Fairness for Growth in the Internet Value Chain

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***Abstract*—Empyrical data show an exponential growth of IP traffic and a corresponding growth of the overall capitalization of the Internet market. However, the revenues generated by the Internet are not fairly distributed among all the players involved in the value chain. In spite of the increasing returns for over-the-top service providers, application developers, device producers, network operators, and content right owners are not taking advantage of Internet evolution. Analysts forecast that in a few years this imbalance will cause the congestion of the network without any motivation for new investments on it, thus ultimately bringing the Internet to collapse. On the other hand, if properly distributed, the value generated by Internet traffic would be sufficient to sustain innovation and growth. This paper demonstrates with mathematical arguments that a fair distribution of the operating incomes across the value chain would maximize the development rate. Furthermore, it analyses the bottlenecks in the value chain induced by the access-based business models currently adopted by operators and often enforced by regulatory authorities. Net neutrality and market law are the pillars of an alternative service-based model which could be adopted to grant to the network the degrees of freedom necessary to overcome its own bottlenecks while reducing the need for policy enforcement.**

***Keywords*-Internet value chain; Growth; Fairness; Sustainability; Neutral Access Networks**

I. Introduction

The exponential growth of IP traffic is not occasional. Rather, it is the result of many concomitant causes: the ever increasing pervasiveness of the Internet, users' addiction to network connectivity, the progressive shift of usage patterns towards bandwidth intensive services, the significant improvements in the usability of interfaces, the ubiquitous availability of connected devices, the increasing share of consumer traffic, and the convergence of popular services (voice, TV, video on demand) over IP networks [5]. Global mobile data traffic is expected to increase 26 times in 5 years, reaching 6.3 exabytes per month in 2015 [6], while in 2014 the annual growth of fixed Internet traffic is expected to become greater than the overall volume in 2009 [7].

The beneficial effect of Moore's law, which keeps improving the performance and the cost effectiveness of network equipment, is not sufficient to sustain this exponential trend, so that continuous investments are required to boost network capacity. The question is: Does the network generate enough value to sustain its own development? According to aggregate financial data the answer seems to be positive, since the overall capitalization of the Internet follows the same exponential trend of IP traffic. A closer look at the Internet supply chain, however, points out a significant imbalance between segments which benefit from traffic growth (including user-interface producers and over-the-top service providers) and segments which suffer from the lack of incremental revenues (including content right owners and connectivity providers) [8]. Such an imbalance risks to impair network development.

Analysts observe that the *capital expenditures* (CapEx) required to fund incremental capacity both in fixed and in mobile networks are much higher than those obtained from the projections based on historical data. CapEx is the amount of money spent by a company to acquire or upgrade its assets in order to increase its capacity or efficiency for more than one accounting period. For a network operator the assets include network infrastructure, equipment, software, sites, and civil assets [9]. The ongoing costs incurred for running the business are called *operating expenditures* (OpEx). Although the revenues of network operators are still sufficient to pay for OpEx, in order for network development to keep pace with the estimated traffic growth, in the next 5 years mobile and fixed infrastructures will ask for a CapEx which is 50% and 30% higher, respectively, than currently planned for the same years [7]. Such additional investments cannot be made as long as operators do not take advantage from evolution. Hence, the imbalance between costs and revenues and the unfair capitalization of Internet value induced by current business models will end up impairing evolution and bringing the network to a congestion which will affect the whole value chain.

Although governmental measures (such as public funding, antitrust rules, and neutrality enforcement) have been often adopted to mitigate this phenomenon [4], they cannot be considered as ultimate solutions to guarantee a sustainable growth and the Internet prompts for new models [7], [2], [10], [11].

This paper starts from the observed and forecast trends of IP traffic and Internet capitalization to investigate how the value should be ideally distributed along the Internet supply chain in order to sustain the maximum rate of development. Extending the analysis recently conducted by the same authors [1] this paper proposes the adoption of a service-based network model (as opposed to the traditional access-based one) which could grant to the Internet the capability of overcoming its own bottlenecks without giving up network neutrality and without requiring external enforcement.

The rest of the paper is organized as follows. Section II demonstrates, with simple mathematical arguments, that a fair distribution of the revenues along the entire value chain is the key to the development of the Internet. Moreover, it shows that, in the medium period, all the players involved can gain a higher benefit from a fair participation in Internet growth rather than from grabbing a higher share in the short term, so that collective welfare matches individual interests. Section III investigates whether and to what extent the results of Section II can be impaired by bit devaluation caused by the increase in network capacity. Section IV provides a detailed description of the Internet value chain, points out the bottlenecks induced by traditional business models, and introduces a service-based value chain as opposed to the current one, which is access-based. Section V proposes a service-based network model and shows how it could be exploited to achieve the conditions to maximize the development by following market law while also preserving network neutrality. Section VI analyses market signs which prompt for the adoption of a service-based model, while Section VII draws conclusions.

II. Fairness for growth

The *value* of a good or service can be defined as its worth determined by the market. The *value chain* (VC) describes the full range of activities which are required to bring the good/service from conception to delivery [12]. To our purposes, we call *value per bit*, denoted by V, the overall worth generated by the processing of 1 bit on the network across the entire VC. We call *operating profit per bit*, denoted by *OpProfit*, the difference between the value per bit and the operational costs *OpEx* incurred at all the N steps in the value chain to manage that bit. In symbols:

$$OpProfit = V - \sum_{k=1}^{N} OpEx_k \qquad (1)$$

The opearting profit at stage n is defined accordingly as:

$$OpProfit_n = V_n - OpEx_n \qquad (2)$$

where V_n is the revenue per bit at stage n.

Assuming that there is a positive overall operating profit, the value has to be distributed over the VC in such a way that the following condition is met at each stage

$$V_n \geq OpEx_n \qquad \forall n \in [1, N] \qquad (3)$$

or otherwise the entire chain would not be sustainable. Then, operating profit can be used to sustain development according to the business models adopted by the players involved. For our purposes, we represent the business model adopted at the n-th stage by the *reinvested earning per bit*, denoted by RE_n, that is the percentage of the operating profit generated by a bit at stage n which will be re-invested. In symbols:

$$RE_n = \frac{CapEx_n}{OpProfit_n} \qquad (4)$$

The development rate that can be achieved at a given stage (say, n) of the VC can be computed as the ratio between the actual $CapEx_n$ and the *marginal CapEx* required to increase of 1 bit the throughput of that stage ($MCapEx_n$). Since the overall capacity of the VC (in terms of number of bits it can process in a time unit) is equal to the minimum of the capacities of its N stages, the maximum development is achieved when all the stages evolve at the same rate. It can be easily demonstrated that this condition is met when the operating profit is distributed in such a way that each stage receives a share proportional to the investment per bit required at that stage ($MCapEx_n$) divided by the reinvestment model adopted (RE_n). In symbols:

$$V_n = OpEx_n + OpProfit \frac{\frac{MCapEx_n}{RE_n}}{\sum_{k=1}^{N} \frac{MCapEx_k}{RE_k}} \qquad (5)$$

In this case, in fact, the development rate will be the same at all stages, avoiding bottlenecks which will cause diseconomies and impair evolution. The common development rate is given by:

$$DevRate = \frac{OpProfit}{\sum_{k=1}^{N} \frac{MCapEx_k}{RE_k}} \qquad (6)$$

As long as the rate is maintained, the development follows an exponential trend which induces an exponential growth in time (t) of the overall capacity of the network (C) and of the profit generated at each stage, that can be expressed, respectively, as:

$$C(t) = DevRate^t \qquad (7)$$

$$Profit_n(t) = (V_n - OpEx_n - CapEx_n)DevRate^t \qquad (8)$$

Both the capacity and the profit at time t are expressed referring to a single bit processed at time 0. This means that, in order to obtain the actual capacity and the actual profit at the time t, Equations 7 and 8 should be multiplied by the values taken by the corresponding figures at time 0. For our purposes, in the following we keep using normalized quantities.

Now assume that one of the players in the VC has the power to capture more value (V_i) than expected according to Equation 5. The consequence will be a higher profit per bit at that stage, but a lower development rate for the entire VC. Referring to equation 8, this means that the player can decide to increase the multiplicative constant of his profit curve, at the cost of decreasing the base of the exponential. Needless to say, this behavior will become counterproductive in a very short time, since the new short-sighted trend cannot compete with the optimal one, which has a stronger exponential.

This simple reasoning demonstrates that the splitting provided by Equation 5 is an equilibrium point that could be autonomously reached in a competitive market where all the stages in the VC are managed by rational agents. In other terms, it represents a win-win solution where the maximization of collective welfare is achieved by the decisions taken by individual agents in the attempt of maximizing their own profit.

III. Dealing with bit devaluation

The previous section has shown that the growth of the Internet market, if properly managed, is not an issue per se, in that it provides the economic motivation to induce all the players to fairly participate in the development required to satisfy the growing demand.

However, the mathematical model has been derived from three main parameters (namely, V, $MCapEx$, and $OpEx$) which have been treated as constants over time. Since, by definition, they are referred to each single bit, they are likely to depend on the amount of bits that can be processed by the network. In particular, both the operating costs per bit ($OpEx$) and the capital expenditures required for each additional bit ($MCapEx$) are expected to benefit from Moore's law and scale economies, which act as negative exponentials.

$$OpEx(t) = OpEx^{(t=0)}\alpha^{-t} \tag{9}$$

$$MCapEx(t) = MCapEx^{(t=0)}\beta^{-t} \tag{10}$$

A similar effect can be observed on the worth of each bit, because of the increasing amount of bits traveling across the network:

$$V(t) = V^{(t=0)}\gamma^{-t} \tag{11}$$

This phenomenon, hereafter called *bit devaluation*, is due to the reduction of the value of a unit of product (i.e., the bit) caused by the increase in the amount of supplied product units (i.e., the overall traffic). This section investigates whether, and to what extent, bit devaluation might impact the results of Section II.

For the sake of simplicity, and without loss of generality, let's assume that in Equations 9 and 10 $\alpha = \beta$. As for γ (which apperas in Equation 11) there are two main reasons, confirmed by empyrical observations, to assess that it has to be lower than α and β: first, because the devaluation of the bits is one of the effects of network development, and it is unlikely that the effect goes faster than its cause; second, because the whole capitalization of the Internet market is growing, while it would decrease if the worth of each bit (V) reduced faster than the costs incurred to generate it.

On the basis of the above arguments, the case in which $\gamma = \alpha = \beta$ can be regarded as the worst-case scenario to be used to evaluate the effects on the development rate expressed by Equation 6. Since the negative exponentials appear both at numerator and denominator of a fraction, their effects cancel out, so that $DevRate$ remains constant over time. On the other hand, if γ was lower than α and β, then $DevRate$ would grow over time.

To better highlight the possible effects of devaluation on profits, Equation 8 is rewritten as the product of three terms:

$$\begin{aligned} Profit_n(t) &= (OpProfit_n - CapEx_n)DevRate^t \\ &= OpProfit_n(1 - \frac{CapEx_n}{OpProfit_n})DevRate^t \\ &= OpProfit_n(1 - RE_n)DevRate^t \end{aligned} \tag{12}$$

where $DevRate$ has already been studied, while the second term does not contain time-dependent parameters. Hence, the only term which needs to be discussed is the first one, which represents the operational profit per bit, the time dependence of which can be expressed as

$$\begin{aligned} OpProfit_n(t) &= V_n^{(t=0)}\gamma^{-t} - OpEx_n^{(t=0)}\alpha^{-t} \\ &= \gamma^{-t}(V_n^{(t=0)} - OpEx_n^{(t=0)}\left(\frac{\alpha}{\gamma}\right)^{-t}) \end{aligned}$$

Replacing the expression of $OpProfit_n(t)$ in Equation 12, in the worst case of $\gamma = \alpha$ the profit at stage n can be expressed by the following function of time:

$$Profit_n(t) = \gamma^{-t}(V_n^{(t=0)} - OpEx_n^{(t=0)})(1 - RE_n)DevRate^t \tag{13}$$

Recognizing that two of the four terms of the product do not depend on time, we can define a constant

$$K_n = (V_n^{(t=0)} - OpEx_n^{(t=0)})(1 - RE_n)$$

and rewrite Equation 13 pointing out its dependence over time.

$$Profit_i(t) = K_i\left(\frac{DevRate}{\gamma}\right)^t \tag{14}$$

Equation 14 clearly shows that the profit keeps growing exponentially as long as γ is lower than the development rate, which is a reasonable assumption (compliant with empirical data) since γ represents the devaluation driven by development. This trend is confirmed by empyrical observations.

IV. The Internet value chain

Among the different ways to represent Internet value chain (VC), one of the most detailed and recent representations is provided by A.T. Kearney [8], which splits the Internet market into 5 segments, namely: content rights, online services, enabling technology services, connectivity, and user interface. In order to point out the differences between access-based and service-based business models, we adopt a 7-stage VC obtained by separating the Internet core from the access network (both of them included into the Connectivity segment in A.T. Kearney's report) and by distinguishing the services provided *over the top* (OTT) from those provided within operators' managed networks (the latter not explicitly mentioned in the above report).

Figure 1. The Internet value chain.

The resulting VC, shown in Figure 1, is composed of the following stages: contents and applications (stage 1), that could be either copy righted or generated by end-users; OTT online services (stage 2), made globally available on the Internet; support technologies (stage 3), which include content delivery overlay networks and hosting services; Internet core (stage 4), made of interchange points and core networks of incumbent operators; online services provided within managed networks (stage 5), which include IPTV services; access networks (stage 6), which include both backhauling and retail access up to the network termination points made available to end-users; user devices (stage 7), which include HW/SW user interfaces and customer premises equipment (CPE) used to connect to network termination points.

It is worth noticing that stage 4 includes both operators' backbones and interchange points, so that Figure 1 does not point out the re-distribution of value within the Internet core, which is governed by peering agreements and managed by international organizations.

According to historical data of market capitalization [7], VC segments have followed very different trends in the recent past: while stages 2, 3, and 7 have known a significant growth from 2004 to 2010 (4x, 2x, and 5x respectively), stages 1, 4, and 6 have not taken any advantage of the fast increase in Internet traffic and their capitalization has slightly decreased in the same period. As for segment 5, mainly represented by IPTV market, the compound annual growth rate is expected to be around 25% until 2014 [13].

The imbalance of Internet market capitalization is schematically represented in Figure 2 in order to provide a qualitative perception of the bottlenecks which risk to impair network development.

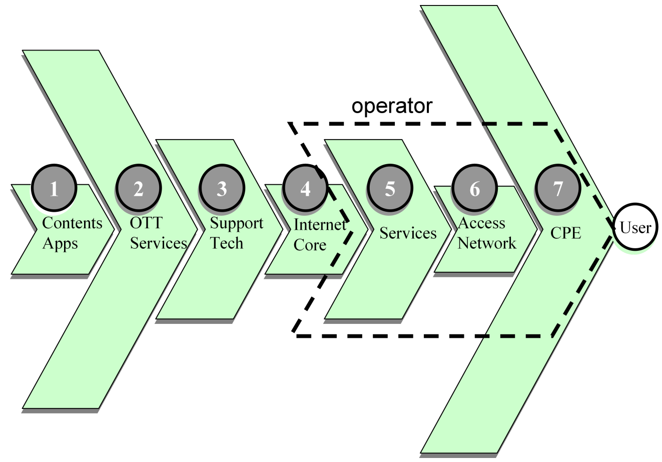

Figure 2. Schematic representation of the unbalanced capitalization of the Internet value chain.

A. Access-Based Value Chain

The current functioning of the network is dominated by two main features. The first one is *vertical integration*, which is the absorption into a single organization (namely, the so-called *operator*) of all the aspects required to go from the Internet core to end-users, often including even the provision of customer equipment (vertical integration is represented as a dashed macro-stage in Figure 2). The second one is the *all-or-nothing offer* of Internet access, which gives to end-users only the categorical choice between subscribing to full access to the network, or being completely cut off. Internet access is typically sold at a monthly flat fee depending only on the nominal (i.e., maximum) bandwidth at user's disposal.

From operators' stand point this business model was originally motivated by the perspective of: attracting costumers with a simple offer, avoiding the operating costs of complex accounting policies, taking advantage from average individual use well below the nominal bandwidth, and exploiting statistical sharing to over-book the bandwidth available.

From end-users' stand point, the model has induced the misleading perception that: Internet bandwidth is the only good customers pay for (while they also pay for access infrastructures and CPE), the nominal bandwidth is the actual one they are entitled to use all the time (while it represents only a peak value they are not allowed to pass), and the more they use the network the more convenient their contracts become (while the monthly rate was determined assuming they would not have used the Internet all the time).

From OTT service providers' stand point, the access-based business model has created a global market where to offer their services without caring about transport, allowing them to deliver most services for free and to get money from commercial sponsors.

It is a matter of fact that the Internet has become a two-sided market where the apparent gratuitousness of traffic has created a short-circuit between the two sides (namely, service providers and end-users), cutting off from revenues network operators, which lay in the middle.

The ultimate effect of this phenomenon is the so-called *cloud computing*: users feel Internet services to be so close to them and reachable at no additional costs, that they keep on the cloud even their personal files that could fit at no cost in the storage devices embedded in their smart phones.

Although such a short circuit has significantly contributed to the diffusion of the Internet and to the development of advanced online services, the model suffers from many weaknesses which make it unsuitable to sustain the exponential development.

First, the advent of a huge variety of services with different bandwidth requirements has created a significant spread of usage patterns with a consequent inequality among users who pay the same fee in spite of heterogeneous needs (for instance, 1% of mobile data subscribers generate over 20% of mobile data traffic [6]). If such a monthly fee is higher than the perceived value of the Internet, individuals may be not motivated enough to subscribe.

Second, there are some stages in the VC of Figure 2 (such as stage 6) which significantly contribute to the costs incurred by operators without generating any direct value, since they are hidden to end-users. This misalignment between costs and revenues impairs innovation because operators are neither motivated to invest in access infrastructures nor interested in boosting the development of bandwidth-intensive services.

Third, as the average individual use gets close to the nominal bandwidth included in the monthly fee, over-booking causes the congestion of access networks with consequent loss of quality of service (QoS).

To contrast these effects, operators have tried to reach scope economies by adopting the so-called *triple-play* market strategy, which consists in providing additional services (namely, IPTV and VoIP) within the walled gardens of their own networks. Moreover, they have been induced to apply *traffic shaping* and *access tiering* techniques in order to delay the congestion of their networks and to mitigate its effects on QoS.

Governments, on the other hand, have come on stage in many ways in order to bridge digital divide, foster competition, and defend end-users' interests. In particular, public funds have been allocated in many countries to finance the development of *next generation networks* (NGNs) and the deployment of access infrastructures in market failure regions, regulations have been enacted to impose incumbent operators to make their infrastructures available to new entrants at controlled wholesale/unbundling conditions, and network neutrality has been enforced by preventing operators from adopting access tiering policies and from establishing commercial relationships with OTT service providers.

If state interventions can play a significant role in triggering development, they cannot guarantee sustainability (if not complemented by private investments and not supported by suitable business models) and they often produce side effects that may even end up thwarting their own original purposes. This is the case of neutrality enforcement and local loop unbundling, which discourage private investments in NGNs by reducing business opportunities, by avoiding bandwidth optimizations, and by making the break-even point unreachable in many scenarios. Moreover, state financial aids, even if targeted only to access networks (stage 6 in the VC), create significant distortions in many other markets (stages 4, 5, and 7 in the VC) because of vertical integration and triple-play market strategies currently adopted by incumbent operators.

B. Service-Based Value Chain

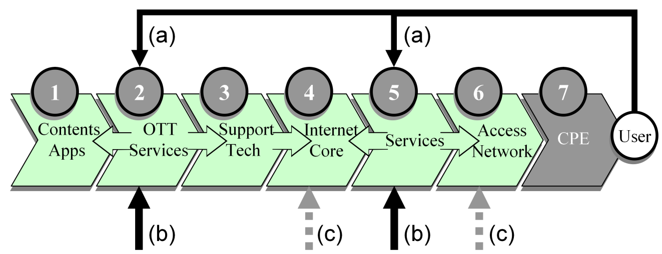

Figure 3. Service-based Internet value chain.

The VC proposed in this section is based on two main features: *vertical separation*, as opposed to vertical integration, and *service orientation*, as opposed to access orientation typical of the current Internet model discussed in the previous subsection.

Technically speaking, separation is an inherent property of the Internet induced by the layered structure of its protocol stack. Network neutrality, which has been one of the main driving forces behind Internet development and innovation, was naturally induced by the layered architecture before becoming a controversial principle. In this context, vertical separation is particularly intended as market segmentation, which enables each segment in the VC to be possibly managed by different actors who interact with all other segments by means of transparent and profitable commercial relationships. Separation also enables each market segment to make business with other industry sectors and public organizations, not represented in the VC, or to be targeted by state financial aids and welfare policies. Vertical separation has been identified by ITU as one of the four technology implications on market structure which prompt for new business models, the other three implications being service innovation, network innovation, and horizontal integration (i.e., network convergence) [14].

Service orientation, which is the second distinguishing feature of the proposed VC, means the opportunity for end-users to directly focus on the services they need, even if they have not yet established commercial relationships with any operator. There are many motivations for focusing on services (delivered both OTT and within managed networks): services/applications are at the top of the TCP/IP stack, they are much more attractive than their enabling technologies (i.e., connection and transport), they provide great opportunities of diversification and innovation, and they have proved capable of taking advantage of traffic growth. Although market capitalization data clearly demonstrate that services are the main driving force of the Internet, current business models do not provide adequate instruments to distribute the revenues along the VC in order to support the development required at all its stages.

An ideal representation of a service-based VC is provided in Figure 3. End-users establish direct relationships with service providers (SPs), who operate both at stage 2 (OTT) and at stage 5 (within managed networks). These interactions, which may or may not involve payments, are represented by black arrows with label (a) in Figure 3, where thick arrows with label (b) represent revenues coming from sponsorships, advertisements, and any other form of business made with stakeholders who take advantage of the Internet without being directly involved in the VC. Both type-a and type-b incomes are collected at stages 2 and 5, even if all stages contribute to the VC. Transparent relations among the actors operating at different stages are then needed to enable a fair redistribution of revenues along the service-based VC. Inter-stage redistributions are represented by horizontal arrows in Figure 3. Finally, dashed arrows with label (c) represent financial aids possibly targeting backbones (stage 4) and access infrastructures (stage 6).

Stage 7 (i.e., CPE) is shadowed in Figure 3 and it is not involved in any inter-stage commercial transaction because it is a thriving market by itself, which is expected to be able to keep following and supporting Internet growth without the need for significant changes in its business model. In other terms, end-users' devices (such as smart phones, net books, PCs, set-top-boxes, ...) can be considered to be already at users' disposal, since customers are highly motivated to pay for them. Hence, they can be neglected in our analysis since they are neither a bottleneck to be overcome, nor a source of revenues suitable to be redistributed along the VC. Notice however that the lack of interactions between stage 7 and the rest of the VC does not mean that CPE cannot be provided by operators (as they are usually in current business models). Rather, it simply means that this kind of scope economies are not considered to be relevant for network development.

Internet bandwidth is nothing but a special kind of service provided at stage 5 by Internet service providers (ISPs) who manage gateways placed between access networks (stage 6) and Internet core (stage 4). Access infrastructures are assumed to be open to end-users, whose CPE associates for free in order to allow them to gain access to online services (including Internet bandwidth). SPs and ISPs pay a fee to the operators managing the access network in order to be allowed to expose their services to connected end-users. As long as SPs share their revenues with access network operators, the latter are motivated to open their networks to end-users, in that they add to the value of the network by making it more attractive for SPs. This allows operators to take advantage of the development of the two-sided market they enable, and provides the motivation required to invest in access infrastructures.

OTT SPs may keep exposing their services on the Internet without establishing direct relationships with network operators. In this case, they can be reached by end-users who subscribed with some ISP to gain access to the Internet, while they will not be reached by end-users who have connected only to the access infrastructure without buying Internet bandwidth. On the other hand, OTT SPs can decide to enter into a contract with an operator to make their services also reachable, within managed access networks, to end-users who associated for free with the access infrastructure. In the first case the traffic generated within the acces network is paid by end-users (as a share of the fee they pay to ISPs), while in the second case it is paid by SPs. Finally, depending on the nature of the services, OTT SPs may or may not share their revenues with content providers (stage 1) and enabling technology providers (stage 3).

Although many different business models can be conceived and adopted, commercial relationships should be mainly based on IP traffic in order to provide the so-called *price-signal* which acts as a positive feedback in triggering and sustaining development.

In summary, the service-based VC provides a suitable support for development and growth, in that it lowers access barriers for end-users, it reduces information asymmetry by avoiding end-users to be billed unawarely for the traffic generated by the services they use, and it allows operators to establish transparent commercial relationships with SPs without violating network neutrality. In fact, neutrality is preserved as long as the same conditions are applied at each stage to all the actors playing the same role in the VC.

V. A SERVICE-BASED MODEL

Moving from an access-based to a service-based model implies a paradigm shift in the Internet VC. While at some stages such change can emerge from the natural evolution of current business models, at some others it prompts for innovative architectural and commercial models. The most challenging issue in this context is the re-design of the relationships among end-users, operators, and SPs across access infrastructures. To this purpose, a suitable support can be provided by the so-called *neutral access network* (NAN) model [15].

NANs are a special category of open access networks [16] conceived to make the access infrastructures economically sustainable in market-failure regions by triggering

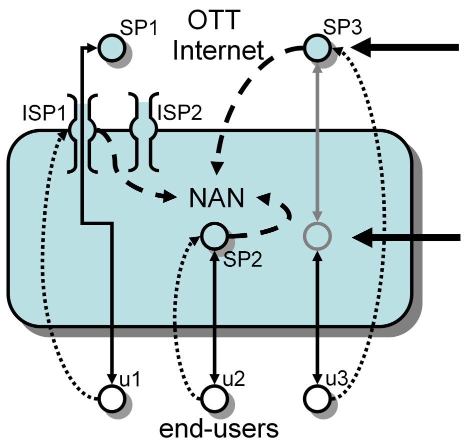

Figure 4. Interactions between end-users and SPs in a service-based neutral access network.

positive externalities and enhancing penetration [17]. A NAN exhibits the features of a full-fledged network by itself, containing a sizeable set of services made available to the users before they register with any ISP. End-users are allowed to associate with the NAN for free without prehemptive registration. Once the users have entered the NAN, they are exposed to all the services made available within the network, including Internet surfing through the gateways managed by ISPs. Registration and authentication are required only to gain access to the Internet or to those internal services which require user identification for accounting, personalization, privacy, or security needs. The entry of a new user into the NAN has a beneficial effect for all other users since it helps reaching the critical mass of users required to incentivize the provisioning of new services. Similarly, the entry of a new SP has a spillover benefit for all other providers since it induces new users to enter the shared marketplace and it contributes to cover the costs of the infrastructure. Service orientation is natural in a NAN. End users have commercial relationships only with SPs (including ISPs), who pay a share of their revenues to the NAN organization. The share is then possibly distributed among multiple stakeholders: real estate owners, investors, and local operators.

Figure 4 represents the possible relations that can be established in a NAN. Vertical solid arrows stay for IP traffic, dotted arrows stay for direct transactions between end-users and SPs, horizontal solid arrows stay for revenues coming from markets outside the VC (including sponsorhips and advertisment), while dashed arrows stay for commercial relationships between SPs and NAN operators. Three paradigmatic cases are depicted, referring to three end-users who are assumed to be connected for free to the NAN by means of their own CPE.

Case 1. End-user u1 wants to gain full access to the Internet. To this purpose, he/she registers with one of the virtual operators (namely, ISP1) offering Internet bandwidth in the NAN. The conditions at which Internet bandwidth is sold by ISP1 include the share he has to pay to the NAN operator for transporting u1's traffic across the NAN. Once on the Internet, u1 takes advantage of the service delivered by an OTT SP (namely, SP1) without taking care of transport. This case reproduces the same user experience of current access-based models, while retaining the benefits of service orientation. Commercial agreements between ISP1 and NAN operators can assume the form of a wholesale contract, but the key novelty is that u1 connected to the NAN before registering with ISP1 and was allowed to choose the ISP as a service.

Case 2. End-user u2 associates to the NAN without buying Internet bandwidth since it is only interested in a specific service (like tourist information, e-government, IPTV, ...) which is supplied by SP2 within the access network. The only relation he/she has to establish is with SP2, who is supposed to pay a fee to the NAN operator for web hosting and transport. Revenues for SP2 can come either from end-users (if they pay for the service), or from sponsors/subsidies (if the service is delivered for free), or from both (if a mixed model is adopted, such as the one of IPTVs providing both free channels and pay-per-view contents).

Case 3. End-user u3 behaves exactly as u2, even if the service he/she wants to use is provided by an OTT SP (namely, SP3). This is made possible by the agreement between SP3 and the NAN operator, signed to expose the online service of SP3 within the NAN. From a technical point of view, this could be done in many different ways, including mirroring, proximity caching, and white listing. The traffic generated across the NAN is then paid by SP3, while the service he/she provides makes the access infrastructure more attractive.

The trade-off between network neutrality, bandwidth optimization, and capitalization is reached thanks to the nature of the commercial relations established at all stages, which are not discriminatory, not exclusive, and inherently regulated by market law.

VI. Market signs

The urgent need for a paradigm shift in the Internet VC can be viewed in many recent events and market signs.

Amazon's *Kindle 2* has conquered the market of e-book readers by freeing end-users from the burden of connectivity. It integrates a hidden SIM card which allows end-users to be always connected (seemlessly) to the online store. The cost of download is included into the price of e-books thanks to an agreement between Amazon and AT&T, which in its turn has roaming agreements with mobile operators all around the world [18]. This is a neat example of a vertical application built on top of a vertically-separated architecture to provide a service-oriented user experience.

Groupon (www.groupon.com) is a deal-of-the-day website which operates in hundreds of localized markets worldwide. The business model is fairly simple: it offers a deal per market per day. If users who sign up for the offer reach a given threshold, then the deal becomes available to all of them and the retailer shares his/her revenues with Groupon. For retailers, Groupon works as an *assurance contract* which guarantees a critical mass which makes the deal like a *quantity discount* [19]. In 2010, Groupon Inc. refused a 6 billion Dollar offer from Google, clearly demonstrating the value of localized on-line business. It is apparent that Groupon could provide its services within a NAN, making it available to local end-users even if they have not signed with any ISP.

In January 2011, Google Inc. accepted to allow publishers to quit *Google News* without affecting the results returned by its main search engine, and to disclose revenue-sharing arrangements for its *AdSense* partners. This agreement ended an antitrust investigation of the *Italian Competition Authority* (AGCM) triggered by the *Italian Federation of Newspaper Publishers* (FIEG) because most people were content with aggregated summaries found on Google News and bothered to click on the links that led to their newspaper websites, costing the publishers advertising and page views. This story shows that services (e.g., online aggregators and search engines) are much closer to end-users than contents (e.g., news), so that it is much easier for SPs than for content right owners to be paid by end-users and sponsors. The agreement found in Italy also demonstrates that it is worth for both categories to find a suitable revenue sharing mechanism which reduces the imbalance and makes the business sustainable.

Google Inc. has provided free Wi-Fi access in Mountain View (CA) for several years and it has contributed to the development of many other municipal networks. In February 2011 the City Council approved a 5-year extension of the *Google WiFi* deal, with an escape clause for Google. There are two signs that can be found in this piece of news: the first one is that OTT SPs are interested in widening their market by lowering access barriers, the second one is that they do not want to take the place of network operators (the escape clause was wanted by Google).

In December 2010 some of the major European mobile operators, including Orange, Telecom Italia, Telefonica and the Vodafone Group, have demanded that popular OTT services, such as those from Google, Facebook, Skype and Apple, contribute to pay for the traffic they generate on their networks. This request, motivated by the lack of return for operators from the exponential growth of IP traffic, has raised network neutrality issues due to the unsuitability of the business models adopted, which do not allow operators to establish commercial relationships with SPs without impairing the neutrality of the connection they provide.

In 2010 the European Commission launched a public consultation on ”The open Internet and net neutrality in Europe” and received answers from 318 stakeholders [20], demonstrating the need for a thorough conciliation of the different interests involved in order to guarantee the development and the openness of the Internet. Similar consultations were launched in 2011 in many European countries. The pragmatic positions expressed by the European Parliament and by the national authorities based on the results of the public consultations clearly show the intent of policy makers to create the conditions for a fair competition in the Internet market with minimum interference from regulators [3], [4], [21].

In the second quarter of 2011 KPN, the incumbent operator in the Netherlands, decided to apply a surcharge on competing Internet-based services (including voice and instant messaging) to compensate the reduced earnings registered in the first quarter. In June 2011 the Dutch parliament approved the world’s strongest net neutrality bill, banning operators from hindering or delaying OTT services and from applying surcharges. At the end of July 2011, KPN announced much higher data tariffs in response to the net neutrality act [22], demonstrating that regulatory intervention, if dispropotionate or precipitate, can turn out to be counter-productive. In October 2011, the digital agenda European commissioner Kroes attacked the unilateral decision of the Dutch Parliament, recommending more careful and coordinated interventions [23].

VII. Conclusions

In spite of the exponential growth of Internet traffic, the unequal distribution of revenues along the Internet VC, together with the imbalance between costs and revenues caused by the business models currently adopted by network operators, risk to impair evolution towards broadband next generation networks.

The Internet supply chain is like a pipeline the capacity of which is limited by the thinnest pipe, so that a fair distribution of revenues along the VC is essential to trigger and sustain network development. This has been shown in Sections II and III with simple mathematical arguments that demonstrate that fairness is the key for keeping pace with the exponential growth of Internet traffic.

The Internet VC has been analysed in Section IV in order to point out the limitations of current access-based models and to propose a paradigm shift towards a new service-based approach. Service orientation, complemented by suitable business models, allows all stages of the VC to take advantage of the attractiveness and diversity of online services and to benefit from the revenues they can generate in terms of sponsorships and advertisement.

Furthermore, it has been shown in Section V that neutral access networks provide a suitable support to the adoption of a service-based model, allowing end-users to connect for free to the access infrastructure and then focus only on the services they need, including Internet bandwidth. The systematic application of not exclusive agreements among the actors involved (service providers, content providers, and network operators) provides the basis for a fair redistribution of revenues along the VC, driven by market law rather than by policy enforcement.

Finally, market signs have been analysed in Section VI to give evidence of the urgency of the paradigm shift envisioned in this paper.

In conclusions, service orientation has been proposed in this paper as the key for granting to the Internet the degrees of freedom required to autonomously find the best balance among the segments in the VC, thus overcoming the bottlenecks and creating the preconditions for development.

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