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NGN USAGE IN FUTURE INTERNET SCENARIOS

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Abstract: *Overlay applications are generating the most of the traffic in today's Internet. Therefore, ISPs have to consider the optimization of this traffic and its associated operational costs. This paper presents the approach of the SmoothIT project to improve the end users' QoE and to reduce the ISPs costs. This approach is based on the specification of Economic Traffic Management mechanisms that are implemented in the "SmoothIT Information Service" architecture. This architecture can take advantage of the usage of NGN transport control functionalities, providing improved QoE to the end users of the overlay applications.*

Keywords: NGN, Overlay Networks, Economic Traffic Management, QoS, QoE.

Introduction

Peer-to-peer (P2P) overlay networks, in which different end users share their resources (content, CPU, storage, bandwidth, etc.), have become a popular option to distribute content in the Internet, due to their inherent scalability. This has resulted in an important traffic growth in Internet Service Provider (ISP) networks [1].

Many algorithms for selecting peers in P2P applications are based on random selection, in order to increase overlay robustness but also due to the overhead and inaccuracy of network (called also underlay in the following) topology discovery mechanisms [2]. Overlays could query the underlay to retrieve topology information and report traffic intentions, but such interfaces do not exist. This information asymmetry, resulting from the lack of communication between overlay and underlay, leads to an increase of provider's costs, due to high traffic in costly inter-domain links, and a possible deterioration of end user's Quality of Experience (QoE).

Therefore, it is desired that the underlay provides some information regarding peer selection to the overlay application. The aim is to support traffic management of the overlay application and to prevent any negative effects on both parties caused by the information asymmetry. Any information exchange should lead to a "win-win-win" scenario for all parties involved (ISPs, overlay providers and end users). This is the approach of SmoothIT (Simple Economic Management Approaches of Overlay Traffic in Heterogeneous Internet Topologies) project [3], which is based on Economic Traffic Management (ETM) mechanisms that take into account both requirements: reduction of provider costs and improvement on users' QoE. In this paper, we mainly focus on ETM mechanisms that employ Next Generation Networks (NGN) capabilities, under an innovative approach whereby ETM components constitute the Service Stratum of NGN.

The rest of the paper is structured as follows: Section 2 identifies the information asymmetry problem; Section 3 gives an overview of the ETM mechanisms and the requirements that are derived for the development of a solution (called SIS, SmoothIT Information Service); Section 4 details the possibility to use the NGN Transport Control Functionalities to improve the end users' QoE; and finally, Section 5 provides concluding remarks.

Problem Statement and Solution Outline

ISPs costs are increasing because: (i) intra-domain traffic is growing mainly due to P2P applications. Due to the lack of interaction between overlay and underlay networks and the selection of non-optimal sources (e.g., peers select other peers from other PoPs instead of peers from their neighbourhood), more traffic than expected has to be managed in ISPs' networks. And (ii) overlay traffic has an important impact to the inter-domain traffic. This is especially important for Tier-2 and Tier-3 ISPs that could experience an important growth in their interconnection costs, especially when transit agreements are established. In case of a peering agreement, if the symmetry of the traffic is not maintained, an initially free agreement could evolve into a charged peering agreement. Moreover, a Tier-1 carrier could experience that the changes in the traffic matrix lead to violations in their interconnection agreements. For both reasons, it would be useful if the ISP provides information to the overlay network about the most suitable peers, based, e.g. on the BGP information available for the different domains.

In this context, SmoothIT [3] is proposing a new element called SmoothIT Information Service (SIS) as the way to facilitate network information to the overlay application. Basically, the type of interactions needed has a request-response pattern. An overlay network element (a peer) requests information (attributes) for a given list of peers and specifies optionally the type of overlay application it is using. The SIS sends a response back with the requested information (attributes) assigned to each peer in the list. Possible attributes include ranking priorities and more detailed information for each peer like locality, link capacity, availability, peer rating. The SIS maintains statistical values of each important parameter for its own Autonomous System (AS) and SIS elements in different ASes may communicate to get the overall view in respect of the parameters specified.

The incentive for the end user to use this SIS service is to improve its QoE, while the ISP aims to reduce its costs. The use of SIS information by the requesting peer is optional. Therefore, SIS will have an impact if its replies lead to a win-win scenario, which is the basic idea of ETM. This approach differs from that by P4P [8], which relies on the collaboration between the ISP and the overlay application tracker (rather than on user queries), while it is richer than the Oracle service of [9], both with respect to the information employed (see above) and to the functionality (see next section). This approach is the first one combined with QoS mechanisms.

SmoothIT Technical Approach

This section briefly presents various ETM mechanisms based on different theoretical approaches that aim to influence and manage overlay traffic. Furthermore, the SmoothIT architecture is presented, enabling the deployment of all different ETM mechanisms in a real network and overlay application.

– Economic Traffic Management (ETM) Mechanisms

Three classes of ETM mechanisms are identified by [3]: 1) SIS-enabled locality awareness, 2) Introduction of ISP-owned overlay entities in the overlay, and 3) QoS/QoE awareness.

In the first class, the following three approaches have been identified: 1) BGP-based locality promotion provides a peer ranking service to overlay applications based on information gathered from BGP, 2) centralized SIS and dynamic locality is motivated by the fact that locality awareness may not always be efficient for the ISP – in fact, locality awareness should be considered only when the network and/or interconnection agreement status implies that is beneficial to do so –, and 3) locality-aware Tit-for-tat/Unchoking integrates locality information into the unchoking algorithm of BitTorrent-like P2P systems. All three approaches are based on the concept of the SIS and try to promote locality awareness.

The second class consists of an ETM approach of different spirit, namely the introduction of ISP-owned peers (IoP) in the overlay [10]. The IoP is an entity equipped with higher bandwidth, storage capacity, etc. that aims at increasing the level of traffic locality within an ISP, improving also the overlay performance. Although the IoP stores and serves content, it is not a standard cache – it runs the overlay protocol in order to acquire content. This mechanism has important legal constraints that should be carefully analyzed.

The third class consists of ETM mechanisms based on QoS and QoE: 1) Overlay QoS provides QoS guarantees to the overlay application exploiting the capabilities of the NGN Transport Control Functionality (which is explained in the next section); 2) Locality-based Traffic Shaping assigns different rates of upload bandwidth to high-bandwidth users with respect to the destination of their flows, whether they are internal or remote; and 3) VPN-assisted Overlays is based on the idea that a VPN that spans across many domains can be formed and offer higher performance for an overlay application. In fact, some of the aforementioned ETM mechanisms can be run within this VPN. Additionally, there are a few uncategorized ETM mechanisms that have been studied by [3].

– SmoothIT Architecture

The design of the SmoothIT architecture took into account the requirements, economical benefits, and legal constraints of ETM mechanisms, assuming the algorithmic core of the proposed ETM mechanism as a black box. For this reason, the input/output requirements of all mechanisms were gathered and grouped based on similarity to form modules. The resulting modular architecture can therefore incorporate already defined and future ETM mechanisms and it can be integrated in real networks, as it shields the ETM mechanism from specific network and overlay technologies, allowing easy replacement and deployment.

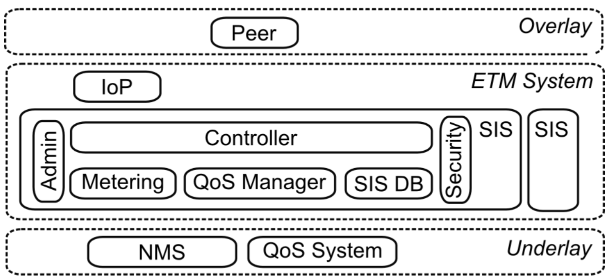

Figure 1: SmoothIT Architecture

The main components of the SmoothIT architecture are shown in Fig. 1. The *SIS* is a central entity of the system and includes several other components. The *Controller* is responsible for receiving the request from the overlay application, performing calculations based on several factors, such as metering and policy information, and sending back the preference values to the overlay application. The *QoS Manager* is used to check the availability of network resources and guarantee resources requested by the end user as well as to enforce QoS policies in the network. It interfaces the underlay by using the NGN transport control functionalities [4] available in the network. The *Metering* module collects network information in order to support the ETM mechanisms implemented by the SIS. This information can include e.g., BGP routing tables in order to support locality based algorithms, and network performance and usage parameters. The *SIS DB* is a repository that stores configuration parameters for each module. The *Admin* module is used to configure and manage the system, while the *Security* module provides authentication, access control, and secure communication functionality.

The SIS provides four interfaces: (i) to peers of the overlay application to feed the ISP with overlay information and get back network information in the form of recommendations (e.g. a rated list of IP addresses), (ii) to the underlying network infrastructure, (iii) to the network administrator to configure policies, parameters of the ETM mechanisms, and (iv) to other SIS Servers deployed in different network domains in order to support the collaboration between different ISPs.

The modular architecture of SmoothIT supports all the ETM mechanisms presented earlier from the functional point of view. For example, for the BGP-based locality promotion ETM mechanism, a Peer gives the SIS a list of candidate partner peers. The SIS retrieves, through the Metering, BGP information related to the candidate peers, sorts them accordingly, and returns the list to the Peer. The Dynamic Locality mechanism builds on this basic operation, with the SIS retrieving network state and usage information as well and using those to sort the candidate peer list more dynamically. In the case of the IoP mechanism, the SIS guides the managed peer in acquiring content, thereby emulating a virtual user for the managed peer. Finally, further control is possible with ETM mechanisms based on QoS and QoE. There the SIS uses Metering and Peer information, not just to sort the candidate peer list, but also to calculate related companion rules that are applied to the Network elements through the QoS Manager and the NGN transport control functionalities, thus becoming part of the service stratum of the NGN. This mechanism is discussed in detail in the next section.

Creating a New Service Stratum

– The QoS Manager and the NGN

If an ISP has its own platform to enforce QoS policies in its underlying network, the QoS Manager interfaces this platform and provides a common interface to the SIS Server. Moreover, if the ISP has no platform for managing QoS policies in its network, ad-hoc solutions must be developed taking into account the commercial equipment deployed in the ISP network (e.g., in order to guarantee low delay, the QoS Manager will interface an IP DSLAM in a xDSL access).

When designing the general solution, it is important to be aware of the current limitations of QoS in current NGN architectures as they are described in [5]. In particular, one of the major limitations is the lack of standardized configuration interfaces in current network equipment. Since SmoothIT aims to re-use existing standards and interfaces, the QoS solution to be implemented in the SIS relies on the current QoS developments done in the field of NGN taking as reference the ITU-T specifications (International Telecommunications Union – Telecommunications Sector).

In order to achieve this goal, the QoS Manager is composed of the following components: (i) the Interface to the SIS Server, (ii) a SIS QoS Core, where specific SIS policies can be applied (e.g., the administrator does not allow to reserve resources for more than 1 Mbps), and (iii) the interface to the NGN equipment. In this case all the SIS related modules will act as the service stratum of the NGN infrastructure.

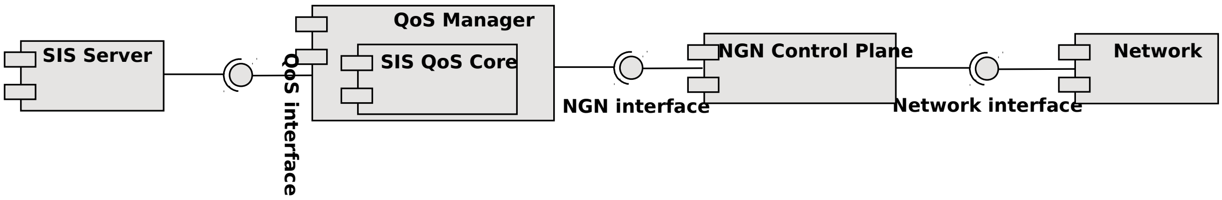

Fig. 2: The QoS Manager

– The QoS Manager Interface

The QoS Manager will provide to the SIS Server the following primitives: (i) *Reserve_resources request* is sent from the SIS Server to the QoS Manager in order to request the resource reservation for a set of flows (with the *QoSRequest* included). This object is composed of the flow(s) description and of the class of service that must be enforced for this set of flows. (ii) *Reserve_resources response* is sent from the QoS Manager to the SIS Server with the response to the request. This response will contain a *reservation_id* if the resources have been successfully reserved and a null value if the reservation was not done. (iii) *Modify_resources request* primitive may be sent if the SIS Server needs to modify the reservation. In this request, the *reservation_id* and the new *QoSRequest* must be provided. (iv)*Modify_resources response* is sent by the QoS Manager with the result to the modification request. (v) *Release_resources request* is used by the SIS Server to release the resources reserved. It has to specify the *reservation_id*. (vi) *Release_resource response* is used by the QoS Manager to notify the result of the release request.

The sequence diagram in Fig. 3 shows how these messages are exchanged in a request-response based transaction which could be implemented based on several protocols, such as SOAP or COPS.

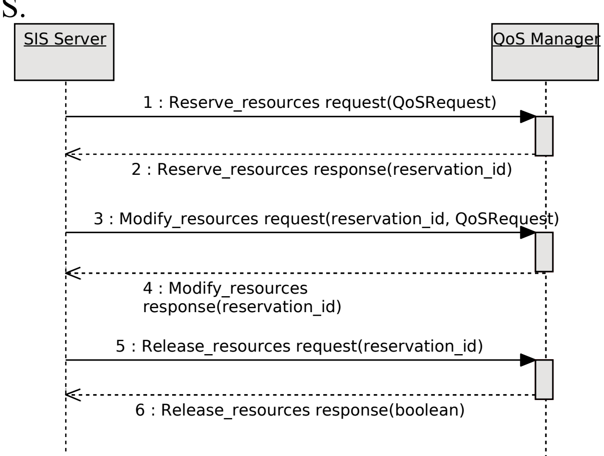

Fig. 3: SIS-QoS Manager request-response Interaction

– Interface to the NGN

Fig. 4 shows the main components of the NGN architecture as described in [6] and outlined next: 1) the **Service Stratum** (composed of the Service Control Functions) is in charge of negotiating with the end users, which are aware of the application/session characteristics. This level could be implemented as an IMS (IP Multimedia Subsystem) core (Session

Initiation Protocol Proxies) or as a service provider platform. 2) The **Transport Control Functionalities** (NACF and RACF) bind the network specific issues to the application plane. They are in charge of managing the end user profile, performing admission control, and interacting with the transport plane. And 3) the **Transport Functions**: where the different network equipments with their own capabilities are deployed.

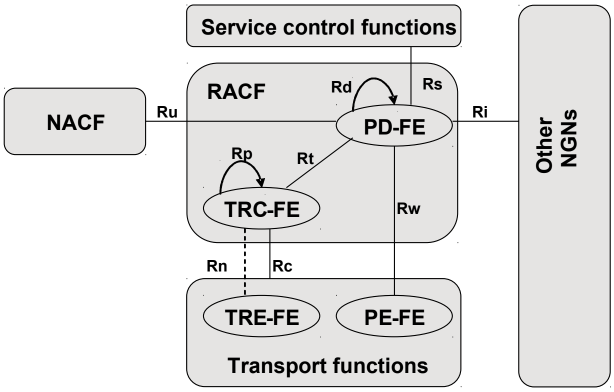

Fig. 4: NGN Transport Control Functionalities

Taking into account this module, the new ETM mechanism – based on the provisioning of QoS guarantees – can be developed by just reusing the Transport Control Functionalities available in the current NGN. For this reason, the QoS Manager just interfaces the Transport Control Functionalities of the NGN. This implies that the SIS Server will be part of the Service Stratum of the NGN.

According to current specifications, the RACF provides the Rs interface that allows the dynamic enforcement of policies for specific flows or the configuration of the user profile (e.g., allowing the usage of ISP services with dedicated bandwidth for Internet access). Therefore the QoS Manager uses the Rs interface, defining a standard compliant solution.

– Use Cases for QoS based ETM Mechanisms

The technical solution described above allows the specification of two interesting use cases:

The first scenario aims to provide carrier class overlay services by using the ISP NGN network capabilities. In this case, the overlay service provider makes a formal agreement with the ISP. The ISP configures its traffic management mechanisms in such a way that it can guarantee some QoS performance objectives to the application. With this mechanism, the ISP obtains benefits from third party applications or can also provide server installation facilities in its premises. Moreover, the Overlay Service Provider (as, e.g., a peer-to-peer streaming based TV transmission) provides the service with higher quality and can, for example, save some costs related to its servers; prioritized the traffic coming from the servers among other traffic, thus leading to an improved service for the infrastructure available; or the ISP can also provide server installation facilities in its premises. Finally, end users enjoy a service with more guarantees thanks to the better provisioning of the service achieved due to the agreement between the ISP and the Overlay provider.

The SIS offers to the overlay users the capability to request QoS guarantees for specific connections. This would be an excellent option for VPN provisioning. This mechanism will be integrated as part of the SIS centralized model, as another service that can be provided to the end users.

These two scenarios could be implemented with the capabilities offered by commercial NGN equipment. Therefore, these scenarios can be just provided by reusing the already deployed capabilities or they can be the source of a new business model that could influence the deployment of NGN equipment.

While QoS-related incentives are clearly central to ETM, the provision of QoS always involves a variety of contractual and technical details. Next we discuss issues on the implementation of QoS for the Overlay Service provider and for the user, including parameters of interest to each of them and other Service Level Agreement (SLA) issues.

– Carrier-Class Overlay Applications

In order to implement this mechanism, the first step is to define the SLA between the Overlay Service Provider and the ISP. This agreement must contain information about:

- Traffic characterization of the application: this input must allow the ISP to identify the application traffic to which it should provide enforced QoS. Therefore, e.g., the overlay should provide the ports used by the application and the IPs used by the servers, in order, e.g., to allow the prioritization of the traffic from the Overlay Services. This option is relevant for overlay solutions also supported by servers, which is usually the case in peer-to-peer streaming applications. Indeed, such applications require certain guarantees for smooth delivery of the content and connections to specific and well-known IP addresses (the servers) can be optimized.
- QoS requirements: the ISP must provide to the Overlay Service Provider a portfolio of services that have been provisioned in its network. This portfolio will be provisioned in terms of Classes of Services (CoS), each CoS will provide its own network performance capabilities in terms of IPLR (IP Loss Ratio), IPTD (IP Transfer Delay) and IPDV (IP Delay Variance), as it is specified in [7].

Following the SIS architecture design, the Admin Interface provides the capabilities to install the SLA between the Overlay Service Provider and the ISP in the QoS Manager that exposes the capabilities to apply the QoS enforcement policies agreed in the negotiation.

In order to implement and deploy this solution, the following issues are taken into account: 1) one of the major advantages of this mechanism is that the expected number of SLA agreements per second will not be high. Therefore, the QoS enforcement can take place without highly dynamic performance requirements at aggregation points of the networks to, e.g., prioritize the traffic from the peer-to-peer streaming servers, both that destined to other servers and that destined to other peers, although the technical approach is different. Indeed, the IP addresses of the servers are well-known. Thus, these flows can be characterized and prioritized in the network without high dynamic performance requirements, as is the case with real peer-to-peer connections. And 2) if connections between peers must be prioritized, the implementation constraints that are described in the next subsection must be considered. The problem arising here is that the IP addresses of the flows are continuously changing, so new policies must be applied. Moreover, in this case, the large number of requests per second that must be managed by the NGN Control Plane could constitute a scalability problem to the solution.

– QoS for Overlay End Users

Users can request specific guarantees for specific connections. In order to implement this feature, in the SIS Servers, the end users provide both the list of peers to be rated and the QoS requirements for these connections. The SIS sends back the rated list of peers, the QoS responses, and possibly the charges applicable to improved QoS.

When the SIS receives the request(s), it interfaces the QoS Manager that will be in charge of interfacing the NGN capabilities available in the domain. In particular, the QoS Manager can request the provisioning of QoS guarantees for specific flows; e.g., provisioning of Streaming capabilities [7] to peer-to-peer streaming applications that need low IPLR and low IPTD. Alternatively, it can request to change the user profile in order to provide more bandwidth to peer-to-peer file sharing applications, in the case that the NGN can support the User Profile dynamic change. In particular, users usually have bandwidth assigned for ISP services such as IPTV and bandwidth for Internet access. The user could request to change this profile.

If the Rs interface provides responses in around 0.5s (needed to configure the policies for a specific end user client) and this is maintained in a commercial environment with a high number of requests/s, this will make this solution suitable to provide QoS incentives by the ISP according to the users demand, which could pay an extra charge for this enhanced service by just reusing the NGN Control Plane capabilities that are being deployed in the different ISP networks.

Conclusions

This paper has presented the SmoothIT approach to optimize overlay network traffic; new ETM mechanisms are defined taking into account both the QoE parameters of the end users and the interests of ISPs and Service Providers. The objective is to find "win-win-win" scenarios where all the players involved can benefit from additionally introduced control functionalities.

As a special case, the mechanism based on the usage of recently standardized NGN Transport Control Capabilities has been described and analyzed taking into account the players involved and different scenarios and business cases. The proposed QoS ETM mechanism provides right incentives to players involved by just reusing the standard NGN capabilities, allowing for both improved services and new business opportunities. The benefits of each player are the following: 1) the Overlay Service Provider is able to provide carrier class services by cooperating with the ISP and by that attracting more users; 2) users can receive a service with better QoE; 3) the ISP can earn additional revenue from third party applications and users by offering QoS guarantees to the end-users and charge them for this "premium" service, additionally the ISP can attain cost reduction from improved traffic management.

The NGN concept seems flexible enough to support novel requirements coming from overlay applications. In order to implement the proposed solution, the SIS will just need to integrate the NGN control plane. This is quite innovative, since this would mean the integration of overlay applications in the NGN framework, representing also a good standardization opportunity.

As future work it is planned to implement the mechanism in a prototype and perform experiments and a quantitative evaluation in order to gain first performance results.

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