

A Discussion of Socio-economic Management and Incentives for the Future Internet

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Abstract— This paper outlines the outcome of a socio-economics (SE) and incentives work group during the “Management of the Future Internet” seminar, held in Dagstuhl, Germany. This covers an indication of key questions and issues, which are classified as important for next steps in network management. Furthermore, the process of dealing with aspects of “Socio-economic Management” is discussed, which determines a hybrid and innovative approach besides traditional network management approaches. This determines a network management in which control is delegated via socio-economic means and to a certain extent to the user and provider with the goal to maximize the overall social welfare and the networks technical efficiency at the same time. This is refined by a set of SE-driven management mechanisms, the discussion of a practical user/network interface proposal, and an example case for managing overlay traffic in such a network management system. Finally, based on a set of ideal SE requirements derived from the analysis of existing approaches, a set of preliminary conclusions is drawn.

Index Terms— Socio-economics, incentives, Future Internet, overlay traffic, network management, charging, requirements, P2P, and QoE.

I. INTRODUCTION

THIS The area of socio-economics (SE) and incentives is being considered today as an important field of interest for network management [5]. This is mainly driven by the fact that traditional approaches of network management have addressed two – probably extreme – sides of the alternative choices: (a) traditional network management [11], driven by a dedicated central manager, and (b) autonomic management [7], in which the technology manages itself. Specifically, the integration of the user, the provider of network services (typically referred to as an operator), and the provider of applications as well as value-added services into the management process seemed to be very much focused onto the operator. Note that the user is defined as the entity, who consumes a service, irrespectively of whether this entity is in a contractual relation with the service or application provider. However, the customer is defined as the entity, which is in a contractual relation with service or application providers. Thus, the customer may not be the same

entity as the user, but he is that entity, which pays for the service consumed. Therefore, the user – either in a residential location or considered as an enterprise – and his/her requirements as well as needs in communications and their management shall be able to receive the permission as well as the technological potential to state or express communication preferences – say in a Quality-of-Experience (QoE) sense or in terms of a Willingness-to-pay – for his/her commercial communication’s field. This aspect is typically referred to as a SE management with incentives, which affects the way users are behaving, the path operators are going in offering services, and those mechanisms used to manage the network and its service provisioning.

In that respect, the major ingredients in understanding the SE of network management, a number of issues and concerns have been raised in the dedicated Dagstuhl Seminar on “Management of the Future Internet”, which do need a clear reply to, to be able to develop a suitable and practically applicable SE management system for the Internet of the future. While those aspects may not be complete at this early stage of the discussion and they may not be fully integrated in a contradiction-free model today, their importance – considered as a separate ingredient and highly relevant factor – in a future SE network management approach is undisputed.

Therefore, the following list of aspects has to be considered for the development of the SE-based network management. Note that these aspects cover to a certain degree a list of requirements to be addressed, which develop into problems not having been solved as of today:

- Sustainability: considering the higher level management aspects of services as well as the communications provided to residential and enterprise users, the business model(s) of operators, value-added service providers, and application providers form the clear mid- and long-term guideline for each of them in a competitive world.
- Charging: the process of charging is considered as an overall term for including the metering, accounting, pricing, and charge calculation into the SE management mechanism for a commercial service. Traditional telecommunications services

do see the term “rating” for these steps to be undertaken within an integrated network management approach.

- **Incentives:** furthermore, incentives determine the key feedback information passed between a service provider and its user(s). These incentives may be of monetary value (typically measured in a currency, such as €, \$, or CHF) or they follow the non-monetary path (such as tokens, quality, or resolution). All in all, the application of these incentives – defined for a service, its offerings, and its deployment – result in smaller costs for the provider to be spent or a higher benefit, in terms of margins exploitable for the service under discussion. At the same time, however, the user will see a better quality/cost ratio of the services he/she is using.

- **Requirements:** especially for the user-specific needs of abstracting away her/his knowledge about communication service qualities in technical terms, it becomes even more important to see that the experience of such a service being utilized needs to be quantified. Therefore, besides the definition of Quality-of-Experience (QoE) [8] – mainly needed for services beyond voice – it becomes crucial to define, in which way QoE can be monitored in a given system, for various applications, and in the most reasonable as well as comparable manner. In particular, in case of non-specified service deliveries, the network needs to react before the user does. This does mean, of course, that the loss of customers within operator’s domains shall be prevented by giving the operator as well as the user the chance to learn about quality deteriorations as well as problems coming up beforehand, or at least as soon as this situation has been detected.

- **Monitoring:** in case of a sensitive network management approach, it is essential to target at the following principle: “You want to see the network react before the user does”. This principle does determine that any change of network conditions shall be detected as well as handled within the network’s mechanisms before the user will be able to recognize it. This includes a “hidden” reaction on the technological level, while the interfaces and user-driven monitoring aspects will be left unchanged and untouched.

- **Autonomy:** this principle just explained leads to the more generic time scale-based distinction of socio-economic management trends. While autonomic decisions on changes of the state or a network access may happen, they need to be applicable in short-term, and they may need to address very short or micro loops between the measurement point and the location of change.

- **Intervention:** human interventions may not be appropriate in such a system, which reacts and acts upon short time-scales. However, human interventions are necessary and needed, especially in the medium- or long-term aspects of networks and communications. While the medium-term planning of services and resources will be driven by business models and their targets, longer-term plans may include full network technology migrations, bandwidth updates on certain links, or even access control for new or misbehaving users. Thus, only human ideas, typically operated in an informal manner, will

have to be covered.

This discussion paper is organized as follows. While Section II does outline the concept of a socio-economic management, Section III does address a selected set of socio-economic management mechanisms. Furthermore, Section IV derives incentive requirements. Finally, Section V summarizes and draws key conclusions.

II. THE CONCEPT OF SOCIO-ECONOMIC MANAGEMENT

If an SE network management approach shall enable the future Internet to cope with all of those – or at least some important of those – aspects discussed above, the management of the process of management itself has to be considered. While in a traditional approach of network management this is based on technical metering and monitoring approaches, typically backed by a suitable accounting infrastructure, a modern and socio economically-driven management approach needs to cover incentives and – at the same time – business models to achieve a feasible, in existing systems implementable, robust, predictable, secure, and trusted management loop.

Thus, the process of SE-driven management has to be developed from purely technical requirements into the field of clear reasons for users to utilize a service or to offer a service within a certain domain. And this process cannot be simply adopted from traditional models of management, since they are stressing too much an operator’s point of view. Or, they focus too intensely onto technical parameter optimizations as such. This determines management approaches, which are extended by a type of SE-“hybrid” dimension and which cover the technical views as well as the service utilization aspects through the user.

Traditional management approaches are more dictated by a manager, who sits in a centralized and quite powerful position. While in short-term cases, such managers are software-based decision points, which operate based on policies or pre-defined behaviors, these managers are embedded into a quite strong hierarchy of additional managers. In full, they form the managerial system, which differs in size and capabilities depending on the application scenario.

More modern management approaches include the autonomic management approach, which is fully integrated into technology – the technology manages itself. Still, the group of devices, the network itself, and all other participating players are managed by the same principle of decentralized managers, which only see a limited range of information sources, but in which case those managers operate in a much more independent manner from each other.

The newest form of management can be termed SE management, which enables all stakeholders participating (user, different types of providers – cf. Figure 1) to decide upon preferences by money or behavior. This form of a SE-based approach combines the shorter-termed management decisions, which are clearly essential to decide on financial incentives, typically granted by charging approaches for a service usage, with the longer-termed human behavioral

decisions, which indicate the business “intelligence” to be integrated. Such a combination of short- and long-term decision loops, which basically determines the integration of automated, software-based managers with human decisions, can lead to a new path of management principles, which always need to balance or even optimize between targets of the technical systems and user needs. Thus, the process of SE-based management will show a number of interesting conflicting issues to be tackled on a purely technical basis as well as a complementing set of aspects, which will encourage providers and users to follow similar models of use and offer.

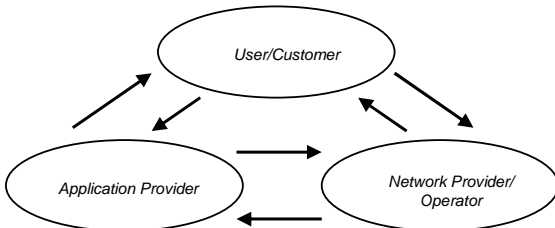


Figure 1: Interrelationships between Stakeholders

A further study needs to investigate in more depth, which differing, unwanted, unforeseen, or unaligned effects may originate from various types of incentives. E.g., consider a company – determining the customer –, which contracts a service for use by the company’s employees – determining the users. In this case there will be a good chance to see incentives very relevant to the customer, which are no relevant or visible to the actual user. Thus, these SE effects are important for a SE management principle applied.

III. SOCIO-ECONOMIC MANAGEMENT MECHANISMS

The key observation on SE-driven management mechanisms is that there exists at least a certain level of cooperation between the network management plane and the data transport plane. This has been investigated in early Quality-of-Service (QoS) models already [2], which introduced a QoS management plane, which controlled a number of per-se independent transport and network layer protocols under a common goal, namely, the provisioning of such QoS metrics negotiated or set beforehand. Thus, it is technology-wise feasible and it already showed a suitable number of effects to be intended.

However, for SE-driven management mechanisms the cooperation – mainly based on open Application Programming Interfaces – between those stakeholders named above becomes essential. While the user remains the initiator of a communication or a service usage, the network operator delivers the connecting platform for such a use. And the application provider runs the detailed service requirements, the user initially needed and the operator is able to deliver (cf. Figure [above]). The key effect of such a cooperation can be described as follows: updates of traditional network management mechanisms are necessary, including updated and enhanced architectural components are required, such as

metering based on user-demands, accounting for user or services – independent of the user’s location, resource allocation updates based on metered data, cooperative protocols integrating user and technical parameters, most likely a support of virtualization approaches for networks and services, and last but not least adapted billing interfaces, which can deal with incentives, its re-calculation into financial values, and a multitude of service characteristics to be charged for on a per-user basis.

In case of such an SE-driven management mechanism to be integrated into a management platform tomorrow, a number of smaller changes of network services are expected. This includes further abstracting of almost all technical networking aspects, since the user needs “sexy” services as such only. Any technology-dependent management pattern is hidden behind the usage scenarios of these services. Furthermore, though debatable, the time for flat fees of service usage will come to an end. While a group of theorists analyze that flat fees are still the most simplest form of charging for service usage, and any additional effort is not beneficial, another group argues that service differentiation by cooperation will become most effective in the future, since a resource-based charging – most likely in a much coarser-grained approach than just accounting for bits and bytes – will stimulate and benefit the set of business models for application providers. The pure network access and Internet connectivity service may remain on flat fees, which may, however, differ based on technology, bandwidth, and services offered on the access link. Additionally, congestion-based charging is available as one option – again at least theoretically – and its application in road pricing scenarios shows its effectiveness. The change of charging approaches themselves changes applications as well as users, either in their technical interfaces (e.g., for expressing preferences) or in usage behavior. These effects determine monetary incentives, which a SE-driven management has to consider.

Nevertheless, non-monetary incentives have to be considered as well for an SE-driven management approach, since peer-to-peer (P2P) networks and applications demonstrate that users change their behavior – in terms of offering or utilizing resources, such as files, movies, or data – in accordance to the results achieved and subjectively rated. Thus, a pure technology-driven analysis as well as operation of such a network will lead again to the more centralized and traditional management approach.

Finally, the implementation of SE-driven management mechanisms has to be discussed as well. In many cases, policies and their enforcement will provide for that functionality, what is required for an implementable solution. Of course, the principle concerns on policies (such as conflict and resolution handling or over-specification and inherent contradictions) will remain in that case. However, the careful design and development of added control loops, governed by compatible incentives, should provide for an effective design and implementation of SE-driven management mechanisms.

Optimizations in the short-term can be achieved, by applying artificial intelligence mechanisms, optimization methodologies for competing service usages, and cross-layer issues, where each of these can be addressed by algorithms in an engineering type of solution. Thus, an effective handling will be attained. For the mid- and long-term optimizations, still humans and their business models in a given context will form the right limits of SE-driven management mechanisms.

A. *Choices of Socio-economic Management Mechanisms*

While the discussion on SE-driven management mechanisms on a slightly higher layer of functionality, effects, counter-effects, and human-machine interventions revealed feasible goals, the clear choice of an SE-driven management mechanism may not be so obvious. This is true to a certain extent, since always the human and his/her specific optimization goal may be subjective. This can be seen by investigating speech and voice quality in wired and wireless networks, where subjective rating schemes have been developed to quantify such behavioral ratings.

Thus, two choices of SE-driven management mechanisms from the human's perspective have been determined: The slider (a) "Price vs. Performance" and the slider (b) "Flexibility vs. Performance". Slider (a) allows the user to signal a preference of either price optimization, so the best possible price for those service requirements posed shall be achieved, or a preference of performance optimization, so that the best possible service for any price shall be obtained. Obviously, this is a subjective selection as well as preference decision, which will differ from person to person, situation to situation, and technology to technology. But in any of these selections of the user, the operator as well as the application provider will see differences in his service usage or offering. Thus, if such preferences can be modeled and determined beforehand, management decisions of providers and applications can be modeled as well, and effects on traffic within the network, traffic on certain links, the load at access points, and services usage can be studied. The same set of arguments and derivations hold for the slider (b) case, where based on the assumptions of a price fixed and its application-dependency, on one hand the preference of the behavior will lead to the best possible performance with a conformant (in the sense of provider's suggestions) user. On the other hand, the optimization of performance will lead to the best possible of such with the "loss" of flexibility (e.g., due to different resolutions of a video stream than requested, but still the "same" content – only in different, technically distinguishable quality levels – can be viewed.

B. *Socio-economic Effects of Overlay Traffic*

One important category of traffic to be considered under the SE umbrella is traffic of overlay networks, including mainly P2P traffic. Due to its growth in importance (measured in bits per second or percentages of an operator's network overall traffic) [3] as well as due to its very close user-based emergence and user-driven preference selection, user-related

SE effects of related traffic and on this type of traffic are interesting to study.

The key effects of such "new" overlay traffic in a provider's network include the fact that independently of the real, physical path selected, the end-to-end (E2E) view of such traffic is crucial for all overlay applications. By definition, these peers want to exchange and interchange data, thus, an underlying infrastructure is considered necessary, but not sufficient. Therefore, the problem of large zig-zag routing effects in a real topology, which may grow worse in case of multi-domain scenarios (determining the most realistic case, though), the traffic flow between peers, between operators, and for overlay applications will not – by far – follow an optimal route. Of course, this is due to the design principle of overlay applications and networks, which have minimal concern, if at all, about the underlay. In case the user's choice could be taken into account at this stage and at the same time the overlay would interact with the underlay, many optimizations are possible.

Although many providers shape P2P traffic today, to avoid overloading and affecting commercial traffic (typically done by port filters, which act partially very slow on changing ports on overlay applications as well as deep packet inspection), it is believed that such P2P traffic alone - independent of the concrete value of traffic - does not put an operator out of business. Such volumes of traffic should be considered from the operator's point of view as a source of additional traffic, which can be charged for, exactly when the right incentives for users, providers, and application providers will be in place. Of course, it is acknowledged that there is a larger pain of operation and traffic smoothing necessary within a provider's network, but this problem is mainly due to the traditional traffic management mechanisms in place and the more central network management models in operation.

The "standard" way of assuming that there is a need to over-provision ("throwing" bandwidth on a link, on highly loaded links, or within multiple sub-networks of a domain) is valid, if the volumes of traffic are considered only. However, the effect on other traffic on that link will be as negative as before, since the lack of QoS provisioned on a link with 99% load will be always visible, independent of a 100 Mbit/s link or a 10 Gbit/s one. Thus, over-provisioning does not solve the principle dilemma of traffic management for overlay traffic. But, clearly negative in a first place will be the increased cost for links, networks, and routers the operator is facing, as soon as the enhancements have been financed. In turn, changing and typically reduced margins of the traffic transported will be seen. Furthermore, the differentiation of legitimate or illegal content arises in the context of P2P traffic. However, this is not taken as a reasonable argument under traffic management considerations, since independent of the legitimate or illegal label, P2P traffic will be in the network, and it has to be managed. Of course, this statement does not support illegal file sharing applications at all and it does not settle the copyright infringement problem, but it covers the fact that such traffic

may disrupt services in an operator's domain, thus, countermeasures against such disruptions are essential.

In any of these cases above, two aspects have not been selectively addressed. Those include (a) network neutrality [9] and (b) Economic Traffic Management (ETM) approaches [6]. While the network neutrality needs a clear definition at first, its implementation has to follow at second. "Network neutrality (equivalently net neutrality, Internet neutrality) is a principle proposed for residential broadband networks and potentially for all networks. A neutral broadband network is one that is free of restrictions on content, sites, or platforms, on the kinds of equipment that may be attached, and on the modes of communication allowed, as well as one where communication is not unreasonably degraded by other communication streams" [9]. An important effect on network neutrality can be observed differently in Europe and the U.S. While the American view has seen in recent years a duopoly in the access market, mainly between cable-based and Digital Subscriber Line (DSL) access networks, the European approach favored an open access network in a regulated access market. Additionally, the reselling aspects in a reseller market have to be considered in an integrated manner. Therefore, these two very different situations will show a variety of different effects on overlay traffic within these access networks as well as on end-user behaviors and their choices of service.

Furthermore, ETM approaches [6] reflect a new way for dealing with incentive issues being integrated into traditional network management approaches. This type of mechanisms investigates incentive relationships between network operators, overlay network providers, and end-users under the joint goal to address an efficient, viable, and technological TripleWin situation (all three stakeholders will be better off participating in a joint traffic handling), which will be beneficial. The underlying cooperative model of these interacting stakeholders, the determination of benefits, and a discussion of drawbacks are under way, e.g., within the EU-funded SmoothIT project [10] or within Working Group 4 of the COST Action Econ@Tel (IS0605) [4].

IV. SOCIO-ECONOMIC INCENTIVE REQUIREMENTS

For all network technologies and related management frameworks in place today there is the need to carry, in an integrated manner, different data sets and streams, such as voice, data, and video. Although the services-integrated data network has seen a decrease of its importance over the years, mainly driven by the fact that very diverse application requirements may not be supported that easily in a pure packet-based networking approach, the combination of as many as possible data streams, in a packetized form, is still the main objective for the Internet and its protocol stack. Once this is assumed and additionally it is assumed that a provider competition is in place and operation, regulation as an add-on is suggested in case of market failures. Either a strongly monopolized situation or a market-based, but regulated situation of network service offers and overlay offers exists –

as mentioned, typical real-world cases are seen in the North American continent and Europe, respectively. Thus, the following case suggests a set of requirements, which have been derived from a generic application example, say a streaming peer-to-peer application.

Thus, with the focus on the European case "the" suitable incentive scheme in support of an ideal network management approach possible with future Economic Traffic Management models should address the following key requirements. Those requirements apply to the user, the operator, and the overlay provider:

- (a) Incentive-compatibility
- (b) Network neutrality
- (c) User-friendliness
- (d) Fair use
- (e) No malicious exploitation of other stakeholder(s)

While the incentive compatibility in terms of its economic definition (if all participants are better off, when they truthfully reveal relevant private information asked for by the traffic management approach) needs to hold by definition, its implementation in the respective technical protocol in use has to be achieved in an efficient – technology view – manner. Furthermore, the network neutrality aspect has to be covered as well, of course, by addressing the North American as well as the European, and then the global, perspective at the same time. In terms of the end-user, a user-friendly application and utilization of such incentive mechanisms is essential to ensure that an easy-to-use system interface will be beneficial for a fast deployment and acceptable to the majority of users. Of course, if users prefer not applying these methods, they shall be free to do so, however, costs incurring within the network operators as well as overlay providers domain may be required to be covered from this user. This includes the clear definition of a "fair use", which requires beyond TCP (Transmission Control Protocol) and better than UDP (User Datagram Protocol)-type of fairness notions. Much further work is required to determine these fairness aspects and its application in the overlay traffic management case. The discussion of these four requirements does lead to the important question of a malicious exploitation potential for any of those three stakeholders. Thus, a proof of such non-exploitation in case of malicious players is essential to be developed.

Therefore, this ideal set of requirements for an SE-based incentive mechanism outlines a wider range of, sometimes and at least by today, contradictory points of views. Those ones can be addressed to be investigated in favor of such an efficient management solution to come for future operators and users.

V. SUMMARY AND CONCLUSIONS

Based on those observations made, it can be stated that social, economic, and business forces must be acknowledged while improving the operation of networks and their management. While traditional network management

approaches tend to focus on the set of technical parameters of traffic, either from residential users in an aggregate manner and from business users in separate Service Level Agreements (SLA), advanced approaches take the specifics of the user into a closer consideration. The most modern approaches start to consider more specifically the overlay traffic, which is assumed to grow beyond those 40-60% of today's overall traffic [3], and overlay network providers themselves. This is not limited to technical parameters only, but it includes, in an economically-driven manner, incentives for the network operator, the overlay provider, and the end-user.

The basic assumption in this type of scenario is given by the fact that the "no competition/single operator worlds" have no clear future, at least in European perspectives, and the centralized, dedicated manager management model start to become less competitive in terms of traffic management and its optimization. The competition between network operators as well as overlay providers enables the best possible inclusion of the user into the overall management process, which typically happens in terms of behavior, flexibility, and detailed user requirements. This approaches show, additionally, very strong links to the areas of Quality-of-Experience (QoE) and its management, which has to be approached in a more holistic manner within traffic and network management. The benefits for users and services, including the best practices available for service management need to be investigated and will, most likely, show a benefit for the network operation. Of course, these benefits do come at certain costs, which can be found in the network technology required for respective protocols in support of incentive transfers, metering data handling, and traffic characterizations.

These technical aspects have started to be of interest of the IETF (Internet Engineering Task Force), which has recently founded working groups in such areas. Those groups include the Application-Layer Traffic Optimization (ALTO) work group [1] and the Techniques for Advanced Networking Applications (TANA) BoF [12] in the Applications and Transport Area, respectively. The need for a standardization of the technical solution, with a clear emphasis on an application-independent approach being preferred, becomes obvious again, once network providers, overlay providers, and end-users will all receive determined benefits and advantages in terms of their service offerings and utilization.

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