# Designing Future Networks: The Investigation of Socio-economic Awareness by the Tussle Analysis

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***Abstract*—The Internet enables the interaction of stakeholders of virtually all commercial, industrial, and private sectors. Thereby, innumerable conflicting socio-economic interests collide through the Internet. Since self-interested stakeholders will try enforcing their interests through technological, economical, or judicial means, the Internet technology and related standards must not only be focused on technical engineering goals, but also need to ensure a fair playing field for all stakeholders. This necessity to consider socio-economic factors, when designing technology and standards, is slowly recognized by academia and standardization bodies and highlighted in this paper. The Tussle Analysis is presented as the first tool for assessing such a socio-economic awareness of Internet technology and related standards. The Tussle Analysis was standardized in Study Group (SG) 13 of the ITU-T and published as Recommendation Y.3013 in 2014. Thus, methods to implement the Tussle Analysis' three steps are presented and discussed throughout the paper..**

***Keywords—Socio-economics, Future Networks, Tussle Analysis, Regulation, Standardization***

## I. INTRODUCTION

The Internet connects the planet. Due to ever-growing capabilities and speed of end- as well as intermediate devices, ways to interact and rates to exchange information with, which were not thought possible a decade ago, are enabled and still exponentially growing. Because the Internet enables the interaction of countless stakeholders of virtually all commercial, industrial, and private sectors, it is carrier for innumerable conflicting interests. Due to the constantly growing technological diversity of connected devices and the Internet's market penetration, these conflicts are settled by technological, economical, or judicial means that can hardly be foreseen during technology design time. Therefore, these colliding socio-economic interests make the Internet a rather unpredictable system. This dilemma was pointed out first by [2], which termed these conflicts *tussle,* the notion also adopted in this paper. Accordingly, [2] postulated the "Design for Tussle" of Internet technology, to preclude these conflicts or at least mitigate their effects for the Internet ecosystem. Subsequently, ITU-T Recommendation Y.3001 [10] (to which the authors of this paper have contributed to) presented "social and economic awareness" as one out of four objectives for Future Network (FN) technology. In the framework of this objective, Recommendation Y.3001 identifies the design goal of economic incentives for FNs. This design goal postulates that FNs are to be designed to provide a sustainable competition environment for solving tussles among the range of participants in the Information and Communication Technology (ICT) and telecommunication ecosystem. In the light of this objective of social and economic awareness and the related design goal of economic incentives, the newly developed ITU-T Recommendation Y.3013 (which was edited by the authors of this paper) suggests complementing the technically-driven FN design and standardization by a clear socio-economic assessment of FN technology [11]. To this end, the Tussle analysis is proposed as a meta-method to assess, if a technology or a standard for FNs is designed in a socio-economic aware and incentive-compatible manner. This method was standardized in SG 13 in ITU-T and released as Recommendation Y.3013 in 2014 [11].

The need to investigate socio-economic factors in the design of FN technology is greatly overlooked in research and, except for the new work of Y.3013 [11], not addressed in standardization (be it standards on how to address socio-economic factors or the consideration of socio-economic factors in standards). Therefore, this paper introduces the content of Y.3013 [11] in order to spark awareness and discussion of this highly important topic. Furthermore, cross-disciplinary research areas that investigate methods for socio-economic analysis of FNs are pointed out.

## II. TUSSLE ANALYSIS

The Tussle Analysis was developed in the framework of efforts to design the Future Internet [13] and is considered to be a meta-method. That is, the Tussle Analysis describes steps to be implemented by specific methods, to assess and improve a FN technology's or standard's compatibility with socio-economic interest conflicts, *i.e.*, tussles. Thus, the Tussle Analysis defines a systematic socio-economic assessment to be performed during technology and standard design in order to anticipate and increase the extent to which this technology or standard is "designed for tussle" [2]. The Tussle Analysis is illustrated briefly in Figure 1 and constituted mainly by the following three steps. Methods to implement the three steps are given and discussed in Sections II.A, IV.B, and IV.C, respectively.

1. Identification of all stakeholders, who are actively or passively affected by the technology.
2. Identification of all stakeholders' interests, conflicts between these interests (tussles), and all means available to the stakeholders to enforce their interests.

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3. For each tussle:
   a. Assessment of the impact to each stakeholder (short-term, mid-term, or long-term, depending on the context).
   b. Identification of ways for stakeholders to circumvent negative impacts (or gain unwarranted advantages), and consequences for the ecosystem, *e.g.*, effects on other stakeholders. These may also include stakeholders, who have hitherto not been affected, *i.e.*, who are not in the set of stakeholders compiled in step 1.
   c. Iterative application of the Tussle Analysis for each such manipulation technique, identified in step b.

In the ideal scenario the tussle outcome (constellation anticipated in step 3) is an equilibrium point, where the following two conditions hold:

1. All stakeholders identified in step 1 derive a payoff that is considered fair and have no means to increase their payoff, wherefore they will not take means to change the outcome, *i.e.*, step 3.c does not need to be applied and, thus, the tussle will not evolve further.
2. No stakeholder of another technology, who was receiving a fair payoff before, gets an unfair payoff after this tussle equilibrium has been reached, *i.e.*, step 3.c does not need to be applied.

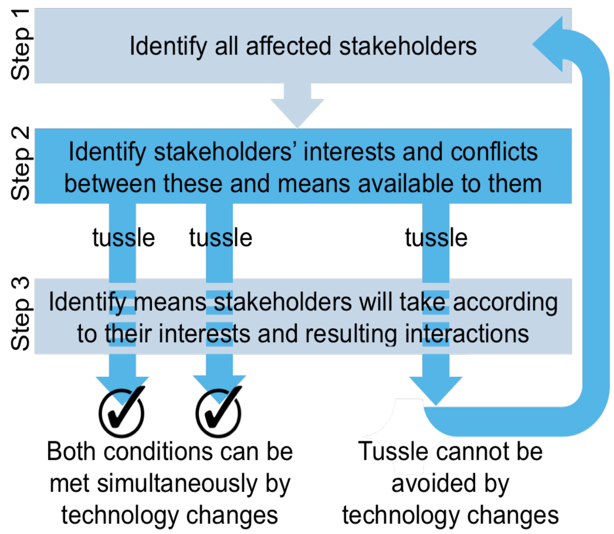


**Figure 1: Illustration of the Tussle Analysis [11].**

If both conditions hold, the analysis of this particular tussle is completed and the focus should be shifted to remaining tussles that were identified in step 2. In case at least one of the conditions is not met, it has to be investigated, how technology specification, implementation, or standardization details can be changed, such that both conditions are met. If no such changes are possible, a new iteration of the methodology must be performed (step 3.c) by making assumptions on the most probable policies adopted by unhappy stakeholders, *i.e.*, it has to be investigated, how the tussle will evolve. Since this subsequent iteration will again reach step 3, it will be investigated repeatedly, whether the evolved tussle can be stabilized by specification, implementation, or standardization changes. Theoretically, this allows for stabilizing a tussle after it evolved multiple times. However, due to imponderability and disturbance of the ecosystem, it is always desirable to stabilize a tussle as early as possible. Ideally, a new technology should immediately lead to a stable outcome. That is, both conditions are met without any tussle evolution, where a tussle evolution is defined as the iterative interaction of stakeholders through technological, economical, or judicial means to influence a tussle outcome in their favor.

### *A. Stakeholder Identification Methods*

In order to implement the Tussle Analysis, a step-wise approach is applied. For the step 1, which is described in this section, one or more of the following three methods may be chosen as they achieve a high level of completeness and relevance with respect to a stakeholder's identification:

*Personal observation* [15] can be applied by any person familiar with the characteristics of the technology or standard, which is to be analyzed. More precisely, an a priori complete set of stakeholders based on own experience and knowledge or literature studies may be compiled.

*Interviews* [12] allow inquiring personal observations from experts that are more familiar with the technology or standard than the person or team actually conducting the Tussle Analysis.

*Role-playing simulations* (partly recommended) [15] may, for example, be constituted by the Delphi method [18] or focus groups [18]. Because several experts have to be in the same room, this method is not always applicable or practical.

*Discussion*: It is crucial to achieve a high level of completeness, since all further steps of the Tussle Analysis depend on the range of those stakeholders identified. If a stakeholder is missing, potential tussles involving that stakeholder cannot be captured in the analysis (step 2 and 3), rendering the analysis as a whole incomplete, and/or leading to incorrect analysis results, *e.g.*, a stable outcome might falsely be anticipated in step 3. Therefore, the methods to implement the first step of the Tussle Analysis have to be chosen with the overall goal of ensuring the highest possible degree of completeness. The best suited method may vary on the technology or standard to be analyzed. Personal observations [15] and interview-based methods [12] are especially beneficial, when applied in combination. In particular, an a priori stakeholder list can be determined by personal observations, which in turn serves as the basis for identifying suitable interview partners. Through these interviews the stakeholder involvement can be validated and other relevant stakeholders can be identified, who were not covered in the a priori stakeholder list. Role-playing simulation methods may also have to be preceded by personal observations to arrive at roles to be assigned. Although role-playing simulation methods are more laborious then other methods proposed, they do show benefits as long as participants are selected representatively. For example, role-plays can be extended to implement step 2 and 3 of the Tussle Analysis. In any case, the stakeholder collection provided in Figure 2 shall be used to verify and extend the list that was compiled with any of these methods.

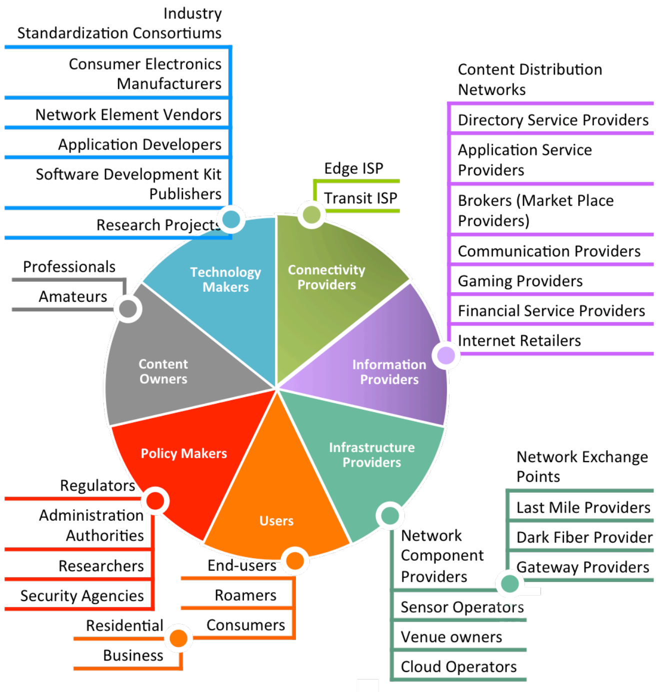


**Figure 2: Stakeholders of the Internet Ecosystem [12].**

### *B. Tussle Identification Methods*

For an embracing tussle analysis it is crucial to characterize in full stakeholders with respect to their interests and the range of means they have available. This is not always easy to obtain, because this information might be considered business-confidential or there might be a hidden agenda. However, in order to implement step 2 of the Tussle Analysis, the following methods are suitable as they achieve a high level of completeness with respect to stakeholders' interests, conflicts, and means available:

The *MACTOR* (Matrix of Alliances and Conflicts: Tactics, Objectives and Recommendations) method [8], [9] gives an overview of possible alliances and conflicts in a business ecosystem. When applied in step 2 of the Tussle Analysis, the goal is to document candidate tactics (strategies) that can lead to other outcomes and evaluate the attractiveness of each outcome to stakeholders.

The *SWOT* (Strengths, Weaknesses, Opportunities, Threats) analysis (partly recommended) [20] is a framework for understanding strengths, weaknesses, opportunities, and threats faced by a stakeholder and thereby concluding on strategies reasonable for him. The SWOT analysis allows evaluating the attractiveness of potential outcomes to stakeholders, but rarely studies interactions (reactions and spillovers), which will be relevant for step 3 of the Tussle Analysis.

*Risk management* [4] is a method for identifying candidate factors that can have a negative effect on a system and for quantitatively or qualitatively evaluating those effects in order to take precautions. Therefore, this method, when applied in step 2 of the Tussle Analysis, is particularly suited to evaluate how reasonable it is for a stakeholder to take certain means to minimize risks. Also, this method can be deployed to anticipate the expected payoff for a stakeholder, when taking certain means.

Beyond those methods also role-playing simulation [15], personal observation [15], and interviews (partly recommended) [12] can be applied in step 2 of the Tussle Analysis.

*Discussion*: If participants were selected carefully, role-playing simulations, such as the before mentioned Delphi method [18] or focus groups [16], are the best-suited methods, because they endorse a group-based approach rather than an individual approach. Bringing several motivated and knowledgeable experts into a group, each expert adopting a dedicated stakeholder role, increases the likelihood of relevant tussles being identified (see [15] for detailed information on how to guide these role-playing simulations). This is supported mainly by the confrontational, debate-oriented, and direct (but moderated) interaction among participants in, *e.g.*, a focus group. If effects of group dynamics should be avoided, the Delphi method may be chosen over the discussion-oriented focus group method. Individual approaches, such as personal observations [15], risk management [4], and the MACTOR method [8], [9], determine recommended methods as well, especially when personal observations are combined with risk management or with the MACTOR method. Even though not based on thoughts, ideas, and opinions of several experts, a risk management's focus on identifying candidate factors with a negative and quantitatively or qualitatively evaluated effect on a system is highly beneficial in identifying tussles. Equally, the MACTOR method is suited for the identification of tussles due to its focus on giving an overview of possible alliances and conflicts in a business ecosystem. The SWOT analysis [20] might be selected as an alternative instrument to the MACTOR method, and interviews might determine a valid instrument to complement personal observations, especially with respect to the validation of tussles identified in interviews with stakeholders.

### *C. Tussle Impact and Manipulation Methods*

Step 3 is the most complicated step of the Tussle Analysis, as here not lists of objects (stakeholders, interests, or tussles) have to be compiled, but complex interactions need to be anticipated. Furthermore, stakeholders may try to use technology in ways not expected by their competitors, wherefore these unexpected ways are also hard to anticipate when applying the Tussle Analysis. Since step 3 is the most complex step of the Tussle Analysis, the more formal a method (reproducible results), the more risk-oriented a method (dealing with aspects, uncertainty, and probability), and the more dynamics-oriented a method (complex system modeling covering feedback cycles), the better it is suited. Thus, the following methods are suitable to implement this step:

*System dynamics* [6] is able to simulate complex and dynamic systems. When applied in step 3 of the Tussle Analysis, it can, therefore, be deployed to simulate how stakeholders interact over a longer period of time. Stakeholders as well as their interactions are identified in step 1 and step 2 of the Tussle Analysis and are encoded into system variables and statistically driven events, respectively. The main focus is the assessment of outcomes and their evolution over time.

*Game theory* [1] is suited best, when a single interaction of stakeholders has to be assessed, *i.e.*, which actions stakeholders will chose initially not considering subsequent actions. Even though multi-round games are technically possible, game theory is less suited for the investigation of such evolutionary aspects due to its high modeling effort.

Beyond these two methods, which are exclusively recommended for step 3 of the Tussle Analysis, also risk management [4], role-playing simulations [15], interviews (partly recommended) [12], the MACTOR method (partly recommended) [8], [9], and SWOT analysis (partly recommended) [20] may be deployed.

*Discussion*: Risk management [4] allows for a qualitative and quantitative evaluation of previously identified factors and resulting effects, considering risk dimensions and probability. Therefore, risk management is well suited to implement step 3 of the Tussle Analysis, as well. However, just as game theory, risk management is not well suited to assess any evolution over time. Contrary, in case of evolution, dynamics, and causal loops, system dynamics [6] is the recommended method. It is suited best to cope with simulations of various outcomes, when multiple stakeholders interact over a longer modeling period. Role-playing simulations, in particular focus groups, profit from their unique ability to capture informally stakeholders' considerations and to understand and reenact their interactions, wherefore they are the best choice, if a rather informal, not quantified method is acceptable. Interviews, the MACTOR method, and the SWOT analysis may determine valid complementary instruments for validation purposes of results originating from the use of other methods recommended.

## III. Example

First, the concept of a tussle and its evolution is clarified in terms of an example. Second, the tussle presented addresses TCP's (Transmission Control Protocol) bandwidth sharing algorithm and is illustrated in Figure 3. Circles correspond to (temporary) tussle outcomes. The vertical positioning of a circle denotes which of the stakeholders shown on the left favors the outcome. In particular, if the circle is vertically centered, all stakeholders consider their share appropriate/fair.

TCP's bandwidth sharing algorithm is considered fair, because when *k* TCP connections are instantaneously active in a bottleneck link, then each of them will receive *1/k* of the bandwidth. Since each user of the bottleneck link desires to increase its share of the link, interests of users of a bottleneck link collide. Thus, with the introduction of the Peer-to-Peer (P2P) technology, TCP's bandwidth sharing algorithm lead to unfairness, since P2P users can open multiple TCP connections for the same file and, therefore, get disproportionate bandwidth share in relation to traditional users. In addition to being unfair, this outcome was also unstable, because the ability of an Internet Service Provider (ISP) to offer other services was threatened by the increase of P2P traffic. Therefore, ISPs responded by introducing middle boxes for inspecting data packets. These dedicated machines use technology, such as Deep Packet Inspection (DPI) techniques, in order to identify and throttle P2P traffic. Even though this allowed for enforcing fair bandwidth sharing in bottleneck links once more, it was not a stable outcome again: P2P applications started performing traffic obfuscation, *e.g.*, by encryption, in order to decrease the download time. At the same time, DPI technology, which was installed to throttle P2P traffic, allowed ISPs to identify traffic that directly competes with complementary services they offer. A famous example has been an ISP's attempt to degrade the quality of third-party Voice-over-IP (VoIP) services offered by Application Service Providers (ASPs) that threatened traditional telephony services often offered by an affiliate of the ISP [22]. This is an example of a spillover to another functionality, which was solved in the case presented by affected users asking the regulator to intervene (judicial means) for discouraging anti-competitive tactics.

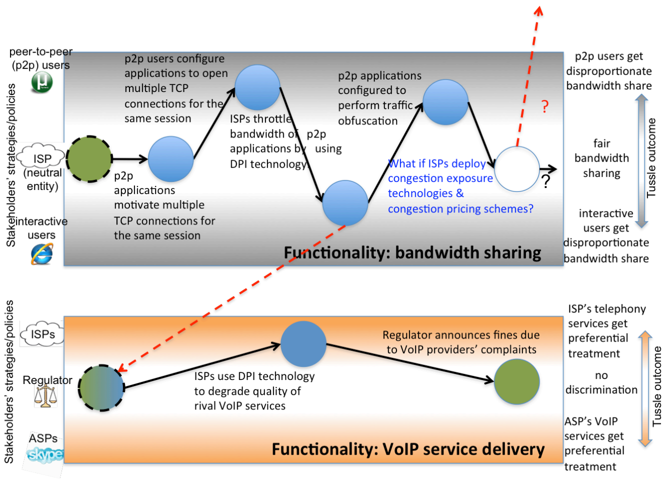


**Figure 3: Example of a Tussle for Bandwidth Sharing [11].**

## IV. Room for Improvement

The Tussle Analysis and the implementation of its three steps have been carefully compiled by a committee of European experts [26] on socio-economics of Internet technology and put to test by cooperation with several European research projects [12]. However, because the field of socio-economics in FN technology is still young, open issues remain and are pointed out in three dimensions below.

### A. Methods to Implement the Three Steps

While a broad spectrum of methods is already given to implement the Tussle Analysis' three steps, as discussed above, additional methods may be suitable to implement those three steps. Also it may be specified in more detail, which method is best to be applied in which case. Furthermore, all methods listed so far, are known from literature. Thus, the design of customized methods to implement the three steps of the Tussle Analysis may be reasonable and has to be investigated. This is a highly cross-disciplinary undertaking, because it does not only require a high degree of technical knowledge to design the method applicable to FN technology, it also demands for a high degree of knowledge on methodology design itself. Since methods are very diverse in their nature (*e.g.*, interview methods originate from social sciences while game theory originates from mathematics) the knowledge needed on the methodological side cannot be located in a distinct scientific domain, but depends on the kind of method to be designed.

### B. Changing Implementation Details

The overall goal of the application of the Tussle Analysis in this paper's context is to change details of standards or technology, such that they comply best with socio-economic requirements before the standard has been formally approved or the product went out to market. However, as the method is hitherto specified, it allows for identifying when socio-economic requirements are not met, but does not particularly guide those changes required for meeting them. Therefore, a methodology can be envisioned for allowing the translation of socio-economic requirements or shortcomings to technical implementation changes or changes in the standard, respectively.

### C. Meta-methods

While the Tussle Analysis proved to be a reasonable approach to analyze FN technology [12], even better approaches to ensure the socio-economic awareness of standards or technology may exist. However, since the design of customized methods implementing the Tussle Analysis' three steps is already highly demanding and requires a cross-disciplinary approach, the design of further meta-methods will be even more challenging.

## V. Advantages of Socio-economic Assessments

The integration of a socio-economic assessment into the design or standardization phase of FN technology will increase the quality of results accordingly. In particular, different aspects highly relevant for the technology's or standard's adoption potential and marketability are likely to be improved.

If a socio-economic assessment is performed by means of the Tussle Analysis, it can be assessed before release, whether an improvement of the technology or a standard is needed to avoid destabilizing or, in a greater sense undesirable, effects on the ICT/telecommunications ecosystem. In case it is not possible to achieve such an improvement by changes to the technology or standard, the prior knowledge of triggered instabilities allows for timely informing administrations about the need for regulations to stabilize an otherwise instable outcome. Therefore, the application of the Tussle Analysis during the design or standardization phase allows for publishing technology or standards without destabilizing effects or, at least, to mitigate destabilizing effects by timely regulative provisions.

Also, the publication of results of a tussle analysis performed increases the technology's or standard's value to and acceptance by different stakeholders. Due to the clear structure of the Tussle Analysis performed on stakeholders, interests, conflicts, and tussles, its results can be disseminated in a comprehensible and compact manner among stakeholders, who will potentially deploy the technology or standard. In particular, if these results indicate a high adoption potential and a highly stable outcome, this determines a strong support and investment signal for manufactures and operators. This in turn will also increase the overall adoption of the technology or standard by customers. Since it allows manufactures and operators to make investments with higher confidence, a socio-economic assessment is also of high interest to them, regardless if the technology or standard is developed in-house or by another entity (as long as the result is disclosed to them). Furthermore, promising research fields will be revealed to academia, *e.g.*, on investigating disruptive technologies, which generate also feedback to be integrated in subsequent technology releases or standards. For administrations a tussle analysis provides reference points to identify the need for regulations and develop these more efficiently. In particular, by describing stakeholder interests, conflicts can be clearly understood and, furthermore, by modeling means available to stakeholders, means taken by stakeholders can be prohibited efficiently by according legislations. Thus, every socio-economic assessment method has to allow for the representation of its outcomes in a comprehensible, compact manner and thus for a fast dissemination.

In order to benefit from these advantages discussed, research projects already apply or have applied the Tussle Analysis to enrich their technology development [14], [17], [21].

## VI. Summary and Conclusions

The Tussle Analysis was presented as a meta-method to allow for anticipating and improving a technology's or standard's compliance with socio-economic requirements. Concrete methods to implement the three steps that define the Tussle Analysis were introduced and briefly and compared. The Tussle Analysis and concrete methods for implementing its three steps are also described in Recommendation Y.3013 [11]. The need for further research was pointed out, which has to be tackled by cross-disciplinary approaches. Finally, advantages of a socio-economic assessment during technology or standard design were highlighted. Among these advantages are the mitigation of destabilizing effects of the assessed technology or standard by triggering timely regulative provisions. If this assessment is implemented by a tussle analysis, the results can be recorded and disseminated in a formal and comprehensive manner. Therefore, the possible set of benefits foreseen for all stakeholders is large compared to today's knowledge.

While the need to account for socio-economic factors in technology design and standardization is recognized in research [26], [14], [17], [21], [7|, [25] and by standardization bodies [10], [19], to the best of the authors' knowledge, the Tussle Analysis and its formulation is the first method to assess socio-economic aspects in the design and standardization of FN technology and standards. Currently the authors apply the Tussle Analysis to selected scenarios (*e.g.*, content sharing in the EU project SmartenIT [23]) in order to identify relevant stakeholders and related tussles in those scenarios chosen.

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