Network architectures for end-to-end business and traffic collaborations among carriers

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Abstract:

The paper describes new ecosystems related to QoS-enabled interconnection models between Network Service Providers (NSPs) to allow for a fair distribution of revenue shares and commitments among all the actors of the service delivery value-chain. It discusses main characteristics of basic Assured Service Quality (ASQ) connectivity products, and how ASQs can be exchanged among NSPs. These new services should allow creating higher social benefits for end customers or over-the-top providers, thanks to assured quality products, as well as new sources of revenues for NSPs. The paper also introduces a reference architectures derived from the TeleManagement Forum with new functional elements necessary for the creation and the composition of such products to allow new type of collaborations between NSPs. The proposed framework provides optional features with different service discovery and composition mechanisms, relying on, first, pre-computed (or "push") or on-demand (or "pull") offers, and second, on distributed or centralized composition implementations. Each of these models having different economic and competition benefits, we finally introduce an early market and economic analysis and possible regulatory impacts offered by these different features.

Keywords: QoS assurance, end-to-end services, Inter-carrier, service discovery, service composition, future networks, future internet, business to business processes.

1. Introduction

Towards new horizons for future options of ICT industry and services, this paper reshapes the current network interconnection ecosystem providing new rules and key topics for regulating the cooperation between Network Service Providers (NSP) and orchestrating the services they can provide to each other and to Over The Top (OTT) parties. A main objective of the architectures is the automatic and on-demand negotiation of QoS-enabled end-to-end connectivity services in order to support high demanding services as well as the growing connectivity needs of Application and Content Service Providers. In this context the specification of an agreement between parties is needed, including business and technical descriptions of the services, that NSPs can buy or sell. Ultimately, negotiated QoS parameters have also to be monitored to check if contract conditions are respected, but this falls out of the scope of this paper.

Such a context describes the general objectives of the FP7 ETICS[1] project [1]. The introduced Assured Service Quality (ASQ) products represent the basic entities for services that will enable quality connectivity. ASQ products relate to the delivery of traffic from one or a set of points in the NSP network to one or more other points, and meeting defined performance objectives. As a result, ETICS is providing a reference architecture including global descriptions of products and envisaged collaboration models between NSPs. The architecture identifies and describes, from a system perspective, the main components and their respective internal and external relationships.

The paper is organized as follows: section 2 firstly defines the per-NSP products and product boundaries as well as how such products can be used for a new interconnection market derived from general technical approach adopted by TMF [2]. Then, section 3 presents the generic ETICS architecture relying on a Network Service and Business Plane (NSBP) governing the network control plane (CP), which performs functions that are needed for efficient controlling and establishment of ASQ paths among heterogeneous domains. Relationships between NSPs to assemble per-NSP products impact the NSBP and the CP, involving three main tasks: the network service discovery, the service composition and the service instantiation on network resources to effectively set-up the service to send data traffic. The paper focuses on the first two steps (service discovery and composition) that can be fulfilled with different technical approaches, which are also discussed in section 3. Finally, beside the above technical objectives in overall, section 4 provides a summary and preliminary business analysis of these technical approaches as well as a possible roadmap for such a QoS-enabled interconnection market.

2. The approach / Basic Definitions

The methodology proposed to arrive at the definition of the architecture (section 3) consists of the description of network services (products) from NSPs, overall processes for the composition of the offers, and an analysis of the TMF approach that will be considered as starting point.

2.1 Per-NSP products and product boundaries

An NSP product consists in the delivery of traffic from one or a set of points in the NSP network to one or more other points. An inter carrier Assured Service Quality (IC-ASQ) good is made by interconnecting products belonging to different NSPs. An NSP product is characterized by business, legal and technical parameters. The technical parameters (SLS, Service Level Specification) are identified in [3] by the addressable points (single point or region, e.g. based on IP prefixes), the Bandwitch (B), the Availability (A) and basic QoS parameters between the product boundaries points (Delay (D), Jitter (J), Loss (L)). Other technical parameters are identified by Time Duration (TD), Delivery Delay (DD) need to make service available. Relevant business parameters are for example a Price (P) and a Validity Period (VP), that defines certain periods of validity (e.g. busy or non busy hours). Typical NSP products have been introduced in [4]. For example, Fig. 1 illustrates two basic ASQ services:

- An ASQ-Traffic termination (ASQ-TA): the customer NSP wants to reach users in a destination region within the provider NSP domain, with certain QoS attributes. The ASQ-TA product consists in the ASQ traffic delivery of traffic from the point of interconnect (PoI), to a destination region.

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- An ASQ transit: it corresponds to the traffic delivery through a transit NSP from one traffic delivery source point (TDSP), to a traffic delivery destination point (TDDP).

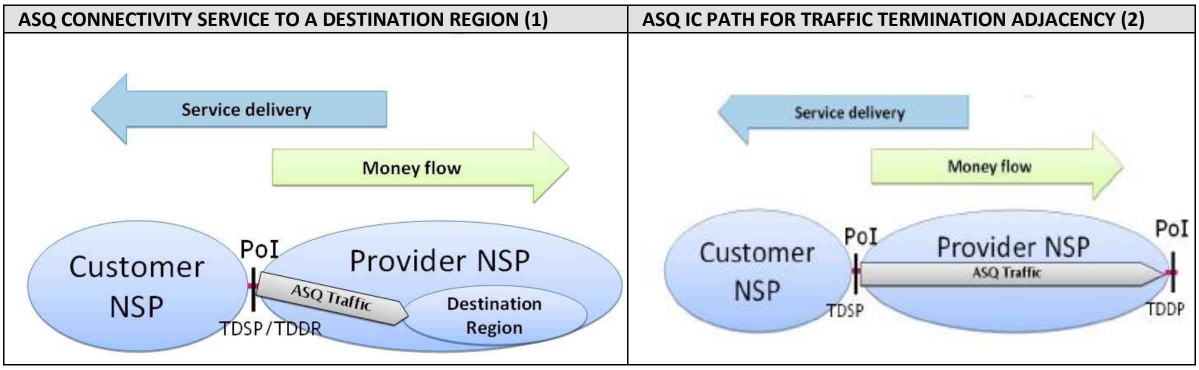

Fig. 1: typical ASQ products offered by a provider NSP to a customer NSP.

The management of IC-ASQ products imposes to define specific roles to study the ecosystem and the relationships between the different actors. The overall ETICS system includes two macro roles: the ETICS community and ETICS customers. The ETICS community, a set of NSPs implementing the ETICS system and processes, provides IC-ASQ goods to its ETICS Customers. ETICS NSPs can be Edge, transit or transport NSPs, while ETICS customers can be non-ETICS NSPs, end customers (consumer or business customers) or Informatin Service providers (InfSP: Content SP (CntSP), Communication SP (CmSP), Application SP (AppSP) or Online Gaming SP (OGSP)). Details of these roles and related interfaces can be found in [3].

2.2 Tele-Management Forum (TMF) approach

TMF addresses essential requirement of service composition across multiple stakeholders and multiple technologies. It has thus been selected as major reference as it allows business objectives like: Enable wholesale services to be offered to community of service providers, mechanism where retail services can be created from a combination of wholesale multi technology services, support business processes related to supplier/partner management and support automation and management of such business processes across domains.

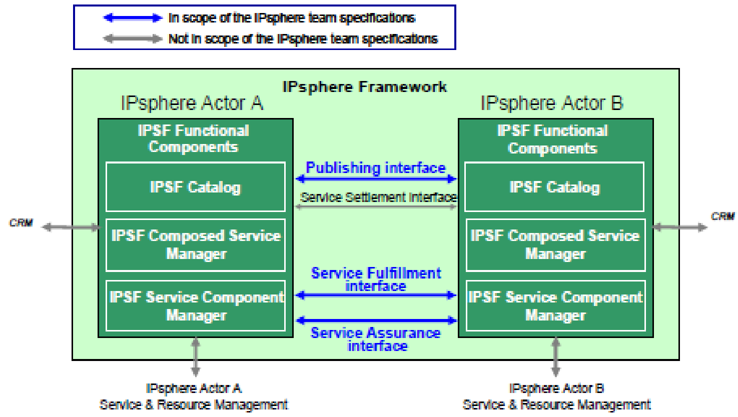

Fig. 2: IPSPHERE Framework

In particular, [2] describes the TM Forum IPsphere Framework (IPSF) that is perfectly in line with the overall goal of ETICS project which identifies the framework for B2B collaboration among actors. According this Framework, service providers can create, offer, deliver and assure premium and predictable services. It is very interesting to review Fig.2 from [3] that identifies all basic elements necessary to have business collaboration between two actors: Catalogue and publishing of collaboration agreements for services, fulfilment and service assurance, north and south interfaces to the Customer Relationship Management (CRM) and infrastructure resources to be involved.

Such architectural components therefore provides a relevant baseline to develop an architecture for inter-carrier services. Due to the complexity and uncertain QoS interconnection market, ETICS has the challenge to try to fill the gap between this general B2B framework and precise business processes to be implemented by NSPs for selling/buying ASQ goods. How business processes are linked to the network infrastructure control and management is also addressed by the ETICS architecture.

3. Etics architecture: composition of NSP goods

3.1 Product offer composition mechanisms

Before describing the ETICS reference architecture, we explore in the following sub-section how communities of customer and providers can cooperate to compose offers in order to satisfy a customer demand. The composition of final offer will include two tasks:

- Service Discovery - to find the right set of NSPs that can provide the final offer
- Service Composition - to allocate individual QoS objective per NSP.

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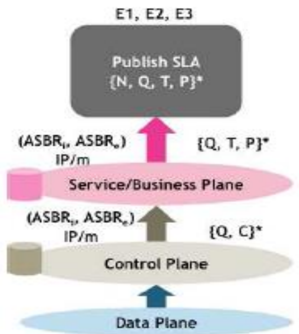

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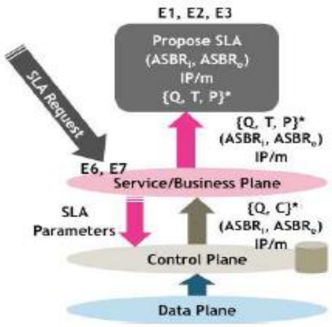

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Fig. 3: IPSPHERE Framework

This section introduces most probable (Fig. 3) scenarios to compose final NSP offers where the service composition and discovery tasks can be done separately (on-demand product offers composition or **“pull model”)** or at the same time (pre-computed product offers composition or “**push model**”).

3.1.1 On-Demand product offers composition (PULL MODEL)

The ETICS community starts computing the composition of NSP products only upon the reception of a customer request. Likewise, each NSP will typically create an offer for a product only upon the reception of an explicit SLA request to create it. As such, in the pull model, no offer exists before the reception of a specific request for it. When an NSP receives a request for a connectivity product, it is free to decide whether to provide it or not depending on its policies. The offer for products are computed according to the SLA request and are then offered.

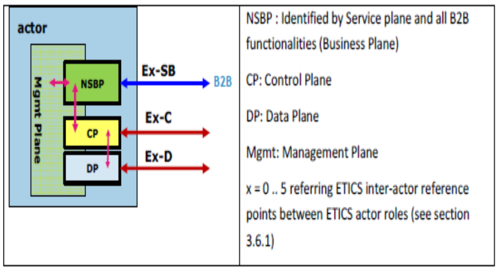
3.1.2 Pre-computed product offers composition (PUSH MODEL)

In this second case, NSPs products are pre-computed in the form of well defined final offers. This type of scenarios is called push model because NSPs push their offers in a repository, also known as service catalogue. These offers need to be shared by other members in the community in order to be able to compose a final product. A product is represented as an SLA that contains both technical QoS parameters each NSP claims to provide (SLS), and additional business information (optionally a price).

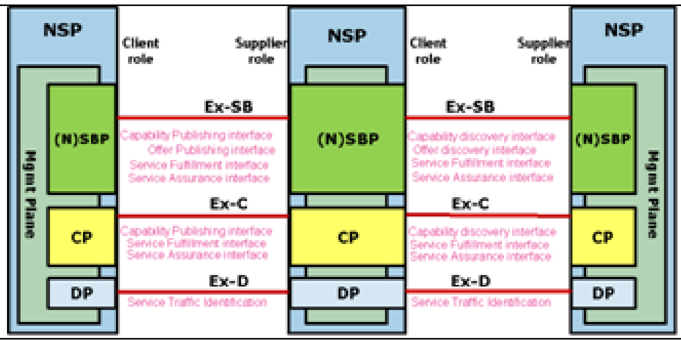
3.2 ETICS Reference Architecture

The overall architecture adopted by ETICS applies the TMF generic solution framework where the planes shall communicate with the corresponding planes of another NSP through identified interfaces. The reference architecture of ETICS shall group together the CRM in the Network Management plane, which will remain internal to the domain of the actors.

The terminology of ETICS uses the concept of planes instead of layers of TMF. Nevertheless, it is possible interface by interface to make an analysis of possible technologies behind and thus to identify the involved layers between the planes. For example the IPSphere framework will involve layers of applications, the control plane L3 (PCE, MPLS...) and infrastructure layer of IPSphere with control plane technologies involving L1, L2 and L3 [5] accordingly.



a)



b)

Fig. 4: ETICS reference architecture layers and interfaces

Fig.4 a) show the layers involved in the ETICS reference architecture and interface capabilities exchanged at each plane. Indeed, the NSBP, CP and DP can be involved in inter actor collaborations. For these Planes, 3 logical external interfaces (Fig 4.b) (Service Business, Control and Data) are foreseen with Ex prefix, which depends on the precise actor roles introduced in section.2 (see [4] for interfaces definition). This is a system approach that allows the realization of a communication and collaboration model for each actor involved into the IC market. According the type of the actor (i.e: NSP, business customers, information SPs) some of the planes / Interfaces may not exist. This is related to the type of the infrastructure owned by the actor. The Service plane represents the set of systems and processes that are geared towards providing services to users with a predefined quality (SLA) and maintaining state on those services. The Service plane will generally rely on the functions of the CP and/or Management (Mgmt) Plane to affect changes on the Data Plane. It will typically maintain databases on current and future service instantiations and coordinate associated workflow processes. Therefore a general reference architecture can be depicted by introducing respective functional blocks within the three planes (Fig. 5).

Main functions identified are:

- Service discovery facilitator: interacts with the control plane to have information for NSP chain learning [2]. The collected intra domain information will be made available to the offer composer which will use it to perform the NSP chain learning. These processes are therefore applied to the Pull model. This also explains why service discovery and composition are more distinct phases in this model.

- SLA requests processor: receives requests to provide specific offers. Upon the reception of such a request, the SLA requests processor triggers the product offer creation that will be done by the «product offer creator » entity. This process also applies to the Pull model.
- Product offer creator: may interact with the control and data planes or indirectly through the OSS north interface. It makes the resource inventory and creates offers upon the reception of a request from the SLA-requests processor entity (Pull) or in advance (Push).
- Service instance manager: instantiates the offers upon the reception of a request to implement it. It also interacts with the billing/accounting entity to charge for the offer.
- Product offer publisher: this entity stores a catalogue of offers and manages the access policies to this catalogue. The offers catalogue can be either stored only locally and accessed by the central entity or stored at the level of the centralized facilitator entity. The access policies specify for instance which NSPs are allowed to profit from the offers in the catalogue. This function only applies to the Push model where offers are pre-computed.
- Product offers Reception / decision process has for main roles to compare different received offers and to bundle received offers from other NSPs with intra NSP offers to create new offers that will be republished again thanks to the product offer publisher. Again, this function only applies to the Push model.

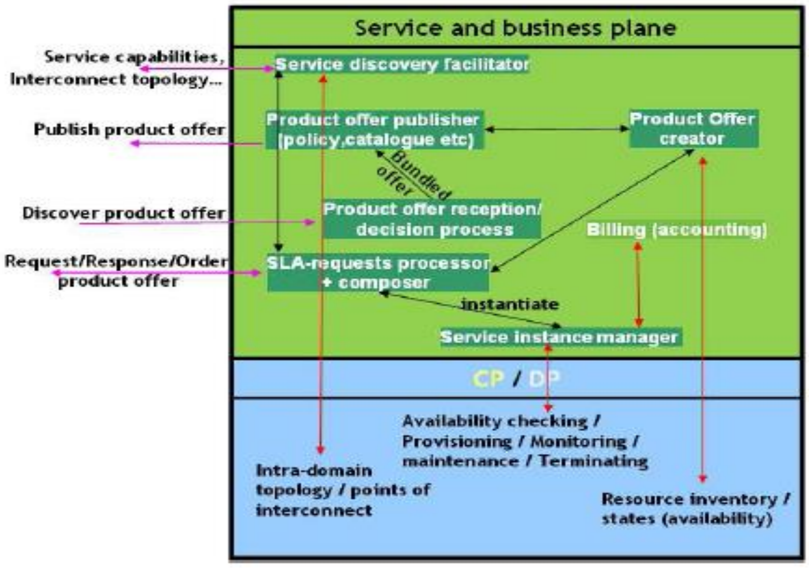
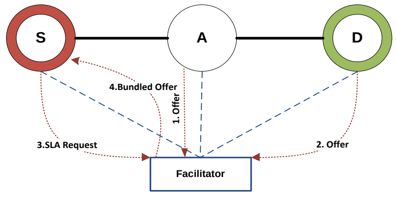


Fig. 5: ETICS reference architecture layers and interfaces

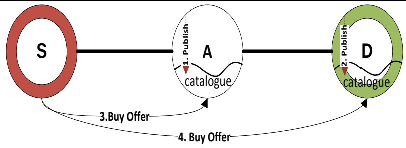
In addition, we can have a "Service Design" block, of the management plane, linked to the "Product offer creator" to define in a human based process the network connectivity service types that the NSPs would like to propose to the market. In parallel a database storing all the configuration workflow processes to instantiate each network connectivity type has to be fed. This specification work can also be allocated to the Service Design. The entries of the database are consulted by the "Service instance manager" when service instances have to be provisioned on the network infrastructure.

As explain, not all functions are required if NSPs decide to choose a specific service and composition model. In that case, the above architecture can be customised according the pull and push scenarios introduced in section 3.1, removing unnecessary functions or processes. Beyond the push/pull mechanisms, products may be made available and composed in different ways:

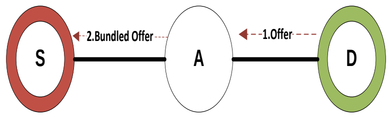
Fully centralized by a **single centralized entity** "**Facilitator**" for the whole community: offers (push) or service capabilities (pull) are known from a neutral entity acting as facilitator between the ETICS customers and the NSPs of the community. NSPs are therefore only sellers for a single buyer centralizing customers' requests, which provides a confidentiality between NSPs, as only the central facilitator knows NSPs' offers.



Centralized by any NSP: instead of having a single facilitator, each NSP can be facilitator for some requests (e.g. the customer-facing NSP), and be seller for others. Then, offers should be known from each NSP willing to act as facilitator.



Distributed through NSPs: in this case, each NSPs treat its part of the End-to-End demand and forward the request with the remaining budget to following NSPs. Each NSP is therefore buyer and seller in E2E demands. In a push, mode, this is very similar to the way BGP operates when it builds an E2E route. Upon the reception by a router of a route to a given destination, a new route to the destination is formed and is propagated. As for BGP, an offer decision process is needed in order to choose between different offers concerning the same destination.



Therefore, taking into account the overall compositions mechanisms, the ETICS reference architecture allows for implementing six distinct features, having both their own technical and business properties. However, the success of such approaches will be mainly dictated by the business justifications. Therefore, before further analysis technical details of the six features, we have tried to provide a first business analysis to define priorities and a possible roadmap of the different features, which is explained in the last section.

4. Business analysis and market vision

Hereafter, we perform a first analysis of the architecture scenarios of section 3 from various points of view: market maturity & economics criteria and regulation/neutrality.

From the market & economics point of view globally the push feature is envisaged to appear later than the pull one. Indeed, in absence of large QoS market so far, pre-computing offers may lead to less relevant offers, while the pull feature is intrinsically more adapted to discover customers' expectations. In addition, in order to support the push model, operators would have to create new processes, update published offers regularly and closely monitor the usage of their network resources with respect to their published offers. This may create a higher entry cost compare to the pull model, if there are not enough stable demands justifying specific pre-computed offers, thus inhibiting NSPs' willingness to implement it. On the contrary, on mature market, such segmentation of most demanded offers may provide cost benefits to the push model. Therefore we envisage a global roadmap where pull features should be used for early markets, and may progressively evolve towards push features when the market is gaining maturity. Independently from the push or pull features, how offers are composed also provide different market opportunities: centralizing the service composition (in a unique facilitator or within few big NSPs as composer) allows for externalizing all costs of "offer composer" and "offer publishing" for most NSPs, lowering in particular the entry barrier for smaller NSPs. A per-NSP model is also attractive to trigger demands. However, centralization scales less so the foreseen roadmap naturally moves towards a distributed composition when the market grows in size (number of NSPs and offers per NSP).

From a regulatory point of view, we do not see major differences between push and pull. While the push model may be perceived as more open with published offers stimulating competition, but over time, the multiplication of demands should bring a similar visibility on the different offers in the pull model. The fully centralized model should intrinsically provide a more neutral market behaviour: the composition is not done by a single NSP and may be governed by common objectives and rules, agreed by participating NSPs. However, to be accepted by NSPs, such model must show benefits they could not have without having this central facilitator but it can neither be a mean to form a coalition where NSPs would agree on unreasonable prices. Therefore, this model must act for the global sustainability of the ecosystem, maximizing the social welfare of customers having access to ASQ goods but also providing incentives for NSPs to participate. Further work is required to understand if this is a realistic objective not imposing too strong regulation barriers for NSPs. On the contrary, decentralization may lead to incomplete knowledge and local deviations and probably to increasing of price. The per-NSP composition model finally may introduce biased behaviours as the composing NSP for given demands might put higher priority to its own objectives than to community objectives. This is however a behaviour that can be observed on any market where an actor can have strategic advantage to gain market power. Thus, it should be verified that if multiple NSPs are implementing this per-NSP composition (on overlapping market segments), market competition would not be sufficient to auto-regulate such biased behaviours.

5. Conclusions

The complexity and uncertainness of the market for QoS interconnection force the research communities and industries to identify valid B2B approaches and precise business processes to be implemented for the benefit of all involved actors (customers, operators and internet players). The paper firstly defines the type of network products (ASQ goods) allowing for such sustainable collaboration among providers and buyers. By proposing a reference architecture with different service discovery and composition mechanisms, the lead project FP7-ETICS highlights this complexity and raise important questions for the future network ecosystem sustainability. The paper is focusing on processes enabling carrier collaboration at the service plane, providing an early analysis and a first roadmap of possible QoS-enabled interconnection market. Future works illustrate the dual approach of the ETICS project: on the one hand, the business analysis will be further developed in order to provide recommendations and qualitative arguments on realistic QoS-capable interconnection models. On the other hand, the project is progressing on the detailed technical implementation of the reference architecture, including the protocol specification, a scalability analysis and prototype implementations to demonstrate the feasibility of approaches and de-risk possible field trials.

Acknowledgments

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