Toward a new Telco role in future content distribution services

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Abstract — **as Content Distribution Services become at the center of network use, OTTs strengthen their dominance over the internet. On the other hand, operators like Telcos see their role shrinking to "dumb pipes" providers. This paper introduces a new Telco role in future content distribution services. In particular, it focuses on the "value" that Telco, as a network operator, can bring to CDN providers and Content providers. Value is assessed with respect to both users' trends and content ecosystem evolution. After our review, we reached two conclusions. Many of Telco assets are likely to be of interest for other content players. An open and efficient control infrastructure is the key for reaching an enhanced business position of the Telco.**

Keywords- Telco-OTTs Cooperation, Network architecture, Business position

I. INTRODUCTION

introduced in order to implement a policy based resources Following the advancement of the Internet and of Web services (Web 2.0), telecommunication companies (Telcos) went through a profound transformation, both from the business and technology points of view, driven by a paradigm shift from a state of affairs where voice represented the core business and the majority of the traffic towards one where content in the broad sense plays the central role.

The overall ecosystem changed with the development of the so-called Over the Top (OTT) players, enabled by the always increasing capacity of the Internet and of the access networks, both fix and mobile. The OTTs brought new content related applications leading to new users' experiences; a process that has been accelerated with the fast development of social networks and Peer-to-Peer (P2P) systems.

Content Delivery Networks (CDNs) are a key component of this new ecosystem. By bringing the content closer to the consumer, they achieve two main goals: to enhance the quality of experience and to significantly alleviate the pressure on the core of the Internet.

The value chain of content provisioning is, in a simplified view, composed of four main families of players: content producers (professionals, e.g. BBC, Canal+ and "prosumers" like probably the reader of this paper), content providers (YouTube, Netflix, DailyMotion etc), CDN providers (Akamai, Level 3 etc) and network service providers.

This paper focuses on the role Telcos play and could play in the Content Distribution arena as well as on the control level architectures that may enable taking a strong positioning in this market. CDNs, the systems on which content distribution rely, can be classified in two main families: those that use the Internet for the connectivity requirements and those based on end-to-end managed networks (as usual, the border is not always clear since a combination of both types of connectivity may be used). Leveraging the control Telcos have in their networks is a key element of success and therefore joint network and CDN design a most relevant approach.

Usually the main clients of CDN providers are the content providers (CPs). Telcos have a major skill: they have a direct contact with a broad portfolio of clients. Different business models are here possible: Telcos may follow the classical approach and sell services directly to CPs (e.g.: Sponsored Data Connectivity). They can also sell services to existing CDNs in order to extend coverage and enhance quality without additional CAPEX and, finally, they can sell services to final users, either packaged with the content they provide or for high guaranteed quality access to content provided by 3rd parties. The second model raises the critical question of interconnection and CDNs federation. In all cases, content delivery is a major opportunity to create value leveraging Telcos' infrastructure, a critical issue as basic connectivity services became in most cases a commodity.

The main contribution of the paper is the analysis it proposes of possible evolutions of Telco control plane required in order to enable flexible business models, enhanced joint network and CDN operation and related cost reductions. A special focus is provided to the second model cited above and the requirements rose by the federation issue.

In Section II we briefly describe the state of the art of content distribution services. In Section III we identify the key challenges rose by the evolution of end users' expectations and of the overall ecosystem. In Section IV we focus on Telco position with respect to present and future content distribution services. Section V is devoted to the specific challenges faced by Telcos when positioning services to CDN and OTT players. We figure out that, even though Telco owns important assets and competencies, there is a clear need for designing an efficient control plane answering specific requirements we identify in previous sections. A generic description of the future Telco control plane is given together with the conclusion in Section VII.

II. FUNDAMENTALS OF CONTENT DISTRIBUTION SERVICES

From now for, we focus on content provided by content providers (as opposed to prosumers) and on CDNs (as opposed to end-to-end non-managed P2P systems).

The infrastructure of Content Providers relies on proprietary solutions that, in addition to content and related metadata management (including popularity estimation) and storage, encompasses customer related functionality like authentication, authorization, accounting, billing, profiling, content adaptation… Content popularity assessment and users profiling facilitates an optimized usage of resources. Managed Scalable content Distribution requires CDNs. There is a moving equilibrium between CPs and CDN providers. Indeed, CPs usually delegate content distribution (at least for the most popular content) to CDN players but some like YouTube deploy their own CDNs.

In CDNs, Content Distribution relies on proprietary solutions, including of course caching content closer to end users and in some cases advanced acceleration capabilities as well as routing at CDN level based on network and CDN state assessment (monitoring).

Content Delivery relies on fundamental Web protocols and general architectures: DNS for content names resolution (content URL) into IP addresses, HTTP for content exchange (GET/POST) between users and CDNs/CPs servers and RTP/RTSP for managing streaming contents. When CPs delegate content distribution to a CDN player, a DNS or HTTP based redirection phase is performed prior to content requests handling at the CDN level. Content Delivery is also enhanced through browsers' evolution from HTML towards HTML5. HTML5 introduces new functionalities which include support of dynamic contents, interfacing with terminal peripherals, support of non-connected mode and APIs implementation. In parallel, terminals are enhanced in order to enable users' interaction (e.g.: Graphical user Interfaces support).

Beyond content distribution and delivery, CPs and CDNs implement, in a proprietary manner, limited clients' management and session control functions that are required prior to content delivery (authentication, authorization, Charging etc). CPs may also offer some value added services to end users such as portals personalization per end user and provision of intelligent tools for browsing the content catalog.

CPs may rely on more than one CDN in order to better ensure quality of experience and master costs (e.g. Netflix relies on three CDNs). However, they lack good federation solutions to facilitate the management of the overall so composed system.

III. CONTENT DISTRIBUTION SERVICES NEW CHALLENGES

As content distribution services evolve, different stakeholders involved in content distribution and/or delivery face new challenges. Stakeholders are major CPs like YouTube and Daily Motion, international CDN providers like Akamai and Limelight and ISPs including Telco operators. Encountered challenges are due, in a first place, to an evolution of users' usages and expectations but cannot be, at the same time, dissociated from an overall change occurring at the ecosystem level.

In this section we first identify those challenges and then study their technical and business level impacts on different stakeholders. Finally, we provide generic guidelines enabling stakeholders to face the identified challenges.

A. Overview of users' usages and expetations evolution

Main aspects of users' usages and expectations evolution can be summarized as follows [1] [2]:

1. Increasing demand on non-linear content: Users' consumption of non-linear contents and especially videos is rapidly increasing. By 2015, the number of requested videos per user is expected to double and the mean volume of a requested video is expected to triple thus making video traffic exceed 80% of global internet traffic.
2. Higher QoE constraints: Both fix and mobile end users are tending to expect better content latency (delay of start of a media session) and jitter (continuous media sessions). Moreover, they are tending to consume high resolution contents such as HDTV and 3D videos.
3. Extended Mobility Requirements: As most end users are becoming mobile oriented, more internet traffic originates from mobile devices. Indeed, the volume of mobile traffic is expected to exceed, by 2015, the volume of traffic generated by PCs. Furthermore, every user is equipped with a multitude of mobile devices that are able to connect to many types of accesses. Offloading an ongoing media session from an access to another or from a device to another will hence become a necessity. Many of the listed mobility aspects can no longer be uniquely handled through network level mechanisms like Mobile IP. Indeed, many cases of geographic mobility (change of the geographic domain), access mobility and of course

device mobility cause a change of the "service" IP address (the IP address used by a service or an application to reach an end user). These cases are referred to as "vertical mobility". This latter should be handled at the application level by the concerned content players (CPs, CDN providers and eventually Telcos).

4. Increasing users-based content generation: With the spread of social networks, users are tending to generate more content and to share it with others.

5. High appreciation of customized contents: Users highly appreciate personalized content catalogs (portals) that take into account their preferences (history), their "social circle" and their current context (location, personal etc). OTTs are trying to catch this trend. For instance, Google introduced its new search engine 'Google + your World'. Users also appreciate the content resolution to be dynamically adapted to their contexts evolution (Excellent content resolution when access conditions are perfect or when the user is located in a professional context etc).

B. Overview of Ecosystem Evolution

Major evolution aspects of content ecosystem include the following points:

1. Rising of new content types: New types of content are emerging. The most relevant ones are those generated by systems like M2M [3] and the Internet of Things (IoT), including sensors and WSANs. Those systems will generate an exponentially growing amount of content with an extremely high diversity and with very different structure and requirements from what we know today.

2. The Big Data trend. Content generation will be automated through technologies like stream reasoning applied for example to social networks. The Big data intelligence will be more and more distributed. Related cloud based applications will therefore spread out of large datacenters and the content distribution will be better integrated with the correspondent cloud based applications.

3. Evolution of access and packet core networks: Both deployment of optical fibers at fix accesses and introduction of the LTE (Long Term Evolution) and LTE-advanced mobile access networks enabled more bandwidth to become available in both uplink and downlink directions. Increasing availability of mobile uplink bandwidth enables personal broadcast/ multicast to be supported. The deployment of the "Evolved Packet Core" (EPC) network has many advantages including the support of inter accesses mobility and flexible offloading.

4. Uprising of new technologies: Technologies like Cloud computing, Software defined networking (SDN) and Content Centric Networks (CCN) have emerged, although they are today at different levels of maturity. Cloud computing; through both Storage and Network as a Service models (SaaS/ NaaS); enables the allocation of virtual (routing and storage) resources required for providing a well-defined service [5]. CCN introduces a new paradigm for routing and in-network caching which is based on named content [6]. SDN decouples the control plane from the data plane and enables dynamically controlling network resources for better mapping of content flows over the network [9]. In addition, it facilitates the deployment of network devices that can be virtualized and proposed in the same box slices for networking and for content distribution. Hence, it can be considered as a tool for enforcing SaaS and NaaS cloud models at a mono or multi domain scale.

C. Evolution Impact on Stakeholders

Many of the previously listed aspects of users' and ecosystem evolution raise technical and business level challenges for different stakeholders. These include (but are not restricted to) traffic load and diversity, scalability, federation and SLAs requirements, new functional requirements and new business models.

Increase of content generation and consumption will result in a high traffic load in ISPs networks thus affecting the QoE perceived by end users. Although highly distributed, CDNs risk not being scalable enough when dealing with events like highly changing contents popularity and peak demand on contents. Furthermore, network probing techniques adopted by internet based CDNs may not provide an accurate assessment of the underlying network state. Moving toward a federation of internet and Telco based CDNs is an efficient step towards enhancing the scalability of end to end content distribution while preventing the congestion of ISPs' networks. Similarly, the establishment of QoS related SLAs (Service Level Agreements) between internet based CDNs and ISPs is likely to enable a more content and network aware delivery of contents to consumers. However, addressing SLAs and Federation issues requires putting in place new interfaces, protocols and functional blocs as well as managing the control complexity behind.

Beyond traffic load, change of traffic structure (e.g.: IoT related traffic) requires an evolution of radio interfaces and a deployment of semantic gateways and content nodes that are able to host and forward new content formats.

Supporting vertical mobility requires putting in place many control functions that should be distributed among content players. Functions include vertical mobility tracking, content re-adaptation (if needed) and flows redirection.

The Emergence of the Big Data trend and of Cloud Computing, SDN and CCN technologies raise many challenges for all stakeholders but can be considered, at the same time, as an important opportunity for many of them. In particular, ISPs, including Telcos, can make use of their existing routing and storage infrastructure in order to contribute to NaaS and SaaS cloud offers and to establish federation and/or SLA agreements with global CDNs like Akamai. As a consequence, new business models are likely to emerge thus driving more revenues towards ISPs and cutting other operators' (Cloud providers/ CDN providers etc) CAPEX costs. Through allowing network control and virtualization, SDN presents an efficient tool for enabling these business models. Contrarily, CCN, through caching (popular) content everywhere in the network, prevents individual parties from controlling content placement. Thus, we might claim that the business model behind it lack enough clarity.

To conclude, a huge complexity lies behind addressing the identified limitations from a technical point of view. Besides, existing business models are not enough adapted to parties' future positions and should be hence adequately modified.

C. *General thougts for addressing future Challenges*

In order to face the identified challenges; each concerned stakeholder has two major options: enhancing its own infrastructure and/or outsourcing the missing capabilities to 3rd parties. In addition, a better collaboration among the parties may induce cost reductions for all of them, a win-win movement.

An end-to-end solution managed by a unique player is for sure optimal from a theoretical point of vie. Nevertheless, given the state of affairs (deployed infrastructures) and the specific required competencies and existing market positioning, an intelligent share of responsibilities and market position in the value chain through a well integrated end-to-end solution seems to be the more appropriate strategy. Since different stakeholders have different core competencies, complexity can be addressed through mapping the required functions to different actors based on their core competencies and developing the appropriate federation/interworking architecture.

Opening infrastructures that are today based on proprietary solutions presents in itself a challenge. Addressing this challenge can be of benefit for all the players although it requires adapted business models. Let's remind here that CDN interconnection didn't progress in spite of the technical solutions proposed by the IETF.

IV. OVERVIEW OF TELCO POSITION IN THE CONTENT ECOSYSTEM

In this section, we identify a set of potential roles that a Telco can play with respect to content distribution services. Then, we focus on the specific case of providing added services to CPs and CDN providers. We also identify some Telco assets and competencies that can be leveraged in this context. We show the central role of an adapted control infrastructure in order to fully benefit from these assets and to enable flexible business models. We introduce this point by a synthetic description of Telcos current control infrastructure as specified for example by the 3GPP.

D. *Overview of Potential Telco roles*

In order to enhance its position in the content distribution services arena, Telcos can potentially play any of the 3 roles introduced in Section I: Content Provider (CP), CDN Provider and Network Provider (Mobile Service Provider (MSP) and/or Internet Service Provider (ISP)). Some Telcos have already tried to become CPs but haven't witnessed an important success at this level. In fact, statistics show that demand on Telco managed contents and portals is considerably low when compared to demand on OTTs' ones (internal statistics about the demand on Orange managed contents confirm this affirmation).

Telcos are also positioning themselves as CDN providers through implementing their own CDNs which are open to many content types and CPs but are restricted, till the time being, to Telco subscribers. However, it is quite challenging for Telcos to compete in the global CDN market where an operator like Akamai owns more than 15000 severs located in more than 69 countries [7]. An alternative positioning would be a B2B (Business to Business) strategy where Telco managed CDNs becomes the extension of internet based CDNs such as Akamai. This extension has the advantages of widening global CDNs footprint, offloading these CDNs at peak events, allowing a better local/regional granularity and enhancing the QoE perceived by users for some or all contents categories.

Beyond being a CDN provider, the Telco can make use of its traditional "last mile" network provider position in order to add value to CPs' and CDN providers' services and to enable them to face the technical complexity induced by content distribution services evolution.

Finally, it is important to note that some Telcos are also implementing their own clouds. Given the current state of affairs of the cloud market, our remark here is similar to the one concerning the "CDN provider" Telco role: It may be better for Telcos to expose their routing and storage resources to global Cloud providers like Amazon in order to allow them to extend and diversify their NaaS and SaaS cloud offers.

Next, we focus on both CDN provider and network provider Telco roles since we believe that merging both roles enables offering combined CDN and network service to CPs and internet based CDN providers thus leveraging Telcos position in the content ecosystem.

E. *Value Creation Related to Telco assets and competencies*

Beyond their fix and mobile access infrastructure and IP core networks (including PoPs, external plant, locations for base stations, network equipment, information systems and more), Telcos own many assets and competencies that may be of high value to both CPs and CDN providers. They can be summarized in five points: A large portfolio of clients, Ownership of users' information, real time knowledge of users' context (e.g. location), network monitoring and network control and management.

1. Large portfolio of users: Telcos have marketing approaches to reduce churn and have advanced customer relationship management (CRM) solutions. Although these systems could

be enhanced, they represent a main asset to promote their own or 3rd party services.

2. Ownership of users' information: Telcos maintain in their Information Systems and network equipment (e.g. HSS/ HLR) valuable users' information including authentication keys, users' identities and users' service profiles. This information enables them to perform a number of control functions including users' authentication, authorization of users' access to services and billing on behalf of CPs and CDN providers.

3. Knowledge of users' contexts: Telcos monitor, in real time, users' contexts in terms of geographic location, access type and device type, among others. Providing this information to CPs or CDN providers enables the adaptation of both content portals and content resolution to users' current contexts. Portals for instance can be adapted to users' locations and devices capabilities. The format (Codec) and the resolution (encoding bit rate) of a selected content can be also adapted to users' devices and access constraints (in terms of bandwidth). Some may argue that the Telco role is not primordial at this level. In fact, Telco independent approaches like HTTP adaptive streaming (MPEG Dash) already allow this kind of adaptation to take place. Furthermore, Geolocation and other APIs supported by many terminals are likely to provide CPs/ CDN providers with enough information concerning users' location and devices. Thus, there is a moving equilibrium between relying on the Telco for providing context related data to 3rd parties and counting on the terminal for doing so. Adopting the first option has the advantages of alleviating the terminal complexity and adding optimization to the adaptation process (context related data is only sent upon context change and not periodically as it is the case in MPEG Dash). Besides, adopting the second approach requires the support of some APIs and of HTTP adaptive streaming solutions (Adobe based, Microsoft based etc) by all manufacturers for all terminals which is far from being the case for the time being.

On the other hand, Telcos can play a particularly important role in handling "vertical mobility". In fact, as a last mile ISP, the Telco immediately track a change of the service IP address. In reaction, he can inform the concerned CP/ CDN provider of this change so that this latter performs adequate functions if needed (e.g.: content re-adaptation to new user's context). As for him, he can perform functions like seamless flows redirection to the new service IP address.

3. Network monitoring: Through being able to monitor their own networks, Telcos can gather information about both network state and transported traffic flows. Network state monitoring (network topology, links capacities, routers load, QoS metrics, etc) and better understanding of the traffic structure might be helpful for enhancing CDNs performance.

From a static topological point of view, Telcos can inform a CDN provider where to distribute, on a national or regional scale, his various surrogates. In order to make this decision, Telcos should consider the zones targeted by content distribution (footprint), transit routers availability in these zones as well as transit/ peering links capacities. The Telcos can even update their topology in order to provide better access to CDNs. This scenario is particularly interesting in the mobile architecture where the first Telco router providing entry to the IP network is relatively centralized (e.g.: a limited number of centralized GGSNs exists in Orange France network). Thus, Telcos can give advice about surrogates' placements and provide local breakouts for ensuring a "short-cut" path to contents.

On the other hand, dynamic monitoring of content flows allows Telcos to gather granular statistics about users' demand on content (content demand per footprint). These statistics can help CDN providers in updating both the capacity of their regional/ local surrogates and content placement in these surrogates. Better efficiency is thus reached in terms of speed of requests handling (better estimation of surrogates' capacities), latency of content routing (better surrogates placement) and dynamicity of content distribution (better surrogates update ratio). Beyond the listed benefits, traffic monitoring allows the Telcos to maintain content related users' history. This history can be used by OTTs for portals and/or advertisements customization purposes. In addition, since Telcos are aware of both source and destination of content flows, they can perform a flow based charging of users on behalf of CPs/ CDN providers.

Finally, networks (and caches) state monitoring allows the Telcos to track the evolution of their links bandwidth and of their caches capacities. This information is then mapped to the users' demand. Based on it, operations aiming to prevent bottlenecks and overloads and to enhance routing efficiency can be performed.

4. Network Control: Telcos have full control over their network resources and can, potentially, provide bandwidth on demand. In fact, users' and network state information as well as real-time requirements from 3rd parties (e.g. CDNs) can be astronomically processed, based on predefined policies, in order to optimize resources allocation.

In this context, Telcos can propose QoS related 'Service Level Agreements' (SLAs) to CPs and CDN providers, thus adding value to these players' services. Established SLAs can be enforced through many mechanisms. One mechanism consists on using VPNs for routing content flows. Others involve marking packets, enforcing paths and dynamically rerouting content flows. Telcos can also propose federation agreements to global CDNs. Depending on agreements description; Telcos contribute the capacity, type and placement of the caching resources that should be allocated. Let's note that allocated resources may be standalone caches like transparent proxies or may belong to a controlled overlay network like a managed CDN. In the future, these resources may be even integrated within network equipments like routers (in-network caching). Next to resources allocation, Telcos should update the distribution of contents based on the evolution of users' demand but also on load considerations. Tools like inter caches contents migration and requests redirection (HTTP or DNS based) are relevant to use in this context.

Beyond establishing agreements with 3rd parties, Telcos can use monitoring information in order to enhance routing efficiency and content distribution in their domains. This

enhancement can be achieved through the same control tools listed above. The only difference between both scenarios is that Telco decision in this context is not motivated by revenues' gain but rather by the willingness to maintain a high performance network which is always available and which ensures the best possible QoE for end users, the ultimate judges of the overall service.
Concerning mobility support, Telcos can use their mobility tracking capability in order to reroute content flows toward new users' contexts (accesses, devices, IP addresses etc).

We consider that the previous analysis supports the fact that there is a clear business opportunity for advanced B2B added value services targeting the overall enhancement of content delivery value chain. Proposed services include: Authentication, Billing, context notification, vertical mobility support, QoS related SLAs, content distribution related federation agreements, reporting of users' behaviors and generic topological information/ advice. Thus, collaborating with the Telco or buying the cited Telco' services should enable CPs/ CDN providers to reduce their costs while maintaining their business attractiveness in the content ecosystem. Moreover, such services may facilitate the positioning of new comers, which may delegate to the Telcos several control and users management capabilities.

F. *Control plane role and requirements*

The control plane plays a key role when deploying the previous cited services. In fact, an adapted control plane enables identifying the useful assets for answering an added value service request and makes a relevant use of these latter in order to provide the target service. For instance, providing the authentication service to 3rd parties requires putting in place a specific control plane functionality which allows challenges exchange between the third party and the end user while not disseminating the secret shared between the user and the Telco. Federation issues require an adapted control plane that makes dynamic decisions concerning servers and contents placement. A control infrastructure is usually composed of various functional groups and interfaces among them plus a set of APIs that facilitate their usage by other system components. The architecture may be centralized or distributed, but in all cases signaling transport require specific care and in some cases specific functionally/infrastructure. In the next session we present typical Telcos control plane architectures in order to analyze their applicability to deploy the B2B services we recommend in this paper.

G. *Overview of Telco Control Infrastructure:*

The functional groups and interfaces that totally or partially perform the required control capabilities have been defined by different standardization organizations including the 3GPP (third generation partnership project). Next, we select a set of Telco entities based on their potential relevance to the services cited in B. Some of these entities appear in Figure 1. We use here the 3GPP terminology.

To begin, HSS (Home Subscriber Subsystem) and HLR (Home Location Register) directories manage users' information (identities, authentication keys, subscriptions, rights, etc) and profiles (service profiles, etc). Accessing these directories enable services like authentication, authorization and charging to be performed. The Authentication, Authorization and Accounting (AAA) server authorizes, authenticates and charges a non-trusted access network connecting the user to the to the Telco network. It interacts with the HSS and enables the cited functions without providing 3rd parties direct access to the HSS (one of the most critical components of the security architecture). The "Policy and Charging Rules Function" (PCRF) has been control for QoS enforcement. Its main role is to authorize and pre-allocate resources in order to ensure a certain QoS at the bearer level. The Access network discovery and selection function (ANDSF) has been introduced in EPC context. It enhances available access networks use through providing rules for access networks discovery, inter accesses mobility and inter accesses routing to terminals. These entities were introduced in different 3GPP specifications [11] [12] [13].

On the other hand, IMS has been introduced by 3GPP as a signaling architecture which aims to control the delivery of multimedia services to fix and mobile end users [14]. IMS decouples the control plane from the underlying data plane. In addition, it is agnostic to the access technology. It interfaces with application servers (see below) in order to provide any type of application requiring sessions' control [4].

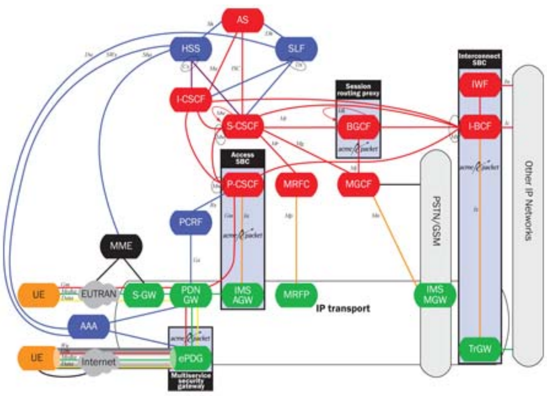

Figure 1: IMS Design as defined in 3GPP IMS Release 8 [19]

IMS relies on a signalling protocol called Session Initiation Protocol (SIP). SIP aims to create, modify and terminate a media session taking place between two or more participants [16]. A SIP message may contain different body types including a SDP (Session Description protocol) body. SDP describes multimedia content sessions. It is used for purposes of session announcement, invitation or media parameters negotiation [17] between parties involved in the service. Other protocols than SIP (including Diameter and RTSP) are used at some of IMS interfaces. IMS overall design is illustrated in Figure 1.

The core of the IMS architecture consists of the "Call Session Control Function" bloc that includes 3 functional groups: the P-CSCF, S-CSCF and I-CSCF (proxy, serving an interconnecting CSCF). Roughly speaking, the CSCF enables signaling messages transport and processing both at intra and inter IMS domains levels, registration process handling, services profiles storing as well as establishing and maintaining sessions' information.

IMS application layer includes a number of "Application Servers" (AS) referring to services implemented on top of IMS. Some SIP based ASs such as "Presence" enhance IMS control through providing value added multimedia services [4]. In addition, SCC (Service Centralization and Continuity) AS [8] provides media session continuity upon change of users' accesses or devices. Other ASs like IM-SSF and OSA-SCS [14] ensure the interfacing between SIP and other protocols and frameworks in order to open IMS to other non-IMS Telco domains or to third parties. As noticed in Figure 1, entities like HSS, PCRF and AAA do not natively belong to IMS. However, these are considered as part of the IMS design since they are accessed, for control purposes, by core IMS entities.

Thus, beyond being service and access agnostic, IMS provides a bunch of functionalities including integrated users' authentication authorization and charging, session mobility control, bearer QoS control, media negotiation and Presence.

V. DISCUSSION: ENABLING ADDED VALUE SERVICES TO 3RD PARTIES

We analyze here whether the control plane capabilities introduced in the previous section answer the requirements rose by the services we urge on in this paper.

HSS/ HLR directories enable fulfilling services like users' authentication and authorization on behalf of OTTs (authentication as a service). Performing these services requires accessing HSS/ HLR which cannot be done directly by 3rd parties because of security reasons. The GBA authentication proposal explained in [15] solves this problem through introducing the BSF, a Telco based intermediary between 3rd parties (NAF) and end users.

The PCRF architecture facilitates a flow based charging of users on behalf of CPs/ CDN providers. It is aware of some elements of users' contexts such as users' IP addresses, access networks and available access bearers. PCRF is also aware of any kind of mobility or access conditions change (change of a user's IP address, access network, bearers' number or description etc).At the same time, , PCRF enables some form of network control through performing operations like gating control and QoS authorization and enforcement at the bearer level (GGSN/ P-GW) [11]. This generic description of PCRF operation shows that it can, eventually, play a role in providing many of the services cited in B. Support of mobility at the network level (network based tracking of mobility, flows redirection), enforcement of QoS related SLAs, billing and context notification are among the "value-added" services that PCRF can cover. However, many limitations prevent PCRF, as currently operating, from providing these services. Indeed, PCRF is Telco based and does not present open interfaces (e.g: APIs) to 3rd parties. A mediator entity should be hence introduced in order to enable the openness and flexible interworking between the Telco system and 3rd parties. Furthermore, the monitoring and control allowed through the current PCRF operation are restricted to the Telco access network. Extending PCRF operation to the backbone is likely to enhance Telcos' use of their assets in terms of network monitoring and control thus allowing them to better enforce 3rd parties' SLAs in their networks. Finally, current PCRF operation does not allow a control of in-network caches, a scenario that is likely to emerge in the future.

ANDSF provides user equipment (UE) with many rules (ISMP and ISRP rules) [12] that are relevant upon attachment and mobility. Thus, it may be useful for enhancing inter accesses mobility. In particular, it can indicate whether a user is allowed to move an ongoing content session from an access to another and can provide the UE with some preferences concerning new access choice. In order to perform this role, ANDSF should be aware of routed content constraints in terms of bandwidth or delay. Interaction with CPs/ CDN providers should be hence added to current ANDSF operation in order to better manage inter accesses mobility.

As previously explained, IMS architecture allows many control functions to be performed. When matching these latter to services cited in B, many similarities can be identified. To begin, many aspects of vertical mobility (inter accesses/ devices mobility) are handled at the control level by the SCC-AS. Subscribing to the Presence service (presence AS) allows a party (eventually a CP/ CDN provider) to gather valuable information about users' behaviors and context: device, location, feeling, personal context (work/ leisure), social circle (friends), preferences in terms of content [4] etc. SDP negotiation allows the exchange of terminal capacities (Codec, media type etc) related context information between parties involved in the content service. Charging can be performed at the network level through PCRF but also at the control level through dedicated charging functions [4]. Let's note that control level charging in IMS either refers to sessions establishment (session based) or to special events (event based). The CSCF bloc is able to gather statistics concerning content sessions trough handling users' registration. Authentication and authorization operations rely on HSS.

Finally, QoS is enforced through interacting with the PCRF and is based on the output of the SDP negotiation.

Based on this analysis, we might state that, apart from what is currently performed through individual entities like PCRF and HSS, the Presence service, the media negotiation process and the control level support of vertical mobility are the main IMS features that are likely to be of interest to CPs/ CDN providers. However, since media negotiation and mobility handling both rely on SIP based messages (Invite, Refer, Re-Invite etc) and procedures (SDP negotiation), they are unlikely to fit content distribution services current context. Indeed, major content players (CPs and CDN providers) do not support SIP and rely on HTTP. Hence, apart from the inefficiencies of PCRF Operation, adopting IMS as a Telco control plane requires a HTTP to SIP (and vice versa) protocol conversion, a solution which is not optimal given the induced overhead and the fact that not all SIP messages have direct equivalent in HTTP (e.g.: Update and Refer signaling messages). Furthermore, since the presence service relies on a "Publish/ Subscribe" paradigm, it may be decoupled of the IMS context. Presence AS can be hence solicited by third parties through mediators.

Based on previous analysis, Telco current control infrastructure is unlikely to enable the Telco to change its business position in content distribution services ecosystem. . This infrastructure makes a partial and incomplete use of Telco assets/ competencies especially in terms of network monitoring and control. In addition, it does not present openness to OTTs. Thus, an evolution of the control plane is required. On the other hand, the arrival of HTML5 based applications and, more important, of the WebRTC architecture, is a key opportunity to move into a better interworking between the 3GPP and W3C solutions, a key step in enabling at low complexity and in a standardized way the services we advocate.

VI. CONCLUSION AND PERSPECTIVES

Content Distribution services are today mainly provided without end-to-end management and therefore without end-to-end quality control. The main reason for that is that the value chain is composed of players that, for some of them, have no interaction at all. Telcos could commercialized B2B added value services targeting CPs and CDN providers, as described in previous sections to, on the one hand, enhance this state of affairs and, on the other hand, reduce the complexity and costs of players like CDNs, therefore allowing a better scalability of the major players and facilitating the entrance of new companies.

Nevertheless, we showed that such a movement couldn't be efficiently done without enhancing and extending the control plane used by Telcos. Among the various issues we are working on, we can mention the definition of the overall architecture, which will encompass enhanced versions of existing EPC/3GPP entities like ANDSF and PCRF. Operation of these entities should take into account extensions proposed in section V. Interworking with HTTP/DNS and webRTC/ RTCWeb based solutions should be facilitated. In order to present openness to CPs/ CDN providers, Telcos control planes should provide APIs allowing a controlled access of CDN providers/ CPs to Telcos based services. Finally, beyond being open to third parties, future Telco control infrastructure should enable a dynamic allocation of resources based on requirements and vision of state. SDN approaches may be interesting to consider at this level. Such approaches will facilitate the introduction of virtualized equipment, providing simultaneously network and CDN capabilities, moving into an ultimate integration of the capabilities required for efficient Content Distribution Services operation.

REFERENCES

[1] Cisco Visual Networking Index: Forecast and Metholology, 2010 - 2015. June 2011

[2] Internet Traffic Report: http://www.internettrafficreport.com/main.html

[3] ETSI M2M Communications Worskhop, February 2011: http://www.etsi.org/WebSite/document/EVENTS/ETSI%20M2M%20Presentation%20during%20MWC%202011.pdf

[4] M. Poikselka and G. Mayer (2009) "The IMS: IP Multimedia Concepts and Services" (Third Edition) , Finland: John Wiley & Sons

[5] B.P. Rimal and I. Lumb. "A Taxonomy and Survey of Cloud Computing Systems", In *NCM 2009*, Seoul, Korea, August 2009

[6] V. Jacobson, D.K . Smetters, J.D. Thortnton and M.F. Plass. "Networking Named Content", In *CoNEXT '09*, New York, USA, 2009

[7] A. Su, D.R Choffnes, A. Kuzmanovic and F.E Bustamante. 'Drafting Behind Akamai (Travelocity-Based Detouring)', In *SIGCOMM 2006*, Pisa, Italy,September 2006

[8] S. Husain, S.Isobe, K. Mahdi and A. Kunz. " 3GPP IMS-Based Inter Devices Collaboration", In *NTMS 2011*, Paris, France, February 2011

[9] Open Networking Foundation. "Software Defined Networking: The New Norm for Networks", ONF White Paper, April 2012

[10] S. Levy. "Going With the Flow: Google's Secret Switch to the Next Level of Networking", In *WIRED ENTREPRISE*, April 2012

[11] 3GPP TS 23.203: "Policy and charging control architecture", Release 11

[12] 3GPP TS 23.402: "Architecture enhancements for non-3GPP accesses", Release 11

[13] 3GPP TS 23.002: "Network Architecture", Release 11

[14] 3GPP TS 23.228: " IP Multimedia Subsystem (IMS)", Stage 2, Release 11

[15] 3GPP TS 33.220: "Generic Authentication Architecture (GAA); Generic Bootstrapping Architecture (GBA)"

[16] IETF RFC 3261: " SIP: Session Initiation Protocol"

[17] IETF RFC 4566: "SDP: Session Description Protocol"

[18] 'High Scalability' Website: http://highscalability.com/blog/2008/3/12/youtube-architecture.html

[19] 'Acme Packet' Website : http://www.acmepacket.com/mobile-solutions-architecture-3gpp-ims.html