by templates and transformed in information models. Furthermore, the service sharing does include a prior exchange of service related information like service description, resource requirement, QoS description and associated charging and accounting methods, abstracted by the term capability. In points of simplification a standardised model for exchanging capabilities shall be designed, capable of beeing extended and irrespective of the concret capability information tuple.
Approaching this challenge, a point of principle shall be discussed: ”Reusing of existing technologies and, where applicable upgrading by adaption and extension, or defining new architectures and technologies from scratch¿‘ With respect to the evolution of communication networks the preference in this thesis is set to the former approach.
Aiming the design of an architecture and the correspondent information model for exchanging services considering QoS and aware about QoS resources between IMNs, several tasks are included in this research work.
Firstly, the Network to Network Interconnection (NNI) between IMNs shall be analysed from the viewpoint of the standardisation bodies, including frameworks and functional architecture models as described in the recommendations from the ITU-T. Due to the fact that currently some partially standardised proposals exist, respectively to different releases, a comparison of these suggestions is required in terms of interoperability. Related

to signalling and media plane various tasks are defined, depending on used border functions, interconnection types (SoIx/CoIx) and interconnection modes (direct/indirect). Furthermore, requirements in signalling plane as described in standards from the 3rd Generation Partnership Project (3GPP) as well as the European Telecommunications Standards Institute - Telecommunications and Internet converged Services and Protocols for Advanced Networking (ETSI TISPAN) working groups are matter of interest in terms of interoperability as much as additional interfaces and protocols used on NNI which have been defined for inter-domain and intra-domain interconnection.

The main subjects as a basis for analysed issues within the dissertation objectives in terms of interconnetion of IMNs may be specified to service and capability based dynamic interconnection, Service Level Agreements (SLA), Interworking Function (IWF), Resource Admission Control Subsystem (RACS) interconnection, mapping between QoS parameters and IP packet processing parameters, reporting framework integration and the Topology and Resource Information Specification (TRIS).

Consequentially, the dissertation thesis objectives can be defined by distinction into the following parts:

An architecture providing the Service Discovery and Distribution (SDD) in IMNs by specifying the mechanism as well as the related protocols;

An interconnection architecture providing a dynamic routing related to SLAs, capabilities and resources on the basis of the Capability Exchange Mechanism (CEM) and its underlying protocols and information model considering the topology and resource awareness;

The Service Level Agreement (SLA) definitions, adapted by a capability related classification comprising the availability of correspondent resources in consideration of potentially required topology hiding.

Interfaces and functional elements of the access management and service control implemented at the application layer shall be defined on grounds of clarification, but in purposes of operator selected vendor dependencies.

An overview about the proposed architecture providing service sharing between different network operators is depicted in Figure 1.1.

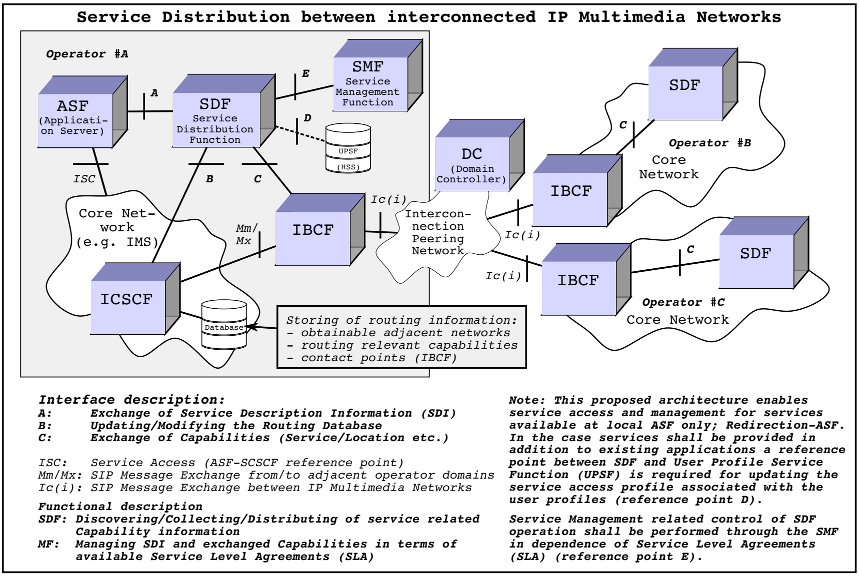

Figure 1.1: Focus of the Thesis

In summary the following contributions will be served with this document:

1 Analysing existing possibilities of IMN-NNI qualified for service sharing

2 Modelling a SDD mechanism

3 Classification of network and operator dependent capabilities

4 Description of a future-proof capability exchange information model

5 Evaluation between the proposal and partly existing similar mechanisms

2 IP Multimedia - Network to Network Interconnection

2.1 3GPP/ETSI TISPAN Interworking and Interoperability

A general interworking reference model for control and user plane interworking is defined formerly in Release 6 [1, ETSI TS 129162 v6.2.0] and enables the interworking support between IM CNs and IP networks for IM services using IP version 4. The ETSI TISPAN reference architecture for control and user plane interworking supports interworking between IM and IP networks for IM services and is shown in Figure 2.1 [2, ETSI TS 129421 v8.0.1]. The IMS and the SIP based multimedia network may use IP version 4 [3, IETF RFC 791] or IP version 6 [4, IETF RFC 2460]. Interworking with SIP [5, IETF RFC 3261] based IM networks including SIP UAs and SIP servers is provided by the IM CN subsystem.

To communicate with external IM networks the IMS uses the Interconnection Border Control Function (IBCF) in the SIP signalling path, the Interconnection Border Gateway Function (IBGF) in the media path. Furthermore the IWF provides an interworking between TISPAN SIP profile [6, ETSI ES 282 003] and other IP multimedia signalling protocols (e.g. H.323 or SIP-I) when required.

Interconnecting different IM CN subsystems shall support end-to-end service interoperability. Aiming this issue the Inter-IMS Network-to-Network Interconnection (II-NNI) between two IM CN subsystem networks has been adopted as recommended from [7, 3GPP TS 23.002] and [8, 3GPP TS 23.228]. In release 6 [1, ETSI TS 129162 v6.2.0] the UE uses the Call Session Control Function (CSCF) in order to communicate with the external IM network entities. This fact has been limited in release 7 and the CSCF

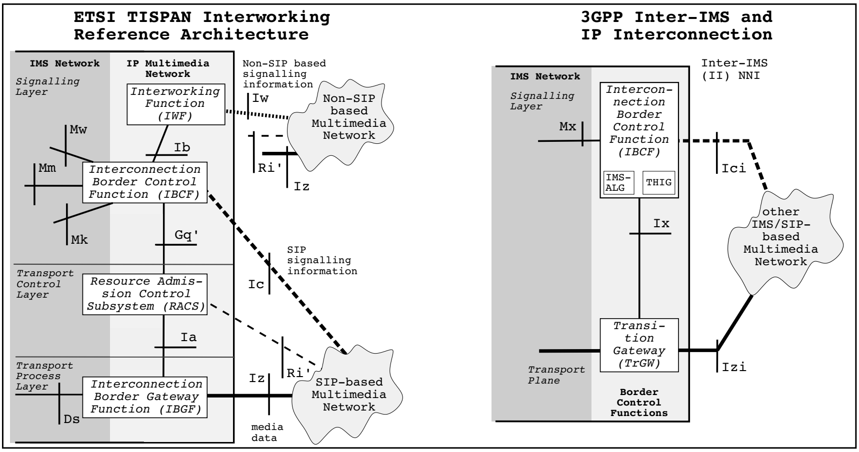

Figure 2.1: 3GPP/ETSI TISPAN Interconnection Architecture

can communicates directly with SIP UAs or with SIP proxies in an external IP multimedia network only if IP version interworking or Network Address (and Port) Translation (NAT)/(NAPT) is not required.

Otherwise, the functions of an IMS-Application Layer Gateway (ALG) and a Transition Gateway (TrGW) enable the communication between CSCF and external IM networks [9, ETSI TS 129162 v7.3.0]. IM CN subsystem elements and interfaces designed within the 3GPP specification supports IPv6 only, irrespective that other methods providing IP version interworking deserve further study [10, ETSI TS 129162]. Providing the IMS service delivery or IMS roaming, interconnections at a control plane level through the IBCF containing the IMS-ALG (Ici reference point) and at a transport plane level through the TrGW (Izi reference point) are required, illustrated in Figure 2.1 [8, 3GPP TS 23.228], [11, ETSI TS 129165 v8.5.0].

The Interconnection with Next Generation Corporate Networks in peering mode (specified in [12, ETSI TS 182025 v2.1.1]) is out of scope in the present document [13, ETSI ES 282001 v3.4.1].

Interconnecting domains assigned by various network operators is defined as Inter-domain Interconnection. A negotiation of SLAs between the involved administrative areas is a common practice, enabling a billing basis for the exchanged network traffic. Reference points named below are used in such Inter-domain IMN-NNIs:

- Ic/Ici Inter-domain Reference Point between IBCFs
- Iw Inter-domain Reference Point between IWFs
- Ri' Inter-domain Reference Point between SPDFs
- Iz/Izi Inter-domain Reference Point between IBGFs
- Mm Inter-domain Reference Point between CSCF/IBCF and other IMNs

Interconnecting domains assigned by the same network operator is defined as Intra-domain Interconnection. On the part of standardisation groups network border related reference points have been defined as follows:

- Mx Intra-domain Reference Point between CSCF/Breakout Gateway Control Function (BGCF)/IBCF
- Mb Intra-domain Reference Point between IM CN Subsystems
- Rd' Intra-domain Reference Point between SPDFs

2.2 Overall Interface and Protocol Requirements

Service layer interconnection may be served with IP-based networks depending on the involved subsystems or Signalling System No.7 -based networks [14, ETSI ES 282001 v1.1.1], [15, ETSI ES 282001 v2.0.0]. The latter type is out of scope in this thesis. The IBCF entity and possibly the IWF entity in the service layer perform the IP-based interconnection to/from IMS CN components or the PSTN/ISDN Emulation Subsystem (PES) at the Ic reference point and the Iw reference point respectively in which the IBCF and IWF communicate via the Ib reference point [14, ETSI ES 282001 v1.1.1]. Furthermore, the IWF may support interworking between SIP-based IM network domains using a different SIP profile and non SIP-based IM network domains [15, ETSI ES 282001 v2.0.0], [2, ETSI TS 129421 v8.0.1]. Each subsystem involved in interconnecting IM CN domains includes the appropriate functions in support of interconnection with other IM networks. Such functions may include the:

- interaction with transport resources through the RACS, NAPT and firewall functions included;
- insertion of the IWF in the signalling route (if necessary); and
- screening of signalling information.

The RACS may be interconnected at the Ri' reference point. In such case the resource management model established through the Ri' Reference Point is able to support a granularity of resource management services. These services are available at the level of interconnected domains or at the level of application sessions. The latter case, the Ri' reference point is used for the indirect resource reservation procedure between an Application Function and the RACS of another authoritative domain. So the RACS in the Application Function's domain relays the resource reservation requests through the Ri' reference point towards the RACS in the other domain [15, ETSI ES 282001 v2.0.0]. Protocol specifications related to the Ri' reference point in inter-domain and to the Rd' reference point in intra-domain interconnections are not completed yet.
Interconnection procedures at the transport processing sublayer with IP-based networks will be performed through an IBGF entity at the Iz/Izi reference point. Due to the fact that interconnection with IP-based networks depends on the subsystems involved, the IBGF may behave autonomously or acts under the control of the service layer. In latter case it will be controlled either through the RACS for services, involving the IMS core component or the PES [15, ETSI ES 282001 v2.0.0], or through the responsible IBCF directly [8, 3GPP TS 23.228].

3 Service Discovery and Distribution (SDD)

3.1 Currently available SDD and 'prospective' impact

Comparable to the presented proposals a similar Service Sharing System (SSS) have been introduced in [16, Service Sharing System]. The system consists of two interacting network operators, the Service Sharing Provider (SSP) and the Consuming Operator (CO). Both operators run the main functional entity of the SSS, the SSS Application Server (SSS-AS) within their networks, configured in dependency of the claimed function. The SSS-AS located on SSP side offers service related information towards the SSS-AS located on CO side, which is responsible to publish the gathered information as a proxy towards the local resided user agents. The communication between the CO side acting SSS-AS and the user agents is based on the presence service, at which the user agents, interested in services, are subscribed to this SSS-AS. Two aims are claimed by the SSS: enabling 3^{rd} party service reselling across the network borders between IMS based CNs and shifting the decision, which service is suitable for the user under given circumstances, towards the user.
In general, 3^{rd} party services shall be accessed via the IMS Service Control (ISC) reference point between the S-CSCF and the Application Server (AS). In that case the AS has no knowledge about the S-CSCF serving the Public Service Identity (PSI) the Ma reference point shall be used for location procedures towards the I-CSCF, depicted in Figure 3.1, [8, 3GPP TS 23.228], [7, 3GPP TS 23.002].
With the introduction of an IMS-based NGN evolves the question of how to connect the NGNs together and with legacy communication networks. Currently some partially standardised proposals exist to enable these interconnections. One suggestion describes an opportunity to implement partially standardised functionalities inside the IMS core network to enable

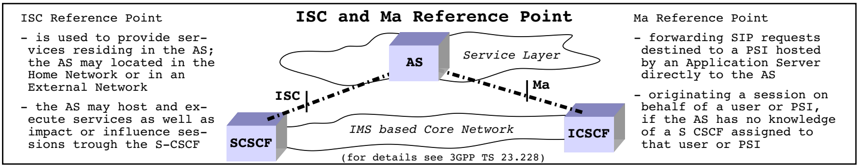

Figure 3.1: ISC and Ma Reference Point based Service Access

dynamic expandability. When carriers have many connections to other carriers, complexity in configuration increases significantly if changes in interconnections with other domains are necessary. As soon as there is a possibility that multiconnections to other networks exist, the selection of the used route requires that all information about the target domain – according to the selection process – is immediately available every time. It is to be considered that information could change itself permanently, demanding an update procedure consequently. Guaranteeing the multipoint interconnection handling allows an adaption of the selection process towards a capability based routing decision mechanism. This capability based routing decision process enables the integration of a Service Distribution and Discovery System (SDDS) exchanging service and capability related information between interconnected IMNs, see Figure 3.2.

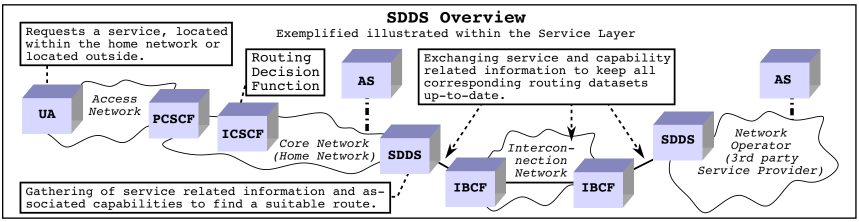

Figure 3.2: Service Discovery and Distribution System Overview

The SDDS requires further mechanisms supporting service discovery as well

as service distribution within the IMN itself. These mechanisms shall base on existing functions, provided by CN or functions from the Internet. Furthermore, the deployment of the SDDS enables the standardisation of SLA templates, followed by simplifications in the SLA definitions and relations between subtemplates.
An adequate mapping between capabilities and subtemplates reduces the administrative effort and enables the idenfitication of dependencies between capabilities and their corresponding subtemplates.
Advantages of the SDDS can be characterised dynamically by an enhancing of the amount of services towards the users, amongst 3^{rd} party service support across the network borders. It comprises service provisioning under consideration of resource, cost, policy and QoS based message routing as well as resource allocation. Hence, the support of redundancy, failover routing and load balancing is improved, in fact independently of the operator's IMN architecture. As a result the efficiency of service offering due to improving the availability, reliability and accessibility, increases.

3.2 SDD Requirements and Open Issues

A contract process combined with a SLA negotiation serve both, the Service Consumer (SCo) and Service Provider (SP) interests [17, TMF GB917-3]. Considering the "collective effect of service performance which determines the degree of satisfaction of an user of the service" [18, ITU-T E.800] and the "degree of conformance of the service delivered to an user by a provider in accordance with an agreement between them" [19, ITU-T E.860] as the definition of QoS, a classification shall be prove beneficially for further approaches [20, ITU-T E.801]. Differences in the service quality agreement as consequence of Inter-Operator QoS parameters can be defined to dependent and independent SLAs and applied to overall service level requirements such as: Service dependent and independent network QoS parameters as well as customer QoS parameters.
For defining the requirements the Service Customer (SCu) shall be motivated to (re-)use elements of the SLA specification methodology, because the standardisation and commonality of the defined elements may improve

the negotiation processes regardless of reducing the costs [17, TMF GB917-3]. Several stages of the SLA specification process may be distinguished, depending on the factors involving the specified step: SLA initial specification, SLA execution, SLA modification and SLA termination. A currently standardised composition of SLA representations associated with templates are included in Table 3.1.

Template	**Representation**
QoS parameter level	Service, Scenario, Session
Quality of Function (QoF) parameter	Speed, Accuracy, Reliability
QoS parameter	Delay, Jitter, Loss Ratio

Table 3.1: Basic Composition of IP based Representation Templates

Considering the interconnection requirements like the horizontal architecture, separate interfaces in each level and different responsibilities a simplification of the present SLA representation template structure is necessary, proposed in [21, SLA focussed on IM-NNI] and depicted in Figure 3.3
Requirements of the reorganised SLA templates in terms of an IM-NNI can be highlighted as follows: Technology independent, Scalablility, Comparability and Compatibility.
Along with shifting the operator's focus from a basic service provider towards a multimedia content and service provider it seems to be advisable to open the market of services. Currently a gap can be identified between the degree of openness in the telecommunication market and the operator concept of providing own services to their own customers. By introducing the IMS a new approach have been developed, enabling the integration of 3rd party services side by side to provider-owned services. Service sharing as part of the 3rd party service integration is one aspect and have been introduced in [16, Service Sharing System]. It has been assumed that an

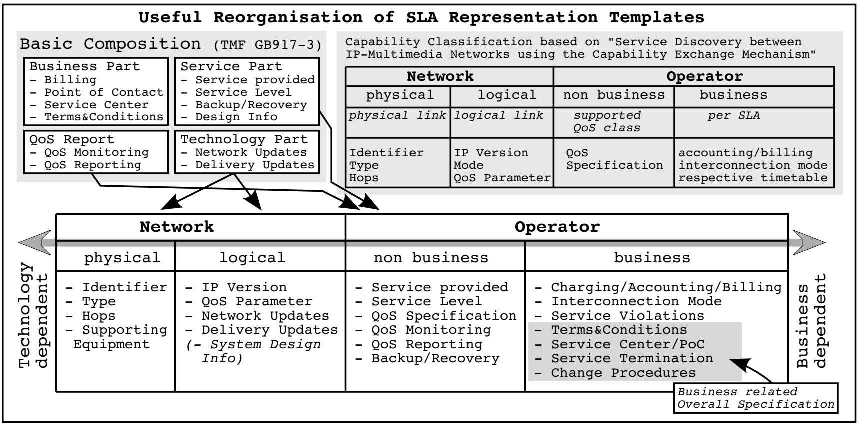

Figure 3.3: SLA Representation Templates

architecture supplement providing the SSS may bring a liberalisation into the market followed by an easier access to services.

Offering 3rd party services towards the own customers require SLAs between the service supplier and the network operator, defining availability, reliability, accuracy and accountability amongst other subjects like QoS parameters and accounting information. Multimedia content as basis for multimedia services shall be distinguished into several types of delivery, resulting in different demands to the allocatable resources.

Only managed traffic types shall be considered in QoS related SLAs, reducing the administrative effort. However, unmanaged traffic shall not be exepcted from SLA definitions and from the service sharing point of view, insofar accounting procedures can be applied. From the technical viewpoint only some minor changes are required in terms of interoperability between 3GPP and ETSI TISPAN compatible IMNs. Reducing the interoperability issues to a SIP-to-SIP interworking and vendor dependent adaptions shall be considered generally as clarified in [**?**, SIP Trunking Requirements].

Adaptions are required within the negotiation of SLAs, based on the tem-

plates as defined in [17, TMF GB917-3]. A generally accepted guideline in negotiation procedures shall base on a standardised capability declaration, distinguished into network dependent and independent parameter-value pairs.
Amongst other minor things mapping specifications between SLA related business parameters and technical resources must be ensured. Applying a classification for mapping purposes results in two main aspects: Uniqueness and Independency.
This basic concept allows the reduction of each classifier and in consequence a simplification in definition of dependencies between them. Whichever occurs, a SLA revision based on a contract change or on an infrastructure modification, from both ways a resolving procedure is supported. Hence, the service provider has the ability to choose a suitable route for a certain multimedia stream under consideration of several aspects such as:

- Sufficient QoS guarantee
- Adequate reliability
- Considered load balancing
- Least cost routing
- Service availability

Performing an adequate mapping of network and business related templates to existing technical resources and business models allows the definition of an independent information model. From the technical point of view functions providing the gathering, collecting and distribution process of capability tuples must be defined, within the local operator domain as well as between interconnected IMNs. Considering the ETSI TISPAN and 3GPP interoperability, requirements dependent on the underlying IMN architecture have to be specified.

4 Service Discovery and Service Distribution Architecture

4.1 Service Discovery and Distribution

The integration of this Domain Name System - Service Discovery (DNS-SD) within the Dynamic Host Configuration Protocol (DHCP) during the IP-Address assignment was not proposed. From the viewpoint of supporting local based 3rd party services in Access Networks a dynamic service location configuration reduces the administrative effort. Finally, the permission to update SeRVice Resource Records (SRV-RRs) may base on certificates related to the service publishers. In the same way the interconnection of several providers may be automated using a dynamic updating of SRV-RRs in the peering Domain Controller (DC). By using a validation mechanism for establishing the security association between a Service Offering Function (SOF) and the DC, it is assumed that a dynamically updated DNS service is trustable enough. The DHCP-based architecture consists of three involved functionalities communicating over one network, depicted in Figure 4.1 and may be qualified as follows:

- SOF, publishing services hosted on itself and discovering these services towards the local DC in order to resolve services on request.
- SRF (Service Requesting Function), requesting services whose location is stored in the DC as described in [22, IETF RFC 2782].
- DC (Function), controlling the local domain in one or two or both terms: DNS-Service (resolving IP addresses or delegating the resolving procedure to a parent DNS-Server); DHCP-Service (enabling an automated host configuration procedure). A DHCP initiated dynamic DNS update may be completed by this service.

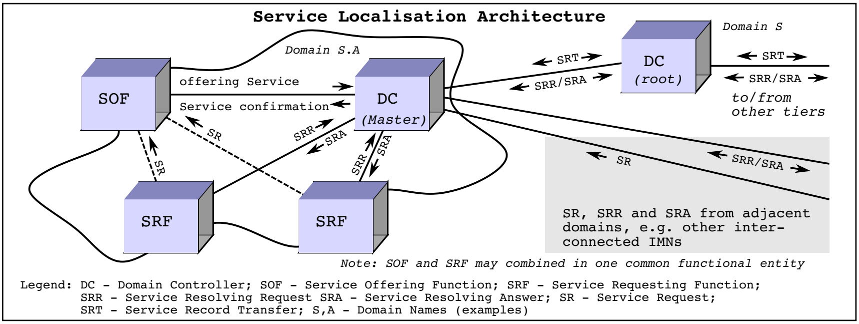

Figure 4.1: Service Discovery and Localisation Architecture

Assuming that the proposed architecture supplies all requirements in information handling, definitions of SDM service types are required. Parameters configured on DHCP client side and server side and their DNS relation, used in SRV-RRs resolving procedures, are summarised in Table 4.1.

As an extension to the existing concept of interconnection from IMS-based NGNs using a dynamic connection of IBCFs, a possible solution was proposed in [23, IWSSIP 2008 Conference]. Increments respective to the Interrogating Call Session Control Function (I-CSCF) are necessary, like the integration of an additional database to store information about available IBCFs locally.

All messages which leave or arrive at the local domain and do not include a valid `Service-Route` Field or `via` Field, have to be routed via the I-CSCF. This guarantees that all messages belonging to a session which do not have an unique or valid path description, will be assigned to a definitive route through the route logic inside the I-CSCF. As a result this route involves subsequently entities such as Serving Call Session Control Function (S-CSCF), IBCF or Proxy Call Session Control Function (P-CSCF).

The information model storaged in the database consists of three types representing one tuple: which adjacent network is represented trough which IBCF with what capabilities available. The adjacent network is equal to

Host side	**DHCP server side**	**DNS side**
Service (i.e. SIP)	SRV-RR (_service)	SRV-RR (_service)
Protocol (i.e. TCP)	SRV-RR (._protocol)	SRV-RR (._protocol)
Port (i.e. 5060)	SRV-RR (port)	SRV-RR (port)
Weight (0-65535)	SRV-RR (weight)	SRV-RR (weight)
Priority (0-65535)	SRV-RR (priority)	SRV-RR (priority)
-	-	SRV-RR (Class=IN) [22]
-	Lease time (32bit)	SRV-RR (TTL)
-	assigned HostName	SRV-RR (target)
-	associated Domain	SRV-RR (name)
Algorithm (ALG)	DNSKEY-RR (ALG)	DNSKEY-RR (ALG)
PubKey	DNSKEY-RR (pub-key)	DNSKEY-RR (pub-key)
-	Lease time (32bit)	DNSKEY-RR (TTL)
-	-	DNSKEY-RR (proto=3)
-	-	DNSKEY-RR (Class=IN)

Table 4.1: Mapping between host related information towards the SDM

the possible target domain, the IBCF represents the gateway and the capabilities specifies the resources that shall be considered along the network path. This information model is similar to routing models in general, represented by the destination (address), the gateway towards the network containing this destination and a metric symbolising the path costs, hop count or load depending on the available resources [1] [24, IETF RFC 2328], [25, IETF RFC 5340], [26, IETF RFC 2453]. The connectivity state, the operating state and useful other conditions shall be represented by flags.

Several functional entities are involved in the architecture providing the support of the Dynamic Expandability of IP Multimedia Networks located

[1] The distance vector plays a secondary role because session control messages are not subjected to the same conditions like the media data in the media plane. Resources capable to handle these media data by guaranteeing the required QoS are represented by abstract capabilities.

in different segments of the network interconnection. Under the responsibility of the I-CSCF all SIP messages destined to adjacent IMNs will be forwarded towards the qualified IBCF located at the network border in the Session Control Layer (SCL). Resource reservation procedures at the CN border are unaffected while the I-CSCF performs a selective routing decision in dependency of available resources towards the choosen network path. Messages forwarded in the SCL between interconnected IBCFs shall follow the guidelines as standardised by 3GPP and ETSI TISPAN working groups for interconnected IMNs. A summarised view of the architecture has been illustrated in Figure 4.2.

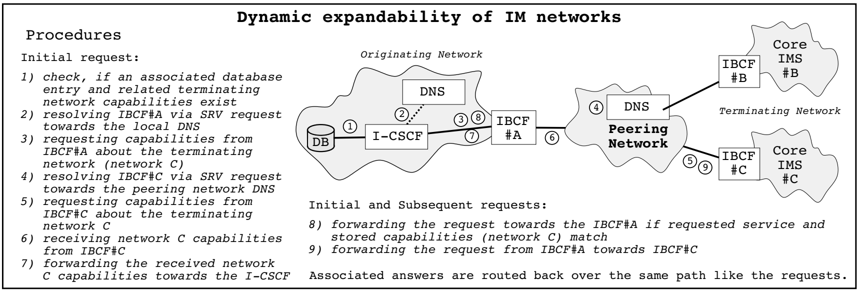

Figure 4.2: Dynamic Expandability of IP Multimedia Networks

A potential solution to extend an IMN providing a SSS consisting of two parts, the Service Discovery system and service Distribution System (SDDS), proposed in [27, 16th VDE ITG 2011]. Compared with information about available services, related accounting and billing as well as SLA dependent (re)selling are exchangeable now between IMNs by providing a CEM.
The SDDS bases on functions, entites, data flows and data models defined for the presence service. For distribution purposes a Passive Presence Service (PPS) model is used, saving the complexity needed by a centralised solution.
The underlying Capability Exchange Information Model (CEIM) represents information tuple describing services, gateways, metrics and further

parameters qualifying a suitable network path for a specific session. Due to the non-determined parameters and value ranges a future-proof structure is defined open for contrivable information tuple. It should be considered that all exchanged information shall be relevant to determine a proper routing decision for SIP message routing against the background that the session related resource allocation must be performable. Taking into account a qualified model representing resource an topology information exists, this Topology and Resource Information Model (TRIM) defined in [28, ETSI TR 182022] may be reused in an adapted way and the CEIM is classified as follows:

- Logical topology: Description of logical entry points, exit points and pipes; mapping between physical and logical topology
- Routing information: Description of connectivity represented through the physical and logical topology; identification of involved entities traversed by media flows
- Resource information: Modelling a hierarchy of resources describing shared capacity at network elements or between traffic classes; measurements about currently used resources may included
- Service information: Description of provided services, required resources per session; dependencies between services, session keys (decryption of protected content if applicable in transit scenarios)
- Accounting and Billing information: Details of accounting procedures (online/offline), time and/or volume conditions, (re-)selling/franchise information

In consequence of differenciated relationships between the exchanged information and the responsible functional entites inside the CN a further classification shall be taken in terms of identifying the Capability Information User (CIU), the Capability Information Collector (CIC) and the Capability Information Sources (CIS).

4.2 IMN related Extensions

4.2.1 Capability Exchange in Peering Networks

Deploying the PPS between IMNs supports an exchange mechanism to share network related capability information between IBCFs acting as the entry point of each interconnected IMN. From the operators viewpoint the PPS decreases the complexity compared with a centralised Presence Service (PS) by avoiding a public PS server function inside the IMN peering network. So the PPS excludes an additional administrative aggrement for this PS server function and simplifies the effort balancing by defining the same PPS complexity for each participant. The implementation of this proposed PPS simplifies the adoption independently from the underlying IBCF standard, see Figure 4.3.

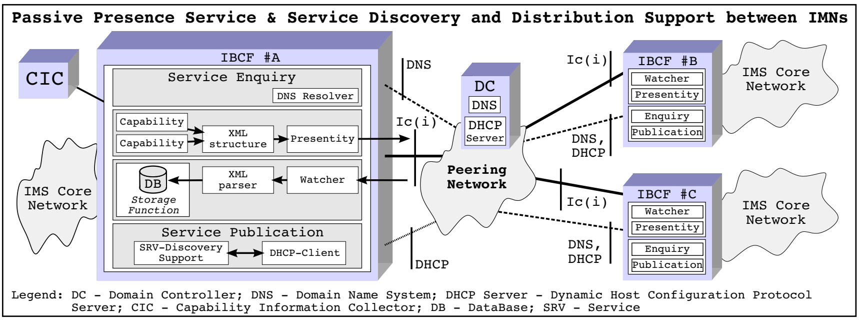

Figure 4.3: PPS based Capability Exchange between IP Multimedia Networks

An alternative may consists of a PPS located at the network border without any interaction with CN functions. In such a case the IMN acts as a transit network only and the IBCFs exchange the gathered capability information among themselves.

According to the SDM applied in general the same mechanism shall be supported in the peering networks. It simplifies the location of available adjacent IBCFs and it enables a load balancing by using the balancing mechanism applied through the DNS itself [29, IETF RFC 1794]. Each IBCF shall lookup SRV-RRs through its service enquiry function to determine suitable IBCFs of possible interconnected IMNs before starting any direct communication with them unless a static IBCF configuration specifies another interconnection policy. Realising the failover handling involves a valid PPS contact list on each IBCF side. After the moment where the link towards another IBCF fails an alternative route must be choosen by an internal algorithm to prevent an interconnection loss.

The proposed DHCP based SDM includes a second part, the service discovery via DHCP while assigning a host configuration. Applying this method allows a fully dynamic service distribution within the peering network without any administrative intervention as long as a correspondent SLA exists. In that no valid SLA exists the dynamic network configuration and SDD reduces the administrative effort to a minimum, necessitating policing rules for handling the gathered information by the usage of black or white lists. It is proposed that each IBCF shall support the service offering towards the DC using its service publication function. In general the involved functional entities and their reference points supporting a dynamic configuration of IBCFs located within the peering network is depicted in Figure 4.3.

Integrating the SDDS into an ETSI TISPAN standardised IMN supporting SIP-based as well as non-SIP based IMN interworking is also possible. Similar to the 3GPP extension the IMN requires the Sx [2] reference point extension only. As described in standardisation documents the Ic reference point (IBCF $\leftrightarrow$ IBCF), the Mm, Mw, Mk reference points towards the CN functions and the Ib reference point towards the IWF are not affected by the SDDS, [30, ETSI TS 123002 v8.6.0], [2, ETSI TS 129421].

Due to the fact that 3GPP architecture and reference point descriptions have been adapted by further releases from ETSI TISPAN side it is impossible to distinguish from standardisation proposals in newer releases such as 9, 10 or 11. These newer releases limit the reference points to Ici, Ix, Mm, Mw an Mk, but from the SDDS viewpoint no impacts are identifiable

[2]Sx abbreviates capability Service eXchange

as long as SIP is supported on the Ici reference point. An SDDS integration into an ETSI TISPAN IMN up to release 8 is illustrated in Figure 4.4 limited to the Mx reference point on CN side in terms of simplification.
An integration into 3GPP conform SIP-based IMNs supporting II-NNI only prohibits the interworking with other non 3GPP and non-SIP IMNs. Existing reference points defined in II-NNI scenarios are unaffected in supporting additional SDDS related SIP-based capability exchange messages. The Ici reference point (IBCF ↔ IBCF) described in [8, 3GPP TS 23.228] and [31, 3GPP TS 29.162] as well as the Mx reference point described in [32, 3GPP TS 24.229], [31, 3GPP TS 29.162] and the adapted Mk and Mm reference points, see [7, 3GPP TS 23.002], require no changes, depicted in Figure 4.4.

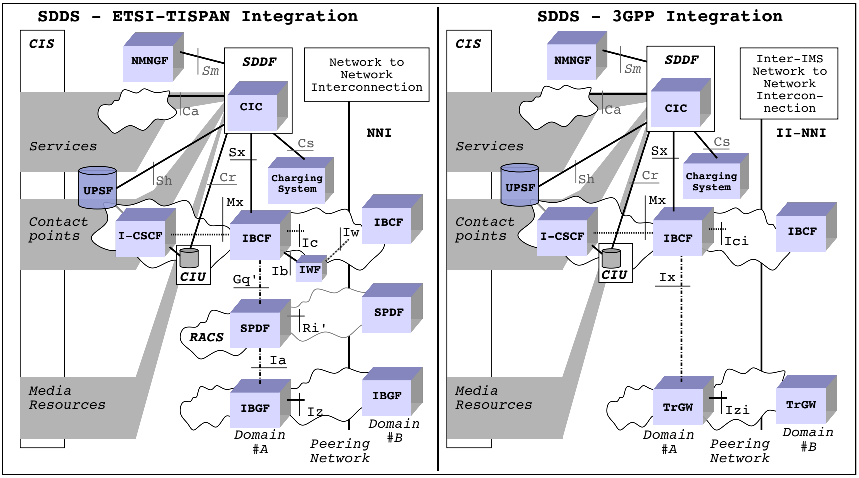

Figure 4.4: Service Discovery and Distribution System Integration

Information about charging and billing are not mandatory but useful in a cost sensitive routing determination. Depending on the local policy rules operators offer volume or time based accounting information in a variably granularity. In certain cases where charging and billing information are structured in the same way only minor changes shall be needed for a proper interworking. In all other cases a normalisation must be performed guaranteeing a comparability between the exchanged accounting information.

Among other duties the User Profile Server Function (UPSF) stores and handles service profiles describing a set or subset of available services provided to UAs. A particular service supplied by a server needs several information required by the UA in order to use it. The server name or its IP address, the associated port and a trigger description for matching criteria(s) must be stored at least in a service profile.

In the case services may be offered by 3^{rd} party service providers two cases in the service location are distinguishable: via a global unique name or an IP address, and via a proxy server forwarding the request to the next suitable server. Comparing these two cases results in scalability and load balancing differences. Only the latter case supports load balancing as well as scalability independent from the stored service information.

Using the SDD functionality the latter method shall be supported to prevent unnecessary administrative effort. Shared services are stored in associated service profiles by service triggers and domains. The server name acting as the contact point shall include the application like *Presence* or *Conference* followed by the domain supplying the service towards the operator domain. Then all request to 3^{rd} party services will be forwarded to the local I-CSCF for SIP routing discovery purposes.

The I-CSCF discovers the appropriate route from the home network towards the terminating network and choose a suitable IBCF at the network border interconnecting the local IMN with the next transit network or the terminating network directly. In the case resources along the choosen route are insufficent another route will be choosen through the involved I-CSCF(s). This successive determination process guarantees load balancing as well as a failover mechanism. Franchise agreements for local IMN providers reselling services will be provided as well.

Full scalability is guaranteed through the I-CSCF co-located routing database as soon as multiple routes to a single service are available, in which the service is presented by an unique name and the subdomain is partly

wildcarded, e.g. *Presence.*.nl*. In this case all available subdomains within the domain *nl* are considered on I-CSCF side. A partial scalability is given insofar as multiple servers are stored within the Home Subscriber Server (HSS) service profile. Depending on implemented sub-functions load balancing may be also supported. The procedures applied in this scenario are similar to procedures choosing the appropriate S-CSCF in registration scenarios, [8, 3GPP TS 23.228].
In summary two entities inside the CN are responsible for storing routing relevant information, the HSS for services available within the operator network and adjacent IMNs and the I-CSCF co-located routing database for interconnection paths towards adjacent IMNs. Local services may be addressed directly via the service profile information and 3rd party services shall be addressed indirectly by the service name or the server and the related domain. These indirect addressing assures that the service request will be forwarded to the I-CSCF, see Figure 4.5.

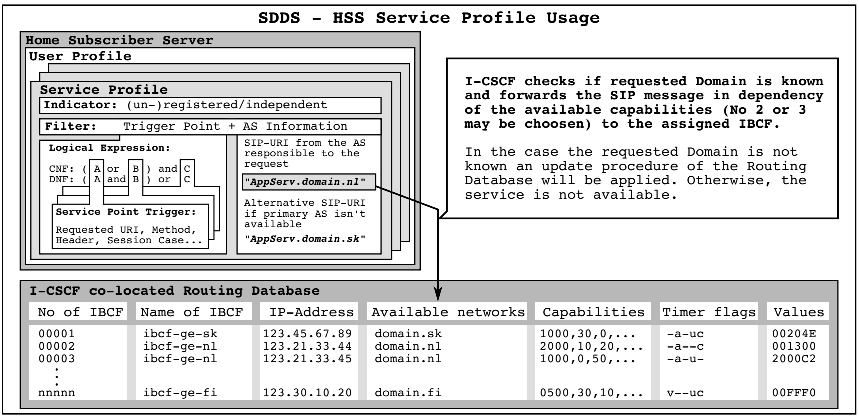

Figure 4.5: Exemplified Service Profile Usage in SDD Scenarios

Acting as a transit network does not require the HSS, the available services may be configured in static way and routes are stored in the I-CSCF data-

base only, or it may be configured dynamically using the CIC. Initial filter criterias are not checked within the transit network. This must be done in the originating network before determining the correspondent server.
The examination of capability tuples represents an important point where a dynamic service update in reselling and franchise scenarios is required. Considering which information are required for accessing services stored in the HSS service profiles, update procedures between CIC and HSS shall be applied via the Sh reference point using the information tuples defined in [33, 3GPP TS 29.229] and the exchanged messages in [34, 3GPP TS 29.328]. In this case extensions to the existing information tuples are required and the correspondent guidelines shall be considered. Update procedures, affecting the I-CSCF routing database only, do not require interactions with stored service profiles unless an indirect service location refers to the modified entry in the routing database.

4.2.2 Capability based Routing Algorithm

Assuming the exemplified SLA Templates correspond with network and operator dependent capabilities, an algorithm is needed solving the dependencies and results in one or more equivalent routing decision tree(s). In consideration of the circumstances the algorithm shall scale, supporting top-down and down-top resolving and beeing applicable in a distributed environment, a splitted computation have been choosen. Part one consists of the preprocessing of the possible capabilities depending on the choosen service or the disposable network resources, see Figure 4.6.
Part two determines all possible routes using the preprocessed capability validation, see Figure 4.7. The result $H[x;y]$ consist of a solved tree identifying all valid routing decisions guaranteeing the associated interconnection path, charging rules, service classification, QoS, monitoring, IP path and ingress/egress points. With the next step the operator may choose one of the possible routes on the basis of routing costs, load balancing and further more. Of course, these additional dependencies may also included within the capability matrix $C[i;j;k]$.

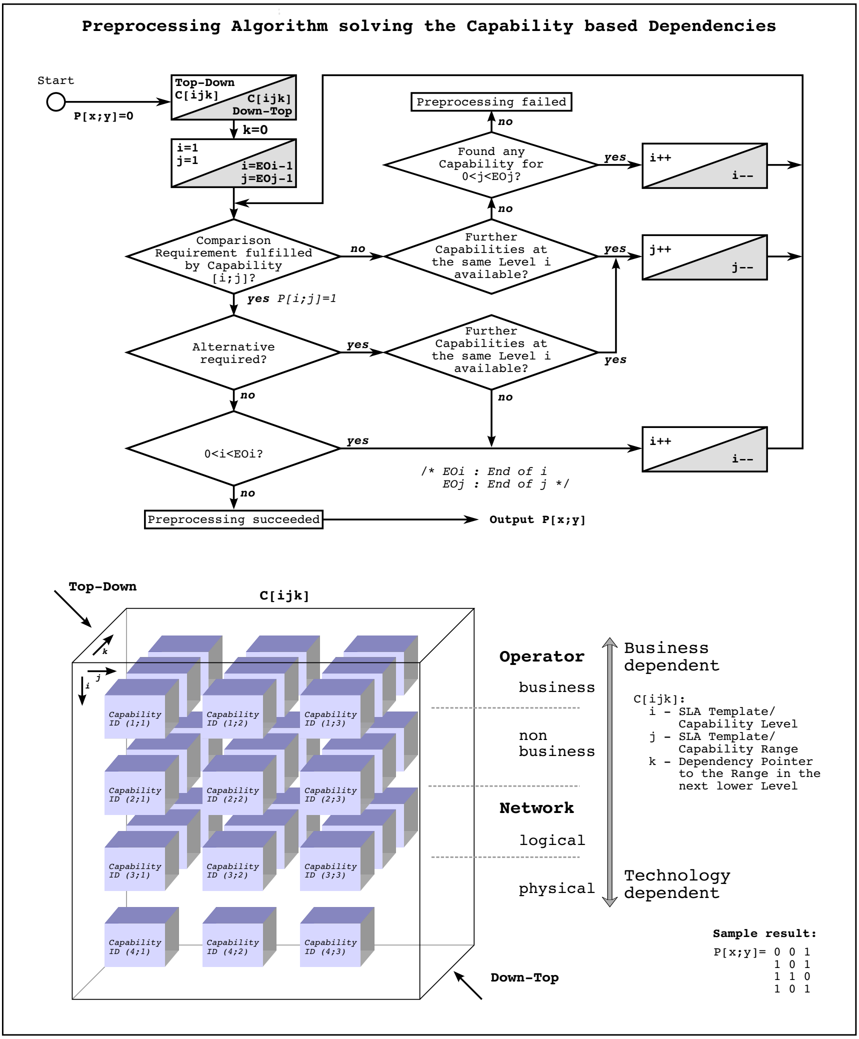

Figure 4.6: Preprocessing Algorithm

Algorithm solving the Capability based Dependencies

```
/* P[x;y] : Input Matrix from Preprocessor
   H[x;y] : Output Matrix containing the
            solved Trees                   */
```

Recursive Iteration Method

```
solve()
{ for ( 1<k<EOk;k++ )
  { if ( P[i+m;G[i;j;k]] == 1 )
    { store H[n;i+m] = G[i;j;k]
      if ( i+m<EOi )
        { dir=true
          m++
          solve() }
      else
        { if ( dir == true )
          { n++ }
          dir=false
          m-- }
} } }
```

Dependency Resolver

```
main()
{ i=1; m=1; n=1
  dir=false

for ( 0<j<EOj )
if ( P[i;j] == 1 )
    { store H[n;i] = j
      solve() }
}
```

```
/* EOi : End of i
   EOj : End of j
   EOk : End of k */
```

Exemplified application corresponding to the Figure:

```
P[x;y]= 0 0 1      H[x;y]= 3
        1 0 1              1   3
        1 1 0              1   1   2
        1 0 1              1 3 1 3 3
```

C'[ijk]

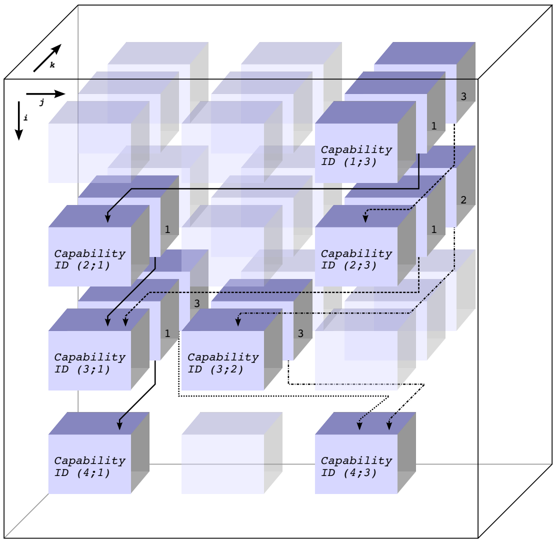

Figure 4.7: Algorithm to resolve the Dependencies between Capabilities

5 Evaluation

5.1 Comparison and Evaluation

The decentralised architecture of the proposed SDDS allows a CEM sharing the administrative and functional effort to each participant in suitable parts. By providing an overlay support within the interconnected IMNs a higher level of scalability and reliability is attained through load balancing and failover mechanisms. Among the point-to-point association between IMNs using the SDDS, the multipoint-to-multipoint [1] association is supported as well. These advantages are provided in compatibility aspects by the same token, where 3GPP as well as ETSI TISPAN compatible IMS and non-IMS based IMNs may interconnected. Reusing and adapting of existing systems like DNS, DHCP or Presence subdivides the proposed SDDS into several parts, acting each as a stand alone system or in combination, depending on the underlying network architecture and whose prerequisites. Depending on the policies defined in the user profile only services shall be enabled matching the initial filter criterias as well as correspondent charging agreements. Privacy aspects are kept carefully in respect within the local regulations and user rights, by hiding all user relevant information [2] before exchanging the abstract capability tuples.
The Windows Communication Foundation (WCF) supports another comparable model providing the discovery and distribution of services within a network. Based on the WebService-Discovery Protocol (WS-DP) an API for publishing services as well as finding published services is provided.
Compared with the DHCP based service discovery and the DNS usage

[1] In analogy to multipoint relationships the definition peer-to-peer association may also used for this term.

[2] By handling abstract tuples related to an interconnection scenario these user information are rendered unnecessary.

for service distribution, the WCF Discovery is equivalent in terms of the centralised model in principle. Given that no interface towards the existing DNS exists a coexisting WCF Discovery is useless, because each network participant have to support the WCF additionally even though the DHCP/DNS is able to provide the same feature.
Compared with the SDDS a network providing Universal Plug and Play (UPnP) enables an exchange of presence and capability information between UPnP devices. The distributed architecture allows UPnP control points to identify capabilities and other features of joined UPnP compatible devices by using protocols like HTTP, XML and the Simple Object Access Protocol (SOAP). An absence of DHCP and DNS servers does not affect the UPnP operation mode, because link-local addressing is supported without a hostname support, limiting the addressing to IPv4 or IPv6 addresses. A device dependent information may be supported in a vendor dependent way, preventing a standardised handling in particular cases. In general, the UPnP correlates more with a vertical structured architecture, providing its own mechanisms for link-local addressing, information discovery, device description, device control as well as presence and event handling. Hence, a continuative comparison with the SDDS covers the exchange of capabilities only.
Messages originated by a SOAP sender may be traversed through zero or more SOAP intermediate nodes before arriving the ultimate receiver. Due to the fact that no routing mechanism itself or any related semantic is defined for the SOAP architecture, a functionality applying such a capacity can be defined as a SOAP feature within the distributed processing model. Features are extensions and are not constrained, but may extend the framework in terms of reliability, security, correlation, routing and Message Exchange Patterns [3] [35, W3C SOAP 1.2].
The SDDS instead supports several level of relaying capability information, within the interconnected peering network by exchanging SIP messages in II-NNIs and inside the local operator domain by reusing the existing SIP infrastructure. Addressing issues will be prevented by accessing the SIP

[3]Including request/response, unidirectional and peer-to-peer based sessions

addressing methods. Using a point-2-point interface for end-2-end message exchange puts the addressing issue aside, i.e. serving the Cr [4] reference point between the CIC and the I-CSCF co-located routing database.
The previously proposed SSS defines an architecture supporting information exchange about available services between network operators. These service related datasets will be provided towards subscribed users interested in these information [16, Service Sharing System]. Significant differences between the SDDS and the SSS consist in the service discovery and distribution mechanisms, followed by compatibility criteria for interoperability. An architectural comparison highlighting various features in the respective approaches have been illustrated in Figure 5.1.

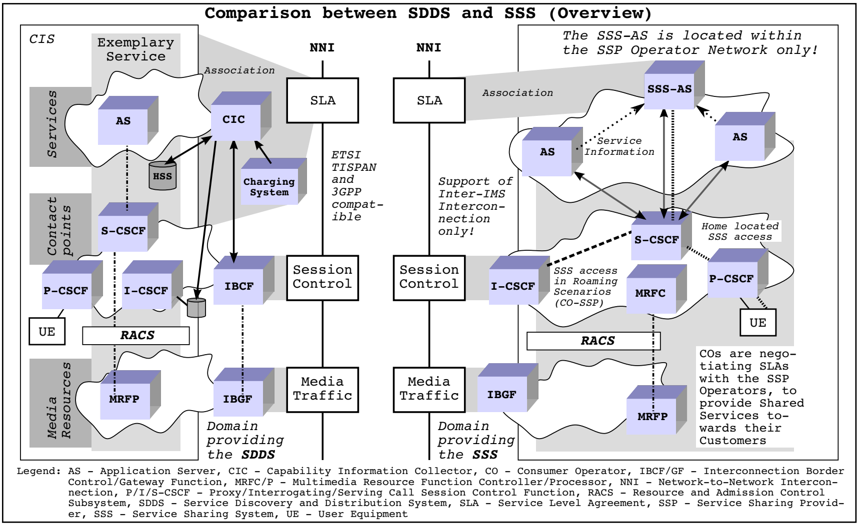

Figure 5.1: Comparison between SDDS and SSS

In spite of various differences in terms of interoperability, responsibility,

[4]Cr abbreviates Capability extended Routing

scalability, data safety and privacy an integration of an SSS-AS within an SDDS operator network is quite possible, insofar as service related information is qualified enough to be applicable in the capability matrix. Enabling an access towards the SDDS and sharing these classified services via the SSS-AS in the inversely rated subject may be turned out quite difficult, because QoS and resource associated dependencies may not be considered sufficiently. An excerpt from the comparison between SDDS and SSS characteristics in a qualified manner have been outlined in Table 5.1.

Criterion	**SDDS**	**SSS**
Architecture	distributed in functional entities; horizontal layered	centralised through the SSS-AS
Scaling	separated functions; separated interfaces	one monolithic function handling the SSS
Overlay Support	provided by the HSS	not supported, SIP only
Interconnection Support	ETSI TISPAN and 3GPP compatible (IMS/non-IMS)	Inter-IMS interconnection only
Capability Awareness	consideration of capabilities/dependencies (network and service)	not supported
Reselling	innately, controlled by regulatory and operator policies; service trade (3rd party)	between SSP and CO only (per agreement); transit not supported

Table 5.1: Comparison between SDDS and SSS

Lobbyist organisations such as the Global Service Coalition accentuate the need for a plurilateral approach in service negotiation, telecommunication service negotiation included [36, USCSI Press Release]. Launching these negotiations at this particular time and concluding it quickly is a legitimate question, especially in the case of needing transcontinental agreements. Basic World Trade Organisation (WTO) documents are inadequate in terms specifying telecommunication service trades, see General Agree-

ment on Trade in Services [37, GATS]. Based on the fact that primarily exporters in the United States are standing to benefit from such a quickly negotiation, the market regulation may act as an important point for counterbalancing [38, Service Trade Liberalisation].
Competition as result of liberalisation may but not must be an answer to improve or cheapen services from the customers viewpoint. It is conceivable that incumbents are reaping its pre-eminence to control essential facilities in terms of preventing 3rd party service access. In interconnection scenarios an effective policy framework is required to force incumbents to open their networks and to share network economies [5]. Supposing an unregulated telecommunication market exists within a local area, a foreign participation may result in a higher gain at the expense of local corporation. Finally, gains may be retained and won't be at regional's disposal. Reservations related to such a scenario have been discussed against the background of telecommunications liberalisation versus the gains for the country within the region of South Africa [40, Liberalising comm. services in South Africa].
Due to the fact that in general trade negotiators are not experts in telecommunication, mechanism must be provided to connect technical aspects changing quickly with business subjects associated with agreements between international cooperations. Within the SDDS a competition in terms of wholesale/resale business in local or long-distance basic and composite services is provided as soon as a regulation framework enables free entrance for 3rd party services as well as non-price discrimination. Extended by interconnection policies a dynamic routing following the regulations is guaranteed in consideration of regional provider and incumbent interests. Potentially excessively interconnection charges may discourages in investment by major suppliers in the technological advance on one side and economically inefficient market entries may induced by too low estimated charges. Both aspects have to be considered by defining interconnection policies [39, Handbook of International Trade in Services].
As mentioned with the introduction of the SSS as a representative extension of an IMS based Service oriented Architecture, the argument "Enabling

[5] "Interconnection policy is the bedrock for regulating the transition to competition." [39, Handbook of International Trade in Services]

3rd party providers' services brings an opportunity to the operators to gain higher profit and satisfied customers." [16, Service Sharing System] shall be rated to be desirable in reference to the facts identified before.
Even an investigation in regulatory and competitive terms at regional level through the European Union as well as at global level through the WTO have disclosed, that in spite of liberalisation efforts a real open competing telecommunication market is still missing [41, Liberalization in Telecommunications].
An overview about considered subjects from the business viewpoint as well as from capability based technical viewpoint in terms of interconnection using the proposed SDDS is depicted in Figure 5.2.

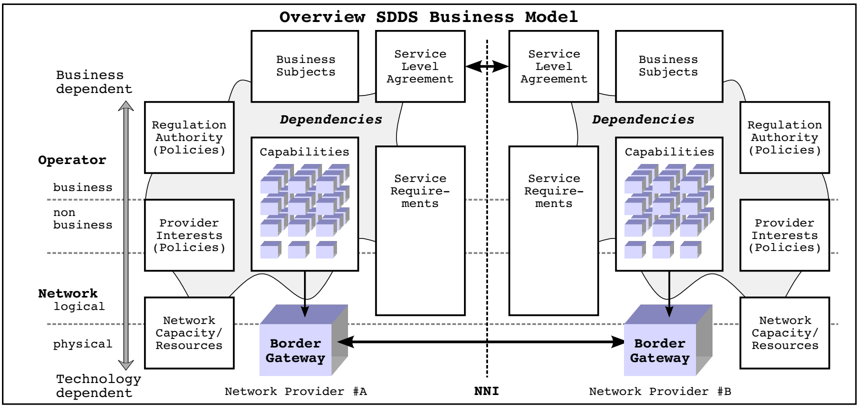

Figure 5.2: Correlation between Business Aspects and Interconnection

Furthermore, the necessity of a regulation authority defining rules for service sharing, compensation, entrance requirements and liberalisation shall be considered, because almost all telecommunication providers comes with unequally preconditions. Otherwise, this inhomogeneous matter of fact could bring monopolisation to bear.
In reference to the generic term Session Establishment Data covering all

routing related capabilities, the SLA based capabilities for enabling a resource and QoS dependent session establishment correspond with it. The proposed capability matrix $C[i;j;k]$ describes qualifiers as well as dependencies combining the following independent subjects:

- i: horizontal level correspondent to the architecture as well as to the SLA specification level
- j: equitable sub-templates within the same level; interchangeable if dependencies are compliant
- k: inter-capability related dependency pointer; one-way dependencies only (top-to-down)

Due to non-limited subjects and their organisation the capability matrix features characteristics such as scalability, distributability and comparability. The resolving process by applying the proposed routing decision algorithm is able to detect all possible decision branches of the decision tree as well as that case where no valid branch is disposable.
For management purposes such as checking both-sided dependencies to support the replacement of sub-templates, or in cases requiring down-to-top dependency resolving the solution is quite simple and feasible with the initial condition: $\forall x, y : h[x; y] = 1$.

5.2 Original Results and Outstanding Issues

Achieved aims of the thesis can be evaluated in terms of the main objectives summarised in Chapter 1 to [42, Dissertaion Thesis, Chapter 1.4]:

1 Analysing existing possibilities of IMN-NNI qualified for service sharing: the SDD scenarios have been discussed in associated aspects and extended by open issues. Lacks, existing in terms of service sharing in general are figured out, depicted of possibilities suitable in regard to effort, complexity and usability. Key aspects in ETSI TISPAN, 3GPP and ITU-T standardisation group have been pointed out and demands have been considered from protocol an interface view.

2 Modelling a SDD mechanism: by providing an interconnection independent (direct/indirect, inter-/intra-domain) SDD architecture for ETSI TISPAN, 3GPP and non-SIP based IMNs, consisting of the mechanism as well as the related protocols, within the local CN and between adjacent IMNs (main focus of reusing of existing solutions).

- It provides a dynamic routing related to SLAs, capabilities and resources on the basis of the CEM and its underlying protocols, information model and routing decision algorithm (Chapter 4.2.2).
- A dynamic service access is enabled in which available network resources and related business terms act as basis for automated routing decisions considering the topology and resource awareness.

3 Classification of network and operator dependent capabilities: based on the

- SLA definitions and adapted by a capability related classification, comprising the availability of correspondent resources in consideration of potentially required Topology Hiding Procedures (THIP).
- Service requirements define criteria that must be satisfied by network resources, operator policies and regulatory demands. A negotiation of these SLAs is supported as well [21, SLA on IMN-NNI].

4 Description of a future-proof CEIM: composed of the information tuple describing services, gateways, metrics and further parameters to qualify a suitable network path for a specific session [6];

5 Evaluation between the proposal and existing similar mechanisms: from the viewpoint of a simplified service integration "service as a network-capability" against the SSS, the WCF-Discovery and UPnP have been

[6] Considering that parameters and values are indetermined yet, a future-proof structure has been defined accepting contrivable datasets and supporting extensibility and scalability. Some required adaptions to the TRIM have been described in detail, looking into reference points and exchanged information tuples. The distinction into logical topology, routing, resource, service and accounting and billing information will closely follow the 7-layer OSI model.

carried out. It can be characterised that cost saving shall be enabled by applying the dynamic acting automated system.

Interfaces and functions of the access managment and service control shall be defined on grounds of clarification, but in purposes of operator selected vendor dependencies.

Evaluating the SDDS architecture model against the current standardisation results in a contrasting juxtaposition as presented in Table 5.2.

Subject	**Interconnection as specified in standardisation**	**Operator network deploying the SDDS**
Service access	direct via the *ISC* reference point	external: via *Mm/Mx; Ic(i)*; and internal: via *ISC*
Service management	depends on available AS interfaces	via NMNGF controlling the CIC and the correspondent matrix $C[i;j;k]$
Service distribution	via connected S-CSCF(s)	via the CIC; depending on regulatory aspects and provider policies
Service discovery	internal: using the HSS Service Profile	external: via the CIC (CEM); internal: via the enhanced DNS/DHCP SDD; HSS Service Profile
Service availability	depends on AS/ network operator	external: depends on SLAs and associated capabilities/dependencies; internal: AS/network operator dependent
Service redundancy	AS entities associated within the same service	external: IMN contact points/alternative routes ($C[i;j;k]$); internal: AS entities for the same service
Service localisation	via the service profile (HSS)	incomming requests: via I-CSCF, via HSS for local services, via $C[i;j;k]$; outgoing request: via HSS Service Profile and I-CSCF

Table 5.2: SDDS related Service Access and Management Architecture

Dependencies between capabilities shall be also considered in management relationship, enabling a mapping between network resources, service requirements, manageable objects and their business relationships. Based on the specifications in ITU-T standardisation boards, such as Business Process View, Management Functional/Information/Physical View, further classifications are required [43, ITU-T M.3060], [44, 3GPP TS 32.102]. A suitable and qualified method for mapping IP processing parameters into abstract QoS parameters in a non-dissipative way is still missing, but required within the upgraded SLA template specification process [45, Mapping QoS/IP Parameters]. Further studies shall be focussed in investigation of session classification and in a particular view about QoS dependencies between interacting sub-sessions, ensuring a passable QoE.
In consideration of applied BCF procedures a sub-classification dependent on the relationship between the involved networks is needed. An investigation has been carried out during the preparation of an IBCF compliant prototype [46, IBCF Prototype]. Several conditions must be factored into procedures, such as message screening, QoS consideration, topology hiding and unhiding or forwarding related location of successional functions and message processing.
It is necessary to define advanced maps applicable in transit scenarios as soon as regulation aspects have been specified. Concerning transparency issues, it is conceivable that CEM related messages shall be exchangeable without applying THIP. However, supporting an overlay CEM within "virtual" session control paths [7] between interconnected IMNs requires a non-affected message forwarding through THIP.
The compatibility in terms of the Content Delivery Network (CDN) interconnection architecture is given basically through a specific transformation as depicted in Figure 5.3. Minor differences exist in terms of the method how capabilities are exchanged: the SDDS bases on a virtual capability overview about all available capabilities, exchanged with adjacent domains and updatable after a time has elapsed or after an event has appeared; the

[7] Adapted from Layer-2/3 technologies such as enabling Virtual Local Area Networks or Layer2/3 tunnels, the CEM information may be exchanged within encapsulated SIP messages or without messages affected by topology hinding.

CDN architecture instead has not the ability of holding such a virtual view and it is required to determine capabilities and their allocatable resources before the service may be requested. The SDDS allows the service access per service request, assuming that the current view and all involved dependencies are valid and hence, the service is available. This awareness is not supported within the CDN architecture [47, ETSI TS 182032].

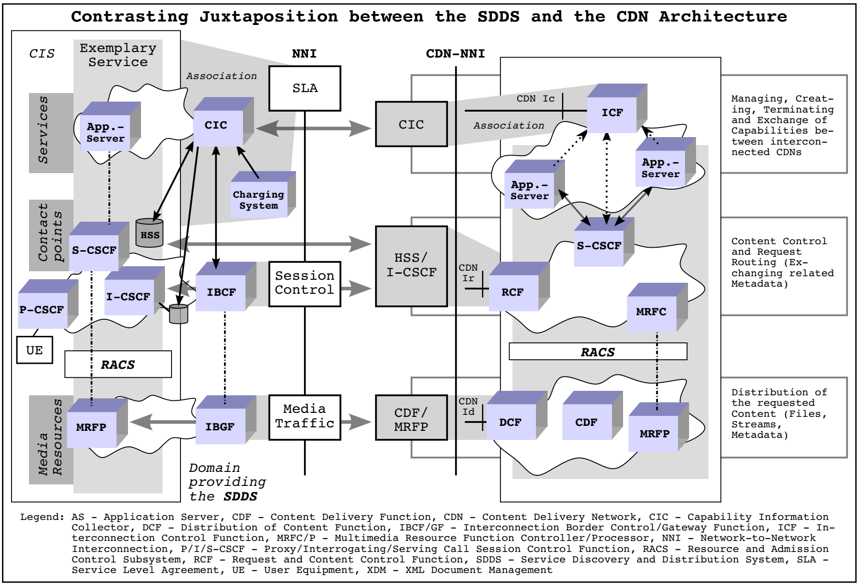

Figure 5.3: CDN Interconnection Architecture by Comparison

Although the interconnection establishment per session or session group in a bidirectional binding negotiation between each involved peer is supported by the CDN, it possess a higher complexity at the network border requireing further reference points and several functional entities. A routing decision function in consideration of allocatable resources and associated costs is not yet defined.

It shall be aimed to introduce the SDDS into the standardisation body, within the ETSI TISPAN working group addressing the Technical Specification (TS) 182032 especially [47, ETSI TS 182032].
Further subjects related to interconnection issues between 3rd party networks shall be also considered. An investigation in general have been outlined in [48, Trunking Requirements for Interconnection].
Further studies shall be deserved with investigation of impacts to the quality and quantity of services as a result of deregulation in telecommunication markets. Additionally, these investigations shall be extended by 3rd party services, competing with the local hosted services.
From the SDDS's point of view a technical, architectural and SLA related mechanism is available, covering 3rd party service provision as well as supporting regulation characteristics.
Among the regulation aspects, overbooking represents another issue. Resources allocated within an established session are reserved slightly more than needed at least by the choosen codec. Common values can be amounted to 10% over-reservation. Assuming that a network operator may be interested to gain its operational grade, an activation of these 10% is conceivable. Otherwise, it may be imaginable that capability information can be reduced by this over-reservation to offer more resources as actual available. Due to the fact that overbooking detection in an inplicit manner is rarely possible, regulation requirements shall be specified to prevent such an impact. Further studies are required for this purpose:

- investigating the impact of the granularity of the capability classification in terms of overbooking prevention, and
- specifying suitable measurement methods to detect a possible overbooking condition as violation of a previous negotiated SLA.

As a result of theses studies the distinction into mandatory, conditional, optional and informative tupel related to capability dependent information shall be applied. The verification of these capabilities as a result of the negotiated QoS in interconnection scenarios has been discussed on the basis of a suitable approach specifying an implicit measurement [49, Evaluation of technical QoS Parameters].

6 Summary

The SDDS enables the exchange of capabilities from the viewpoint of sharing services and composite services. The administrative and functional effort have been minimised by reusing existing technologies as well as through the horizontal layered functional structure. Deploying the proposed system requires nearly the same extensions within the participating IMNs, facilitating the implementation and cooperation between the involved network operators. As a result of 3rd party service sharing it is expected that the variety and accessibility of services may increase, dependent on the local and international inter- and intra-domain regulation aspects. Within the recommended capability specification and mapping procedures a consolidation between technical and business related subjects are realisable. Furthermore, a higher level of scalability and reliability as result of the SDDS architecture improves the QoSE by consideration of allocatable network resources, load balancing policies, regulatory aspects and the minimisation of costs finally.
Beyond the currently standardised IMN interconnection from ETSI TISPAN and 3GPP side, a IM CN independent mechanism has been provided enabling a service and composite service based dynamic interconnection in NGN interconnection scenarios, beeing aware about SLA negotiations and using standardised as well as non-standardised [1] interfaces.
Keeping privacy aspects carefully in respect to regulations the network operator dependent policies allow an anonym service access, favourable from customer's side but not in terms of the advertisment industry. The SDDS supports the privacy by exchanging absolutely needed information in an abstracted way only. Gathering communication characteristics or social networking can be enabled additionally within a separated negotiation be-

[1] Presently, in ETSI TISPAN IMN interconnection scenarios via the IWF only.

tween the customer and the local network operator, but treating this subject deserves further studies about the customer's needs and rights against the wishful thinking from the advertisment industries or the governmental inspection bodies.
By evaluation of the approached CDN architecture it may be evident that this architecture represents a first step to migrate from a vertical to horizontal SLA negotiated service sharing. Aiming the SDDS introduction to the standardisation body shall improve the specification process and the deployment of the SDDS as one option subsequently.
The SDDS supports a resource aware negotiation mechanism able to determine one ore more qualified routes dynamically. Applying the correspondent SLA templates based reorganisation and modification process the existing SLA specification framework can be improved in terms of SLS to resource mapping, resolving of SLS and MP dependencies, the determination of equivalent alternatives and the awareness about available resources. With outlined adaptions a standardised management and service access can be provided independently of the network topology but keeping the reusability of existing reference points and border functions. The service access can be improved in several terms, such as: Reliability, availability, redundancy, scalability and 3rd party accessibility diversity.
Advantages like CN independency, IMN interoperability and deployment beyond ETSI TISPAN or 3GPP recommendations have been realised. Trunking of multiple sessions in transit scenarios by aggregating common resources is also supported, identifiable by the reorganised SLA representation templates.
The capability based viewpoint enables the support of composite services, feasible by the combination of several 3rd party services located within different adjacent domains. Finally the topology and resource aware SDDS allows a dynamic combination of distributed resources within several interconnected peering networks and beyond.
As a result of the service profile based service access the session initiator must be authorised for the particular service by its local service operator and the required resources must be available before a session may be established. These conditions prevent an improper service usage and shifts

the responsibility of provision of valid service access and accounting information towards the network operator.
Within the SDDS the support of forwarding information about available services is essential and enables a multipoint to multipoint service sharing. SLAs and related capabilities are extended by further specifications required in transit scenarios, such as IMN entry points and dependent QoS parameters. Dependencies between the capabilities and agreements are solvable by applying the proposed dependency solver algorithm. Consequently, a reduction of the amount of separate SLA terms is facilitated. Through the specific dynamic allocation of services additional demands are maked in terms of reselling, in the case of service bundles [2] especially.
The formation of prices is unanswered up to now, but assuming, that efficiency increases with specialisation, that 3rd party service providers are qualified for this issue, and that the capacity utilisation increases with concentration of less supplier, a reduction of the price per service shall be happen. But regulations are required to prevent the risk of monopolisation. Even if basic services leave a narrow margin the provision shall be incumbent upon each network operator. Further studies are needed to estimate: how many domains must be served by how many service providers to guarantee a certain level of reliability, but with an effective prevention of monopolisation and price agreements. Moreover, further specifications are required to provide general conditions for reselling in terms of a scalable accounting independent of the 3rd party service providers per stratum and independent of the involved interconnected stratum.
Independently of the CN type, the SDDS supports re-routing mechanisms before, during and after the session establishment procedures have been applied, and without any user involvement as long as the session assignment is guaranteed. Benefited by the SDDS deployment, four types of circumstances can be classified in principle: Before and while starting the session initiation, during the session establishment and the session itself.

[2]Service bundle: a set of services sharing common resources and belonging together.

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