On the importance of system-view centric validation for the design and operation of a crypto-based digital economy

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Abstract

Ubiquitous connectivity, networked computation, open technologies and advances in intelligent web approaches (like semantic web, distributed databases, and intelligent applications) enable the third-generation web, Web3.0. Not least due to advancements in crypto technologies adoption in real world applications, it is now possible to convert the internet of things (IoT) into an economy of things (EoT), which basically refers to a heterogeneous digital economy of everything. Based on the realization of the deficiencies of Web2.0 and the loss of confidence in a central intermediaries based economy, a societal desire to overcome these deficiencies has emerged. The so-called social Web2.0 in fact is dominated by a few quasi monopolistic, central platforms incorporating most of the utility arising e.g. by collecting large amounts of user specific data to feed machine learning algorithms and provide proprietary services based on this. The banking crisis on the other hand demonstrated that the broad society is at risk if these central intermediaries fail. Cryto-technological advancements led to the development of technology, enabling a secure digital economy based on peer to peer trust-less networks, thereby effectively eliminating the need for central intermediaries (which in history regularly demonstrated their fallibility).

In the beginning, the crypto movement has been enthusiastic about the ability to encode all necessities for a digital economy in algorithms and code. However, in the mean time, insight has gained ground that on the one hand, designing the EoT is a quite complex endeavor and the resulting system might fail to achieve the targeted ideals, even when no intermediaries are present. We emphasize this position by arguing that the EoT in fact corresponds to a *complex system operated in open contexts*, for which a sophisticated design approach and a set of measures are inevitable, in order to be able to achieve a valid design and operation.

In addition, we argue that the high level guiding principles necessary for a valid and effective EoT align well with the ideals of the democratized Web3.0 movement, and are no naive rapture, but rather - adequate adoption provided - can lead to socioeconomic efficiency. Over and above, we postulate that in this kind of EoT, commercial companies not only play a role, but can benefit alongside the society. In more game theoretical jargon, one could state that it is rational for the society *and* enterprises to undertake the effort to establish a valid EoT based on these ideals.

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1 Introduction

Ubiquitous connectivity, networked computation, open technologies and advances in intelligent web approaches (like semantic web, distributed databases, and intelligent applications) enable the third-generation web, ***Web3.0***. Not least due to advancements in crypto technologies adoption in real world applications (initiated by Satoshi Nakamoto and bitcoin [1]) it is now possible to convert the internet of things (***IoT***) into an economy of things (***EoT***), which basically refers to a heterogeneous digital economy of everything [2](see section 2.1 for details).

Based on the realization of the deficiencies of Web2.0 and the loss of confidence in a central intermediaries based economy [3], partly due to the banking crisis, a societal desire to overcome these deficiencies has emerged [4]. The so-called social Web2.0 in fact is dominated by a few quasi monopolistic, central platforms incorporating most of the utility arising e.g. by collecting large amounts of user specific data to feed machine learning algorithms and provide proprietary services based on this. The banking crisis on the other hand demonstrated that the broad society is at risk if these central intermediaries fail. The hallmark paper of Satoshi Nakamoto [1] and the thereby kicked of cryto-technological advancements led to the development of technology, enabling a secure digital economy based on peer to peer trust-less networks, thereby effectively eliminating the need for central intermediaries (which in history regularly demonstrated their fallibility).

In the beginning, the crypto movement has been enthusiastic about the ability to encode all necessities for a digital economy in algorithms and code. However, in the mean time, insight has gained ground that on the one hand, designing the *EoT* is a quite complex endeavor and the resulting system might fail to achieve the targeted ideals, even when no intermediaries are present. On the other hand, it becomes more and more obvious that the algorithmic part needs to be accompanied by extra-algorithmic measures, such as social mechanisms for self- and societal-governance (see section 2 for a detailed discussion).

We emphasize this position by arguing that the *EoT* in fact corresponds to a *complex system operated in open contexts*, for which a sophisticated design approach and a set of measures are inevitable, in order to be able to achieve a valid design and operation, as argued in our previous work [5] In this respect we extend the design requirements posed upon intelligent economic networks [6]. We illustrate the relation of the sys^{2}val's basic methodological aspects to the *EoT* design process in section 2.

In addition, we argue that the high level guiding principles necessary for a valid and effective *EoT* align well with the ideals of the democratized Web3.0 movement, and are no naive rapture, but rather - adequate adoption provided - can lead to socioeconomic efficiency. Over and above, we postulate that in this kind of *EoT,* commercial companies not only play a role, but can benefit alongside the society. In more game theoretical jargon, one could state that it is rational for the society *and* enterprises to undertake the effort to establish a valid *EoT* based on these ideals.

Throughout the text, we use ***boldface*** characters for term definitions, whereas *italic* characters indicate the use of already defined terms elsewhere within the document and *italic**references terms defined in [5].

2 *EOT/dEoE:* a complex system operated in open context

2.1 *EoT*, *dEoE*, functions, agents and general digital intelligence

The term economy of things (*EoT*) evolved from internet of things (*IoT*). Internet of things refers to the fact that nowadays, due to ubiquitous connectivity, not only humans connect via the web. It is also possible to build networks of things like sensors, fridges, cars - so called ***IoT devices***. However, connecting everything with everything by itself is of no use. The connected entities need to be able to interact in ways comparable to established economic mechanisms such as search and find, negotiation, payment, settlement, building trust etc. in order to make use of the connectivity. The *IoT* therefore needs to be converted into an economy of things. However, although broadly used, the trailing part 'of things' is misleading. In fact, what is meant by *EoT* is a digital economy of everything (***dEoE***) - a heterogeneous mix of e.g. small *IoT* devices, more powerful digital entities like machine learning based services running in the cloud and humans, interacting seamlessly.

In Web2.0, functionality was basically centralized. The functions of a service could in fact be split into several modules, but there typically is a central point of service providing access. In Web3.0 even smaller modules can be incorporated as individual entities, connecting and interacting with others on their own behalf. These entities are usually called ***agents***. Web3.0 therefore can be understood as a ***multi-agent*** system in which functionality - or in a more general form the ***capability*** to achieve a goal - emerges from interaction of fragmentary contributions [7, 8]. The capability therefore is no longer embodied in a monolithic entity, but distributed across a network of agents, each embedding only a part of the necessary modules. Over and above, individual agents contributions to the network are not guaranteed regarding quality of service and reliability. Agents providing new fragmentary contributions might appear, others disappear. The *dEoE* therefore is a prime example of a complex open context system. See [5] for a detailed definition and discussion of the challenges related to the valid design of such systems.

Due to the fragmentation into (sub-)modules and the possibility to flexibly and dynamically combine these to new and more complex compositions *dEoE* will not only lead to an ever growing capability of the network. Over and above, capabilities will emerge, no one of the designers of the individual agents has been thought of beforehand (*emergent behavior**). The ability of the network to evolve and solve unforeseen tasks might be regarded as a form of intelligence [9]. This is a natural effect in complex, modular systems and has nothing artificial. We therefore refer to the capability of the *dEoE* as ***digital intelligence (DI)***. In contrast to the nowadays mainly monolithic machine learning systems, which are extensively hyped as artificial intelligence, on a closer look however turn out to be at most comparable to quite narrow intelligence, *DI* on the one hand continuously evolves by itself and might therefore in the future lead to what we call ***general digital intelligence (gDI)***. In addition, *dEoE* seamlessly integrates heterogeneous agents (be they representatives of humans or autonomous digital entities) and therefore by its basic construction allows to leverage the synergistic human machine potential. We therefore argue that *(g)DI* will be beyond *(g)AI*.

Based on this insight, it becomes clear that the huge potential of *Web3.0* & *dEoE* requires a responsible *holistic** handling. Due diligence is necessary in design and operation of the total system, specifically also covering the emerging capabilities and effects not even known at individual components design time, just as argued in [5]. Due to the main utility arising from this emergence, it is by no means sufficient to seemingly perfect design and validate on individual modules or functions basis, e.g. stable coin and payment service. It is rather highly essential to apply valid design and operation approaches on a *holistic* basis to the total system. Not least to prevent a

comparable outcome to Web2.0, where the utility and power aggregated in the hands of a few quasi platform monopolists, taking advantage of it to the detriment of smaller competitors and society.

Not approaching the *dEoE* in a *holistic* manner might allow the quasi platform monopolists to extend their power and dominance even further. As an example, think of a perfectly orchestrated open source based initiative, seemingly well designed and governed, however only on the individual function level like e.g. payment. Combine this function with Web2.0 services, such as e.g. social networks, allowing the operator of the platform to then extract crypto-payment related information and combine it with the rest of the already available data from the platform users. The effect of such an approach from a total system level view is by no means in accordance with the ideals of the democratized Web3.0 movement and detrimental to all other participants of the *dEoE*. See section 4 for a detailed discussion.

2.2 Recap of sys2val and relation to *dEoE*

dEoE is a prime example of a complex open context system, as argued in the previous section. Due to the *implicit infinite complexity**, these systems can not validly be designed, maintained or operated in an ad-hoc manner. Instead, more rigorous (systematic and holistic) approaches are required. See [5] for a detailed discussion and the introducion of sys^{2}val, a holistic, systematic and system-based view centric approach providing such strategies. State of the art for complex closed context systems engineering is the holistic approach based on system view, as established by Rasmussen [10] and Leveson [11], with a good track record e.g. in aviation, military and aeronautics. Sys^{2}val is based on this strong fundament and extends it to enhance traceability, completeness- & validation and applicability for open context systems.

In a nutshell, complex open context systems can never be designed, validated and operated in a formal complete manner. In contrast to closed context systems, unpredictability needs to be embraced and dealt with on a systematic basis. The basic ingredients are

- get clear about what should be achieved, based on which ideals and high level guiding principles (*high level goal**, *aimed purpose**)
- iteratively concretize the functional and non-functional requirements while being aware of related assumptions taken (*valid deductive step**)
- do as much as you can based on system understanding (*validation challenge**, *holistic cycle**)
- accept that an a priori complete understanding of later system dynamics and effects will not be possible and therefore prepare well for the unexpected (*validation challenge**, *holistic cycle**)

This translates in the requirement for the design of an antifragile system [12, 13, 14], implementing continuous improvement based on observation (*monitors**). In order to be able to do so, it is necessary to apply prepared and continuously adapted *recovery** and *degradation strategies** (survive the unexpected), feedback the observed to extend system understanding (learn from it) leading to ongoing improvement (get better). This is a continuous process based on a *holistic cycle**.

Regarding societal complex systems, which *dEoE* is a representative of, the design of four mutually dependent basic aspects need to be addressed with due diligence, following the outlined approach. Namely:

- algorithmic mechanisms and protocols
- algorithmic mechanisms based self-governance
- social mechanisms based self-govenance
- societal governance

List 1: The four mutually dependent aspects which necessarily need to be addressed in the design of complex societal systems.

The first two aspects are, in principle, taken serious and addressed via game theory based mechanism design. Having said this, it needs to be added that it holds for the implementation of certain goals like e.g. decentralization and privacy. However, there is no widely discussed and accepted set of goals such systems should implement. This set obviously should include much more than the aforementioned and is an involved matter on its own.

Self-governance of Web3.0 projects, especially in the crypto field, is nowadays mostly following an informal, technocratic model [15, 16]. This is not necessarily the best approach for systems with a large inherent potential to affect the broad society. It is therefore more and more frequently criticized.

And last but not least, due to the rapid advances in the field, inter- and national regulation - mainly responsible to establish a societal governance - lacks well behind (see e.g. the discussion in [17]). However, it is important for projects potentially having an impact on the broad society, to align with inter- and national regulation in order to close the gap. Otherwise, disagreement might arise, as the discussion around the Libra project illustrates [18].

In conclusion, a widely discussed and accepted set of design goals for the *dEOE* should to be established. In addition, it needs to be well understood that these goals can not efficiently be implemented based solely on algorithmic mechanisms. It rater requires a well balanced combination of all the four mentioned aspects. We therefore propose and discuss a *high level goal**, its individual aspects and derived *unacceptable losses** and *hazardous system states** in the sys^{2}val sense in section 4, to stimulate a broader discussion.

These high level ingredients then allow to derive a well balanced combination of measures to the achievement of a valid and efficient design and operation of *dEoE*.

Before detailing out the concrete high level goal, an overview of its role and the relation to the four aspects of listing 1 will be given in the following section.

3 The role of the high level guiding principles in the constitutional process of *dEoE*

3.1 Introduction

The holistic, systematic and system-based view centric approach to the design of complex open context systems, in which emergence plays an important role, has been discussed in the foregoing sections and [5]. In a nutshell, high level guiding principles are used during derivation of the iteratively concretized design and ongoing improvement of the targeted functions of the (total)

system such, that the dynamically evolving system, more specifically its *emergent behavior**, complies with these principles. To this end, monitoring of underlying assumptions, prepared recovery and degradation strategies as well as mechanisms for continuous improvement and adaption (*valid deductive steps**) are necessary. The development goal is to achieve a well balanced and efficiently operating combination of the four aspects given in listing 1 in the previous section, on all levels of concretisation (see also *development goal**).

Figure 1 provides an overview of a constitutional process we suggest for a *dEOE* endeavor. This process will be discussed in the following.

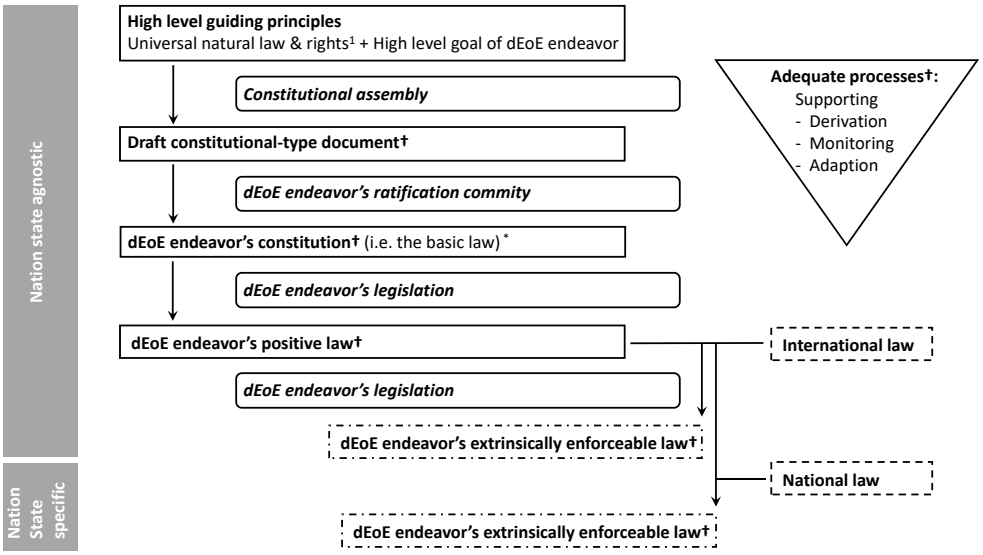

Figure 1: Overview of the proposed process from the high level guiding principles to the nation specific enforceable law. See the text for a detailed discussion.

We deliberately choose the abstract term 'endeavor' to indicate that the process is independent of the type of initiative. It may be applied to the formation of a specific legal entity for the operation of certain aspects of the *dEoE,* the formation of domain specific alliances etc. However, as discussed above, the high level goal always relates to the emergent effects of the total system.

The necessary elements of an adequate sys^{2}val based approach are subsumed in the triangular box to the right. The pervasive character of the application is indicated by the † added to all elements representing results of a *deductive step**.

3.2 From high level guiding principles to the basic law

The most abstract level is formed by the ***universal natural law and rights***. Universal thereby refers to principles and concepts to be most legitimate, not subject to relativism. Universal rights exist independently of human understanding and of the ***positive law*** - and therefore are widely accepted. The term *positive law*, from'to posit', in contrast, relates to the law of a given state, political order, legislature or society. The natural law and rights for example include universal human rights [19] and international covenant on civil and political rights - ICCPR [20], from which i.a. the right to privacy in information technology can be derived (specifically Article 12 UDHR and 17 of ICCPR), see e.g. [17]. We propose to augment the natural law and rights by the aspects

of the high level goal of *dEoE* endeavors, discussed in section 4. Together, these high level guiding principles form the input to the constitutional assembly.

Aspects of the type 'guiding principles, rights and laws' are indicated by rectangular boxes with sharp corners. Specific organs, typically a subset of all concerned entities (indicated by boxes with rounded corners), take *deductive steps** in order to derive a concretization of the more abstract level to a more endeavor-specific interpretation and elaboration. The formation of these organs itself needs to obey the high level guiding principles; they need to be arguably adequate (i.e. *valid*) with respect to the formation (e.g. who can be member of the committee, how are these members selected, etc.) and exertion processes.

The constitutional assembly prepares a draft constitutional-type document, for which a ratification process, typically involving a broader set of community members, is conducted. This combination, both, ensures efficiency and broad acceptance of the resulting ***dEoE endeavors constitution***. The constitution is also referred to as the ***basic law***. We suggest to apply the doctrine of separation of powers, keeping the three aspects of governance, namely legislative, judicial and executive separate and thereby establishing a system of mutual checks and balances[1]. As will be discussed in section 4, the requirement for separation of powers directly follows from the high level guiding principles and is related to the aspect of socioeconomic efficiency.

3.3 Positive law

The *dEoE* endeavor's legislature derives the *dEoE* endeavor's *positive law*. Basically, the *positive law* is a set of provisions and rules for application in day to day business. All aspects of listing 1 are covered by these rules. An example for algorithmic mechanisms and protocols is the well known longest chain rule. Contract-encoded voting, and the process of opinion making preceding a voting are a combination of algorithmic (the voting contract) and social mechanisms (the opinion making). An example for the latter would be a rule which prescribes that, for certain kinds of voting, the pros and cons of the alternative choices need to be documented and accessible for a certain time frame before the voting to all who hold a voting right. In addition, it typically needs to be regulated who has voting rights, the weighting of the individual votes as well as by whom and under which condition alternative choices can be added to the voting.

It is important to note that the *dEoE* endeavor's positive law is not necessarily *extrinsically enforceable* (i.e. enforceable from outside the endeavor).The positive law necessarily needs to respect (i.e. not violating) international law - otherwise operation of the endeavor might be *extrinsically* shut down, based on this. However, some aspects not covered by international law can only be enforced *intrinsically* (from within the endeavor). An example for an *intrinsically enforcement* is, again, the longest chain rule. The system's incentives are - based on game theory - actually designed such, that it is enforced automatically. It is not intended and in fact impossible to take node operators not respecting the longest chain rule to court for not doing so.

This illustrates, that there are several different organs necessary for implementation of checks and balances. The set of organs is a complex conglomerate with *dEoE* endeavor intrinsic and -extrinsic contributions, together adequately covering the four aspects given in listing 1 and establishing separation of powers, e.g. by splitting legislature, judicial and executive.

[1]Note that figure X only shows the organs related to the deduction of rights and laws. It does not include further necessary organs, e.g. judicial and executive institutions.

3.4 Alignment with (inter-) national law

As discussed above, the endeavors *positive law* needs to be aligned with international law. At least not violating it. The endeavors legislature also determines which parts of the constitution should be covered in the basic law such, that it is explicitly *extrinsically enforceable* by international, or even nation state specific law. This, on the one hand serves credibility and on the other hand might even be necessary in order to be able operate or provide service in certain states and regions. It is however important to regulate as much as possible in a nation state agnostic form, for the endeavor not becoming a plaything or fall victim of individual nation states. This separation is indicated in the lower part of the figure.

As stated above, inter- and national regulation (indicated by dashed-line boxes) - mainly responsible to establish a societal governance - lacks well behind the technical development. The high level guiding principles and sys^{2}val based approach to the constitutional process supports the establishment of an effective societal governance, as it works out the relevant aspects which necessarily need to be extrinsically enforceable and therefore should be covered by (inter-) national regulations.

3.5 Evolution of rule sets

The necessary elements of an adequate sys^{2}val based approach, subsumed in the (black box) to the right, also include mechanisms for discourse, decision about and, where appropriate, adaption of the related levels guiding principles, rights and laws. The implementation may be inspired e.g. by Hart's concept of law [21], as proposed by [15]. It is important to note that the permanence of the rule set increases with the level of abstraction. The High level guiding principles are mainly fix. Constitution needs adaption, however only on a sound basis and following a detailed examination, whereas the positive law, and in particular jurisprudence, allows for faster adaption.

3.6 How to approach the process

On first sight, the necessary constitutional process for *dEoE* endeavors seems complex. In addition, it might be argued that there is no state of the art yet. However, there is a huge state of the art e.g. in human societal organization, self governance of open source projects etc., from which can be drawn. It is therefore not necessary to reinvent all aspects anew, but to combine understood and established elements based on the sys^{2}val scheme such, that the high level guiding principles are obeyed.

As usual with complex systems operated in open contexts, we can not a priori design a perfectly valid solution right from the start. Therefore, it is important to establish the processes and measures allowing for an *antifragile* evolution of the system based on an *ongoing holistic cycle** (as discussed in section 2.2 and [5], especially section 2 and 4 ibid.). Phrased differently, sys^{2}val provides the basic principles and measures allowing to establish a lightweight ***meta governance***, which then, together with the high level guiding principles, allows to start an *dEoE* endeavor on a sound basis.

4 Guiding principles for the digital economy of everything (*dEoE*)

4.1 Overview

In system-view based approaches (e.g. STAMP [2] and sys^{2}val [5]), the high level goal represents the most abstract and concise statement of the goal to achieve. All aspects such as guiding principles,

concrete rules and system design are derived from this by a well established process of iterative concretisation.

The negative effect of non-achievement of aspects of the high level goal is referred to as *loss*. *Losses* large enough to undermine the achievement of the overall goal are referred to as *unacceptable loss*. A system state possibly leading to unacceptable losses is referred to as *hazardous system* state and rated as invalid, as it bears unreasonable risk.

Section 4.2 collects some prerequisites for the formulation and discussion of the high level goal for *dEoE,* as proposed in section 4.3. The derived unacceptable losses and hazardous system states are then given in section 4.4.

4.2 Prerequisites

4.2.1 Open-endedness

The adjective 'open-ended' indicates an unrestricted, broad situation with no fixed limits. In the context of evolution of digital systems, it relates to the ongoing development of ever complex capabilities based on emergence in dynamically evolving systems [22, 23]. As discussed in section 2.1, due to the possibility to flexibly and dynamically combine the individual (sub-)modules of the digital economy to new and more complex compositions, *dEoE* will not only lead to an ever growing capability of the network. Over and above, capabilities will emerge, no one of the designers of the individual agents has been thought of beforehand. By this, an ever growing utility will be unlocked.

However, open-endedness does not mean fully unrestricted, as will become clear in the following discussion. In a nutshell, in order to achieve an efficiently growing capability (and hence utility) of *dEOE*, a well balanced set of regulations needs to be applied.

4.2.2 Super modularity

Super modularity, in short, refers to the popular saying that a combination of elements provides more utility than the sum of individual elements utilities. A more formal representation for functions defined over subsets of a larger set is as follows:

Let S be a finite set. A function f is ***supermodular***, if for any $A \subset S$ and $B \subset S$:

$$f(A \cup B) + f(A \cap B) \geq f(A) + f(B) \tag{1}$$

This is a more strict condition than ***superadditivity***, for which

$$f(A \cup B) \geq f(A) + f(B) \tag{2}$$

See e.g. [24]. The difference is in the inclusion of the intersection term $f(A \cap B)$ in eq.1. In order to see the effect of this term, think of two partly overlapping sets. The resulting overlap from combining these sets $(A \cap B)$ may lead to a negative effect $(f(A \cap B) \leq 0)$. If the combined effect (the left hand side of eq.1) still is larger than the summed individual effects (right hand side), the combination still pays off.

4.2.3 Coalition games, coopetition and efficiency

Supermodularity is related to convex coalition games, and the solution concept introduced by Shapley [25, 26, 27]. In coalition games, a set of competitive players may cooperate (on some aspects) to form a coalition. This might e.g. relate to resource sharing, sharing of development costs for basic technologies or sharing of modular capabilities to achieve more complex capabilities, unlocking a surplus. Put simply, even though there might be some aspects for which the players are in competition and on which the cooperation might have a detrimental effect (see the discussion of the intersection term of eq.1), in supermodular systems, cooperation pays off and everybody taking part benefits. The combination of competition and cooperation at the same time is referred to as ***coopetition***.

Coopetition in supermodular systems generates a surplus. The larger the set of agents taking part, the larger the total surplus. Therefore, the goal is to achieve what is called the 'grand coalition'.

A solution to the problem of establishing a stable grand coalition has e.g. given by Shapely [25, 26, 27]. It is based on the distribution of the generated surplus according to the contributions of the individual players. In a nutshell, if any players benefit from the surplus over-proportionately with respect to their to contribution, it is beneficial for the other players to form a smaller coalition excluding them. By this split-up however, the surplus of the total system drops, which is socioeconomically undesirable.

Due to the fragmentation of the *dEoE* into (sub-)modules and the possibility to flexibly and dynamically combine these to new and more complex compositions, leading not only to an ever growing capability of the network but also to emerging capabilities no one of the designers of the individual agents has been thought of beforehand, we argue the *dEoE* to be supermodular. Therefore, it is important to establish a *coopetition* based *dEoE* based on adequate surplus sharing, both, from a viewpoint of most efficient capability increase towards *gDI*, as well as socioeconomic sense.

As a side note, the problem of adequate distribution of a total surplus among the players is, on a fundamental basis, also related to the credit assignment problem of machine learning and AI. In *dEoE,* both topics comes together.

4.2.4 Imperfect information and the non-existence of the invisible hand

The discussion of coalition games and supermodularity already indicated that an efficient generation of surplus and growth of overall capability will, in general, not necessarily arise automatically. It depends, i.a., on the involved topic of surplus distribution, related to credit assignment. The challenge of adequate credit assignment and surplus distribution lies in the non-locality of effects and hence in the impossibility to achieve perfect information for rating a certain contribution or action at a given point in time and system state. For example taking a certain action in a certain system state, or, in the coopetition model, contributing a certain element, typically takes effect in a time-, state- and network participant distributed fashion. There may even arise local positive effects to the actor, while related costs are (mainly not directly identifiable) distributed to others. This effect is referred to a ***externalities*** and related to imperfect information.

Joseph Stiglitz, George A. Akerlof and A. Michael Spence jointly received the Nobel Memorial Prize in Economic Sciences (2001) for their research in the context of the theory of markets with asymmetric information[28]. Stiglitz is a distinct critic of the idea of the invisible hand [29] applied to economics in the sense that free markets should lead to efficiency as if guided by unseen forces [30]. He points out [31]:

> Whenever there are 'externalities' – where the actions of an individual have impacts on others for which they do not pay or for which they are not compensated – markets will not work well. But recent research has shown that these externalities are pervasive, whenever there is imperfect information or imperfect risk markets – that is always.
>
> The real debate today is about finding the right balance between the market and government. Both are needed. They can each complement each other. This balance will differ from time to time and place to place.

Akerlof write in his famous 'lemon markets' paper [28] about market with *information asymmetry*:

> It should also be perceived that in these markets social and private returns differ, and therefore, in some cases, governmental intervention may increase the welfare of all parties.

In other words, free markets (without any intervention) will, in general not lead to efficiency; it is even only under exceptional circumstances that free markets are efficient.

Based on these insights, we argue that the formation of the *dEoE* should not be left over to unregulated markets. It requires dedicated and continuous methodological support establishing such a dynamically adapting balance as mentioned by Stiglitz. Not least to prevent a comparable outcome to Web2.0, where the utility and power aggregated in the hands of a few quasi platform monopolists, taking advantage of it to the detriment of smaller competitors and society. One of the goals of the algorithmic and social mechanisms based self-governance, in combination with societal governance of *dEOE* endeavors is to establish functioning market economy. See the following sections for a more detailed discussion.

4.2.5 The detrimental effect of information asymmetry based platforms and monopolies

Web2.0 showcases the rise of strong intermediaries in unregulated complex markets, as already predicted by Akerlof in 1970 [28]. Due to the pervasive *externalities* and *information asymmetry* in these markets, there exist a large potential (in the famous automobile market example of $price/2$) for intermediary merchants:

> In our picture the important skill of the merchant is identifying the quality of merchandise; those who can identify used cars in our example and can guarantee the quality may profit by as much as the difference between type two traders' buying price and type one traders' selling price. These people are the merchants.

In a wider sense, Web2.0 quasi monopolies are built on information asymmetry, whereas the service provider relates to a merchant ensuring quality for his customers. The merchant may e.g. deal with quality search results, goods, networks of like-minded people, machine learning based services etc. However, the merchant over-proportionately benefits from the unlocked potential. It is important to note that the merchants business model, even though he seemingly reduces the perceived uncertainty of the user, strongly depends on sustaining and extending the information asymmetry. Hence he is a profiteer and at the same time a preservationist of market failure, accumulation ever growing advantage in information and power. As Akerlof states [28]:

> ... private institutions may arise to take advantage of the potential increases in welfare which can accrue to all parties. By nature, however, these institutions are nonatomistic, and therefore concentrations of power -with ill consequences of their own - can develop.

Leaving the field to private institutions intensifying information asymmetry, means allowing draining of ever larger part of the socioeconomic potential for private profit. In addition, this drainage is cutting off the rest of the systems participants from the related supermodular potential. The same holds for (quasi) monopolies in general: they incorporate a subset of the potential surplus such, that they - as far as possible - solely benefit, related to over-proportionate aggregation of surplus and power. This however strongly reduces the total surplus of the system and hence socioeconomic efficiency.

In contrast to that, the goals of the democratized Web 3.0 movement like e.g building trust in trust-less networks, equally accessible to all participants without intermediaries, preserving privacy or at least sovereignty over user related information, or more generally an adequate sharing of effort, benefit, power and responsibilities is no naive rapture. It is also not about eliminating commercial companies. On the contrary, it is targeted at establishing a functioning market economy, characterized by commercial companies not only playing a role, but having a benefit alongside the society.

4.2.6 The role of commercial companies, diversity and minority protection

As argued in the foregoing section, the *dEOE* endeavor is targeted at a functioning market economy. Commercial companies - alongside other agents in the network - are contributors and, due to the supermodularity, benefit from participation. This becomes obvious when considering commercial companies as providing specialized key expertise generating surplus in the total system and being rewarded according to their contribution. Therefore, obviously, investment in competency development pays off, e.g. for companies.

As already discussed, *dEOE* is not about naive cooperation, but *coopetition*. It is important for a functioning market economy to have a healthy competition, e.g. about providing key expertise. Diminishing competition and arising monopolies have a detrimental effect to the total system. Over and above, for complex systems operating in open contexts, diversity i.a. in the form of competence is important for antifragility and hence persistence of the system. Therefore, a competition based diversity on the one hand, balanced by an adequate protection of minorities form the breeding ground for futures contributors of key expertise and hence prevailing efficiency.

4.3 The high level goal

Based on the foregoing discussion, we propose the following high level goal for the *dEOE* - an open ended and adequately decentralized* digital economy of everything (* in the sense of adequate sharing of effort, benefit, power and responsibilities):

> The open-ended *dEoE* endeavor lays the foundations for- and fosters an enduring, non accedence restricted, legal cooperation targeted at the emergence of an open ended, heterogeneous digital economy by pooling and appropriately compensating all necessary competencies and contributions such, that the supermodular potential thereof is unlocked efficiently, inseparably linked to the collective (no aspect can over-proportionately be accumulated by some entities, or separated from the cooperation) and finally leading to the emergence of an adequately decentralized* *dEoE*.

Achieving a true open ended and efficient *dEoE* is, both, a major challenge and may lead to major benefit and power. It is therefore neither expectable nor desirable that a few (non-diverse) or even singular entities successfully initiate and rule the necessary processes unleashing the supermodular potential, finally leading to utility and power in the hands of a (few) monopolist(s).

The necessary efforts, amenities, obligations and responsibilities therefore each needs to be appropriately shared across an adequate number of diverse entities. What adequately means depends on the specific aspect in a specific setting of *context** and *realisation** (see the *validation triangle** for a detailed discussion). A basic measure might be derived from the Gini index, possibly extended by a Shapley value based relation to contribution.

An adequatly operated *dEOE* will generate a total surplus in an efficient way. Legality is one of the prerequisites for endurance and related to acceptance, credibility and hence prevalence. Even so is non-discriminative accedence. The *dEoE* shall not be a cooperation of - and for the sake of a few.

On the other hand, it should not be stoppable by individual nation states, however needs to be in compliance with international law, or more generally stated with societal expectations.

Non-opaqueness of basic *dEOE* modules, competencies and capabilities is an essential prerequisite to the supermodular potential being unlocked efficiently (i.e. the ability to combine everything with everything without access restrictions). However, naive sharing will give rise to free-riders and fast followers cutting down the benefit of the innovators and hence it will undermine the goal of the cooperation. It is rational for agents to behave selfish (they tend to maximize their own benefit), an appropriate compensation for all necessary competencies and contributions needs to be established such, that it is rational for agents to become part of the coopetition based *dEoE*, complying with the established rules. Maximizing the benefit from a local perspective (associated to selfishness of agents) is not evil per se, but the reflection of a necessary contribution to efficiency of the total system. It needs to be counterbalanced such, that entity-local maximization leads to maximization of globally desirable outcomes (i.e. socio-economic optimal results). This compensation also addresses the free-rider issue. Counterbalancing is well accepted; see e.g. the discussion in section 4.2.

Complex *coopetitive* systems formed in the context of selfish entities need to be coalition proof to prevent any coalition of a few to take over and over-proportionately benefit from the generated surplus and hence undermining the goal of efficient maximisation of total surplus, based on adequate decentralisation of powers. Governance, opinion - & decision making, advancement of the framework etc. is part of the necessary competencies.

Globally desirable outcomes could, in principle, be welfare maximization, social welfare maximization, Pareto optimal growth (of e.g. capabilities and benefits) etc. All of these have pros- and cons. The precise combination thereof will depend on the concrete *setting** (see the *validation triangle** for a detailed discussion). Defining the metrics is part of the sys^{2}val based design process. We therefore, on this level, stick with the more abstract formulation 'such that the super modular potential ... is unlocked efficiently'.

Re-investment of benefits in indirectly beneficial activities, e.g. exploration instead of exploitation, support of diversity and protection of minorities contribute to the overall efficiency and goal in the long run. For example exploration under-performs with respect to short-term benefit compared to exploitation; however it improves capability and therefore the achievable benefit in the mid to long run. Maintaining diversity (e.g. of *realizations**) might locally appear inefficient, but will be key to be prepared for *context** / *purpose** shifts in the environment.

'The supermodular potential is inseparably linked to the collective' relates to the fact that if any aspect (benefit, power, etc.) might get over-proportionately accumulated by some entities, or separated from the cooperation, the potential for manipulation of or even dominance over the cooperation grows and hence the overall goal of achieveing a functioning economic market, leading to efficient total surplus maximization is undermined.

4.4 Unacceptable losses and hazardous system states

Based on the foregoing discussion, we propose the following set of *unacceptable losses* and *hazardous system states* for the *dEoE*. Note that this is an intentionally condensed set, from which the aspects discussed in the foregoing sections can be derived. A more specific and concrete elaboration for the various levels of the design and operation process is part of the sys^{2}val based approach.

High level unacceptable losses

1. *dEoE* capability development (and hence benefit to all contributors) stagnating or falling short.
2. Potential contributors are not willing to get part of the cooperation or are leaving the cooperation (to a greater extent).
3. Individuals or coalitions of a few are dominating or over-proportionately influencing the opinion - & decision making, advancement of the framework of the cooperation or are over-proportionately taking advantage of the utility for their own sake.
4. Cooperation repeatedly or massively limited by legal regulations. Possibly finally leading to (quasi) shut down of the cooperation and hence the *dEoE*.

High level hazardous system states

1. The necessary efforts, amenities, obligations and responsibilities are not appropriately shared across an adequate number of diverse entities.
2. Contributor can not participate in proportion to his contributions.
3. Contributor does not (actively) participate in proportion to his contributions.
4. Over-proportionate accumulation of any aspect by individuals or coalitions of a few.
5. Contributor network and capability growing slow, stagnating or even shrinking.
6. Cooperation perceived as suspicious to potential or active contributors (e.g. perceived as not credible, suspect to inadequate sharing of any aspects, discriminating, ...)
7. Cooperation and *dEoE* suspicious to the general public or authorities, probably leading to legal regulation.
8. Inadequate diversity in any aspect / type of contribution(*1)

An important aspect regarding the establishment of Web3.0, and especially crypto-based endeavors is the adequate wage of the early contributors (innovators, investors etc.), on the one hand, while not making permanent a special role for them, leading to over-proportionate influence and benefit. The latter leading to scepticism of potential subsequent contributors and hence under-performance or even stagnation related to a situation of being ***locked-in*** in a sub-optimal system state (e.g. every party benefits much less then possible compared to a *coopetition* style cooperation). Every party so to say fears to reinforce the powers of the competitors, in the long term leading to a marginalization of herself. These aspects are multiply addressed by the above listed hazardous system states.

5 Conclusion

Based on a detailed discussion of the subject, we argue that the upcoming digital economy, *dEoE,* corresponds to a *complex system operated in open contexts*, for which a sophisticated design approach and a set of dedicated measures are inevitable, in order to be able to achieve a valid design and operation. In addition, we emphasize that the high level guiding principles necessary for a valid and effective *dEoE* align well with the ideals of the democratized Web3.0 movement, and are no naive rapture, but rather - adequate adoption provided - lead to a functioning market economy characterized by socioeconomic efficiency. Over and above, we argue that in this kind of *dEoE,* commercial companies not only play a role, but benefit alongside the society. Leaving the field to unregulated markets and private institutions would result in intensifying information asymmetry,as was the case for Web2.0, and should therefore be prevented.

On first sight, the necessary approach for the formation of a *valid dEoE* endeavor seems complex. However, there is a huge state of the art e.g. in human societal organization, self governance of open source projects etc., from which can be drawn. It is therefore not necessary to reinvent all aspects anew, but to combine understood and established elements based on system view centric based approaches for open context systems, such as e.g. the sys^{2}val scheme.

As usual with complex systems operated in open contexts, we can not a priori design a perfectly valid solution right from the start. Therefore, it is important to establish the processes and measures allowing for an *antifragile* evolution of the system, based on an *ongoing holistic cycle**. Sys^{2}val provides the basic principles and measures, allowing to establish a lightweight *meta governance*. Together with - still to be be widely discussed and accepted - *high level guiding principles*, this *meta governance* enables to approach the *dEoE* endeavor on a sound basis.

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