# New Computer Technologies: the Importance of the Ethical Analysis

Alessandro Perini

February 11, 2019

Abstract

This paper aims to consolidate the importance of an ethical analysis during the design phase of a new computer technology. I think that such analysis should be mandatory during the designing of new computer technologies since they have unique characteristics. I will also prove that this analysis can bring practical and moral advantages both to the developer and to users. In general, the deployment of a new technology always brings a bit of uncertainty since the consequences are unknown. This pinch of uncertainty may increase when we deal with computer technologies, since they have unique properties like software complexity and full-testing impossibility. Moreover, despite the usual tangible consequences, computer technologies can also bring a deep change in the perception of the world on its users. This will clarify why computer technologies are so delicate. To understand how the ethical analysis can bring advantages both to the developer and to users, it is important to define how responsibilities on consequences are shared among actors. I will discuss the moral responsibilities that arise from the large scale use of a new computer technology using the Bitcoin cryptocurrency as an example. At the end, it will be clear that despite the responsibilities can be shared among all the actors, the developer has a key role. Hence, his/her opportunity to correctly steer the technology enforces the idea that an ethical analysis during the design phase of a new computer technology is fundamental.

## Introduction

During the design phase of a new technology its characteristics and future ways of usage are determined. Developers with their decisions have the power to steer the way in which users will use their artefacts. On the other hand, users are free to decide if the technology must be used in accordance to the specifications and without violate any moral or legal law, or used in an inappropriate way. Users are free but not always aware. The way in which the technology is designed can push users to perform certain actions that sometimes have hidden consequences. Developers should perform an accurate analysis that aims to find them. The reason why consequences are unknown is the uncertainty that a new technology brings. As we will see, this uncertainty may increase if we are dealing with a computer technology. They have unique characteristics like software complexity and full-testing impossibility. Moreover, as stated by Verbeek (2006a, 2006b), technologies mediate perceptions and actions. This concept indicates the ways in which technologies establish relations between users and their environment. The mediation of perception is the amplification or reduction of some aspects performed by the technology; similarly, in the mediation of action some actions are invited while others inhibited. The basis of this thinking is that technologies should not be seen as pure instruments, but as active mediators. This mediating power is of course given by the developer with his/her designing choices. All these features necessitate an analysis that is not only focused on practical consequences but also on moral ones.

The aim of this paper is to enforce the idea that the ethical analysis is fundamental. My view is that such analysis should be mandatory during the development of new computer technologies. I will prove this first claim trying to explain: why computer technologies are unique technologies; why this uniqueness is critical if we are developing a new technology; why the analysis should be of ethical type and not just an analysis of possible consequences and why it should be performed. Moreover, I think that such analysis brings practical and moral benefits both to users and to the developer. To prove this, it will be necessary to show how responsibilities of consequences are distributed among actors. For this purpose, I will use a concrete example. It will highlight how the developer choices alter users' actions and it will show the practical and ethical benefits of an ethical analysis.

The paper is structured as follows. Firstly, I will clarify the concept of new technology, the concept of computer technology with its unique characteristics and what is intended by ethical analysis and its objectives. I will then describe how responsibility is defined and the criteria by which it is distributed among actors. To better understand the kind of problems that may arise with the release of a new computer technology and the way to distribute responsibilities, the Bitcoin example will be considered. In particular I will analyse what are the three main consequences of such technology. Ultimately, results will be evaluated.

## New Computer Technologies

First of all it is important to define what is a new technology and what is a computer technology. A new technology is something that did not exist in that precise form before its development. It can be a completely pioneering technology, unique and never seen before, or it can be an already existing one that is profoundly modified in order to obtain a new functionality. As examples we can refer to bitcoins and mobile phones. Bitcoin is a pioneering technology since it introduced the concepts of cryptocurrency and distributed consensus, two elements that were innovative at the time of release. A mobile phone, instead, is a modified technology since the idea of long distance communications were already present in traditional telephones, but it introduced the concept of mobility. Both were new technologies at the time of release, but today mobile phone and, at least to some extent, also cryptocurrencies are widespread. The purpose of focusing on a new technology is that the consequences of their use are unknown. Today, the consequences of mobile phones are well known, hence an ethical analysis during the design phase of a new model it is not so important, since it will not introduce any significant change or uncertainty.

Another difference to be clarified is the one between general technologies and computer technologies. With the concept of computer technology, I refer to any technical artefact that is strongly based on software. The artefact can be a physical object or simply the software itself, but software must be the essence of the artefact at stake. For example, a normal washing machine has some software in it, but the essence of the artefact is the mechanical part that performs the washing action. This distinction is necessary since computer technologies have some unique properties (Maner 1996). In particular, software, which is at the base of a computer technology, has two critical characteristics: software complexity and full-testing impossibility. Modern program are very complex artefacts that are the results of a set of components that interact together. As the number of entities increases, the number of interactions between them would increase exponentially. It is very common to reach a point where it is difficult, if not impossible, to fully understand the behaviour of the program, hence the outcomes become unexplainable. Even understanding program code in its static form does not imply understanding how the program works when it executes. This is related to the so-called invisibility factor (Moor 1985). As Moor explained, sometimes the calculations are too complex for human inspection and this inserts uncertainties in the result. The complexity can also bring to the invisibility of programming values that concerns all those values which are embedded in a program but were not desired by the programmers. Another fundamental problem concerning computer technologies is that software is not fully testable (Kaner 1997). Software is a sort of puzzle where single pieces are software components that communicate and operate together. Even testing all the components individually in a comprehensive way, that still remains a challenge, does not guarantee that they will work well when combined. Moreover, trying to test the software as a whole is impossible since it is impossible to test all the inputs and software combinations. As analogy, we can think of a bridge testing. If we know that the bridge should carry a certain load, we can test it with that load and if the bridge performs well, we are sure that the test is valid even for lower weights. For the bridge one test assures infinite correct situations. On the contrary, software does not display such continuous behaviour.

Computer technologies have become essential tools for our daily activities. They are involved in a lot of decision-making processes and they are changing the way people communicate and relate to each other. But algorithms, that are the core of computer technologies, are not neutral. They can incorporate algorithmic bias, i.e. the implicit human values, even without developer intentionality (Hajian et al. 2016). The bias can come from the code, from the data sources or from any other component used by the algorithm, and it can become harmful if it involves ethical principles like fairness, discrimination or privacy.

All the previous listed properties together with the growing pervasiveness of computer technologies in everyday life, the growing complexities of these technologies and the new possibilities that they provide, raise new kinds of questions and make computer technologies completely different from any other (Noorman 2012). From this consideration we can infer two observations. The first is that besides the uncertainty of new general technologies, computer ones add additional uncertainty due to their unique characteristics. The second is that computing adds additional layers of complexity in determining actors' responsibilities on consequences. Hence, a deeper analysis of possible consequences is necessary.

## Ethical Analysis

Shouldn't be enough an analysis on consequences? Why must it be ethical? I think that a simple forecasting of consequences is implicitly focused to much on practical outcomes. The risk is that ethical problems would be ignored. As we have seen, computer technology adds difficulties compared to normal ones. New technologies allow users to perform activities in new ways, and it is common that may arise situations in which we do not have adequate policies. In these cases we encounter the so-called policy vacuums (Moor 1985, 2005). The combination of policy vacuums and the uncertainty of computer technologies can bring to critical situations. It is easy to imagine a technology with undesired features that are exploited to perform unethical actions for which there are not ways (policies) to limit the consequences. To avoid critical situations and to control the strong mediating power, the analysis should focus on intangible consequences. The way in which the analysis must be performed is up to the developer. It can be a simple prediction by imagination or it can be performed with more systematic frameworks like the method of constructive technology assessment (Verbeek 2006a). The important thing is that the developer tries to anticipate all the possible ways in which the technology can be used, both intended and unintended. Based on these usage ways, all the consequences must be evaluated in order to be able to modify the technology. Development and analysis should run in parallel and the results of the analysis should be fed back into the design process.

## Responsibility

Up to now, it is clear what are the challenges that new computer technologies raise, that a deeper analysis on consequences is necessary and that this analysis should focus also on ethical problems. The other point of this paper is that the ethical analysis can bring advantages both to users and to the developer. To understand why, we can focus on disadvantages that comes by not performing such analysis. In particular it is interesting to analyse the responsibilities of actors on consequences associated to the spreading of a new computer technology. To do so, responsibility will be defined together with the criteria by which it is assigned to actors.

A common distinction on responsibility is between active and passive (Van de Poel et al. 2011). Active responsibility is the one concerning all the actions and practices that can be done before something happens; conversely, passive responsibility is a backward-looking responsibility, relevant after the fact is occurred. The process of identifying and assigning passive responsibilities for the use of a certain technology is useful to find out what are the main principles that can define active responsibilities for future developers. Analysing positive outcomes or problems is a good way to emphasise developer's responsibilities.
Passive responsibility involves accountability and blameworthiness. An actor is accountable if s/he can be accounted for the consequences of actions that s/he or someone has performed. On the other hand, blameworthiness means that it is proper to blame an actor for his/her actions or consequences of those actions. To assign blameworthiness, four conditions need to apply: wrong-doing, causal contribution, foreseeability and freedom of action. Wrong-doing is the violation of a legal, institutional or moral norm. Causal contribution is the presence of absence of an action that contributes to the chain of events that led to the consequence. It is also related to the ability to exert some kind of influence on that event. Foreseeability is the ability of the actor to know the consequences of his/her actions. Freedom of action means that the actor must not have acted under compulsion or coercion.

## Bitcoin And Its Consequences

To better understand the variety and unpredictability of consequences of a new computer technology, the related responsibilities among actors and the importance of the forecasting of such implications, the Bitcoin example is used.

Bitcoin is the first decentralized cryptocurrency (Nakamoto 2008). Its peculiarity is that no central administration is needed to ensure transactions and the entire system is maintained by a network of dedicated computers. To verify transactions, these network nodes perform complex calculation and record them in a distributed public ledger called blockchain. Bitcoin is also the most common cryptocurrency and its intensive use has brought major consequences on society, ranging from black markets expansion to global pollution (de Vries 2018, Foley 2018). To analyse and allocate the responsibilities of these consequences we can define four actors: developers, users, miners and regulators. Developers are those who created the Bitcoin infrastructure and can also act to modify it. We can identify as developer both who conceptualized and initially coded Bitcoin and who today maintains it; users are those who use Bitcoin as a payment method; miners are the caretakers of the infrastructure; regulators are the institutions, like governments, that can formulate rules and impose regulations. Beside these four actors, we can also identify the stakeholders. They are all the other subjects affected by the use of technology that cannot directly influence its development or fix the problems that may arise.

The use of Bitcoin has three major implications that are interesting to analyse in order to apply responsibility to the different involved actors. The first one is about its use in criminal activities, the second is about its large energy consumption and the last one is the changing of money perception. All these consequences are the results of the extensive use of Bitcoin, but they have different characteristics. Some of them are perceived as positive while other as negative, some were planned by the developer while other are unexpected and some are a material thing while other are a change of perception.

## Illegal Activities

A major characteristic of Bitcoin is the anonymity of the users. It is practically impossible to track Bitcoin transactions (Nakamoto 2008). Thanks to that, users can move money without being related to it. These features allow money laundering and have contributed to the growth of the darknet, the web place where illegal activities spread. It has been found that approximately one-half of Bitcoin transactions are associated with illegal activities (Foley 2018).

Starting from the fact that anonymity and impossibility of transaction tracking were intentionally wanted characteristics, we can assume that the developer was clearly aware of the problem of the illegal use of Bitcoin. At the time of the technology design this was an active responsibility of the developer since he had the possibility to mitigate the problem or even to stop developing the technology. Usually, related to active responsibility are the developer ideals (Van de Poel et al. 2011). If we assume that the ideal of the developer was to implement a technology with the objective of improving the world, we have two conflicting consequences. The first, that can be considered positive, is the availability of a new useful technology, and the other, that can conversely be considered negative, is the growth of web-based illegal activities. What drives the decision in these situations is the so-called technological enthusiasm that is the ideal of wanting to develop a new technology with strong desire. The developer can be so driven by the challenge that s/he can overlook the consequences or consider the positive ones prevail on the negatives. So, s/he is for sure accountable, but the technological enthusiasm can be considered as a mitigation of blameworthiness.

The other important actor involved is the user. In this case, the user who performs illegal actions using bitcoins is blameworthy, that means s/he is responsible in the sense of being the proper target of blame for his/her actions. In fact, all the four elements necessary to the blameworthiness are present: wrongdoing, causal contribution, foreseeability and freedom of action. Performing illegal action using Bitcoin as a payment to ensure anonymity is wrong both as a moral action, since illegal activities can be generally considered immoral, and as by the law. Casual contribution is clearly present since paying for an illegal good or service is part of the illegal action. The user's knowledge that the action s/he is going to perform is illegal is a reasonable assumption, so that defines foreseeability. In a general case, also freedom of action is present since users are not forced or coerced to perform illegal actions. Under these four assumptions the user is blameworthy, it is fully responsible for using Bitcoin as a payment for illegal goods or services.

Regulators and miners are the other actors involved. They have no responsibility for the spreading of illegal activities associated to Bitcoin. Regulators, such as governments, could ban the use of Bitcoin but this is a very weak way of mitigating the problem, since a person willing to commit illegal activities can easily overcome the problem (using proxies, VPN, ...). It can also be considered immoral since Bitcoin is widely used for lawful purposes. Since they have no other means of action, causal contribution fails, hence blameworthiness cannot be applied. Miners also have this decision problem, they could stop mining bitcoins but, in that way, they will put at risk all the infrastructure. Stop mining means also to lose all the investments they have done in mining hardware and miss all the estimated earnings. This is a sort of limitation in the freedom of action that implies a mitigation of passive responsibility.

Related to the increase of web-based illegal activities there is also a change in perception about those crimes. The common sense, when thinking about Bitcoin, is that it eases the fulfilment of such activities. This awareness can push willing users to commit crimes and pull others, already criminal, to the Bitcoin globe. This is a sort of mediation of perceptions and actions. It is a mediation that involves both users and stakeholders since the perception changes in all the people that knows about Bitcoin, hence not only in its direct users. Two actors are responsible for this mediation, users and developers. We can attribute blameworthiness to users who performs illegal activities using bitcoins since they contribute with the action that is the reason why Bitcoin is thought to be correlated with crimes. Then, we can attribute accountability to the developer since s/he intentionally created Bitcoin to be an anonymous system.

## Energy Consumption And Pollutions

The blockchain, the mechanism on which Bitcoin is built, depends on a compute-intensive algorithm that is largely energy demanding. A recent study (de Vries 2018), suggests that the Bitcoin network consumes at least 2.55 gigawatts of electricity and could potentially triplicate the value in the future, making it comparable with the consumptions of countries like Ireland or Austria. China is the country that hosts most mining facilities and it is the one with the highest power consumption among all countries for cryptocurrency mining (Hileman et al. 2017). Since, like most of the world, it still relies on coal, gas and oil to produce electricity (Dudley 2018), the problem of pollution is crucial.

Usually users are not conscious of the environmental impact of Bitcoin. Even today that the problem is well known, a user could start using bitcoins without being aware of it. This is a good example of how computer technologies can constrain the ability of users to consider the risks or harms related to their actions. In this case, users cannot foresee the consequences of the use and since foreseeability cannot be applied, blameworthiness cannot be assigned. If instead the user is aware of the problem and s/he still uses bitcoins s/he is both accountable and blameworthy.

Miners, on the other hand, are largely aware of the problem and a great part of them think that this is an issue to be resolved (Hileman et al. 2017). Miners can be seen as entrepreneurs that invest capitals in mining facilities and custom hardware equipment to obtain revenues. They are accountable, since their facilities directly contributes to the pollution problem, but they are not blameworthy given that they cannot counteract. In fact, miners don't have the means to modify neither the Bitcoin consensus algorithm, that is the responsible of the huge energy consumption, nor the types of sources that produce the energy their facilities use. Hence, they cannot carry out a causal contribution since they are not free to act. To stop mining is also unlikely due to the investments they have done to build and run the facilities. The lack of a positive causal contribution due to the impossibility to act determines the impossibility to assign them blameworthiness.

Regulators can act in two ways: banning mining facilities or imposing the energy production based on renewable resources. The first one is not really a solution since pollution based on industrial facilities remains even banning mining plants. It could be a solution if mining plants were the only contributors to pollution, but that is not the case. Banning only them would be unfair. Impose energy policy is a solution to the problem but from a wider point of view. It is a slow and indirect way to address the problem. The attribution of blameworthiness fails due to the lack of a causal contribution.

We can assume that the developer was aware of the possible growth of energy consumption of the infrastructure since the used algorithm is largely energy demanding. Even without this assumption, the problem of the energy consumption has become clearly evident during last years. A possible solution to the problem is the change in the consensus algorithm to improve the throughput of the network as suggested in (de Vries 2018). The problem was foreseeable during the initial development. Moreover, the developer failed to react to the problem. With no doubt we can say that the developer is blameworthy.

## Money Perception

One of the main purposes of the Bitcoin currency is to get rid of central authorities and financial institutions. This is possible thanks to the blockchain, a decentralized public ledger of all the transactions that occur. Miners validate transactions eliminating the need for a third party to process or store payments, in this way the community of users and miners oversees the system's security. A bank was the only authority that could ensure money credits and money exchanges, instead, the introduction of Bitcoin removes the need for powerful central authorities and hands control back to the individual users.

The spreading of this technology have generated a lot of new considerations about the essence of money. For example, the shift of trust from the bank to the infrastructure have contributed to change the perception about the role of authorities in money management. Fund can be transferred from owner to receiver without government or banks involvement. Another innovative aspect is that Bitcoin can be considered as a digital bearer instrument. The only essential thing to use it is to have it. There is no need of pre-existing trust between parties. Before Bitcoin, this has never existed in digital form (Andreessen 2014). An additional consideration that one could start thinking about is the benefit of having bitcoins instead of normal currency or even further to have a Bitcoin wallet as a replacement of the bank account. Also the idea of money value itself has changed. Usually the value is given by the authority that manages the system and ensures it. For the Bitcoin, and in general for all cryptocurrencies, money value is not created by an authority, but it is created through use and ensured by the community.

These unique characteristics of Bitcoin, and in general of cryptocurrencies, allow for discussions about the essence of money, how we manage it and the way in which we relate to it. "Bitcoin is meaningful and valuable not so much as an actual complementary or alternative currency, but instead as an index of much broader discussions over the nature of money, credit and capital in the world today" (Maurer et al. 2013, 263).

## Conclusion

The previous discussion revealed how many consequences, both positive and negative, can arise from a single technological innovation and how the related responsibilities can be shared among all the involved actors. The following tables show a summary of that distribution of responsibilities.

### Illegal Activities

| | Accountability | Blameworthiness |
|---|---|---|
| Developers | Yes | Yes, but mitigated by the technological enthusiasm |
| Users | Yes | Yes |
| Miners | No | No. Lack of freedom of action |
| Regulators | No | No. Lack of causal contribution |

Table 1: Actors responsibilities about illegal activities.

### Energy Consumption

| | Accountability | Blameworthiness |
|---|---|---|
| Developers | Yes | Yes |
| Users | Yes | No. Lack of foreseeability |
| Miners | Yes | No. Lack of freedom of action |
| Regulators | No | No. Lack of causal contribution |

Table 2: Actors responsibilities about energy consumption.

### Money Perception

| | Accountability | Blameworthiness |
|---|---|---|
| Developers | Yes | No. Lack of wrong-doing |
| Users | No | No. Lack of causal contribution |
| Miners | Yes | No. Lack of wrong-doing |
| Regulators | No | No. Lack of causal contribution |

Table 3: Actors responsibilities about money perception.

We can see how accountability does not imply blameworthiness. The blame is not assigned if some of the necessary conditions are not satisfied or can be assigned but with mitigations. The other important consideration is that the developer is always involved in the consequences, indeed we can see that in all the cases s/he is accountable. This result comes from the fact that the developer is at the beginning of the chain of responsibilities. Usually, s/he tries to achieve the positive consequences while avoiding the negative ones. Despite the good intentions, the outcome can be the opposite. There are cases where the technological enthusiasm brings to negative outcomes. In the Bitcoin example, although the growth of illegal activities was foreseen, the technological enthusiasm was so strong that the developer decided to release the technology anyway. Similarly, the developer underestimated the consequences of the Bitcoin energy consumption that leads to the problem of pollution.

All the actors that share blameworthiness should take into account the outcomes and be careful about their actions during the use of the technology, trying to forecast the consequences even if they are not evident. This is not easy. In our example, it is unlikely that users foresee the problem of pollution. The technology is available and users utilise it without taking too much care on consequences. There is also the case in which an actor knows about the consequences but cannot counteract, like miners for the problem of energy consumption that are not free to act. In this case they are not blameworthy but they are anyway accountable. Or, again, the anonymity of the currency makes the illegal actions to be perceived easier and less risky pushing users to commit crimes. Users are put in a position where performing an immoral action is easier or nearly inevitable. Hence, these consequences should be foreseen during the development phase. The key actor is then the developer that can avoid these types of unethical consequences on users by performing the ethical analysis. This proves that the analysis can bring moral advantages on users.

Beside to be a benefit for users, this is also an advantage for the developer since s/he has the moral responsibility to develop a harmless technology. Forecast is difficult, but if the analysis is performed with the right effort, the developer cannot be considered blameworthy or at least the blame is mitigated. Supposing that an unwanted consequence take place, if the analysis has been performed, the foreseeability element of passive responsibility is not present and the blameworthiness cannot be assigned. This proves that the analysis brings moral benefits to the developer.

The practical advantages are easy to see. Since the analysis is a forecasting of consequences, it allows the developer to better the product and helps its development. Instead, the practical benefits for users are that the product will be a better and harmless one.

As we have seen, new computer technologies have unique properties that make their development a critical phase. They can be powerful mediators of perception and actions and they introduce strong uncertainty due to software complexity and non full-testing possibility. Developers have both practical and moral advantages in performing an ethical analysis. The same is for users and, in general, for the other actors affected by the technology. For these reasons I think the ethical analysis is mandatory to develop a good new computer product.

## References


Andreessen, M. (2014). Why bitcoin matters. New York Times, 21.

de Vries, A. (2018). Bitcoin's Growing Energy Problem. Joule, 2(5), 801-805.

Dudley, B. (2018). BP statistical review of world energy 2018.

Foley, S., Karlsen, J., & Putniņš, T. J. (2018). Sex, drugs, and bitcoin: How much illegal activity is financed through cryptocurrencies?.

Hajian, S., Bonchi, F., & Castillo, C. (2016). Algorithmic bias: From discrimination discovery to fairness-aware data mining. In Proceedings of the 22nd ACM SIGKDD international conference on knowledge discovery and data mining (pp. 2125-2126). ACM.

Hileman, G., & Rauchs, M. (2017). 2017 Global Cryptocurrency Benchmarking Study.

Kaner, C. (1997). The impossibility of complete testing. Software QA, 4(4), 28.

Maner, W. (1996). Unique ethical problems in information technology. Science and Engineering Ethics, 2(2), 137-154.

Maurer, B., Nelms, T. C., & Swartz, L. (2013). "When perhaps the real problem is money itself!": the practical materiality of Bitcoin. Social semiotics, 23(2), 261-277.

Moor, J. H. (1985). What is computer ethics? Metaphilosophy, 16(4), 266-275.

Moor, J. H. (2005). Why we need better ethics for emerging technologies. Ethics and information technology, 7(3), 111-119.

Moser, M., Bohme, R., & Breuker, D. (2013, September). An inquiry into money laundering tools in the Bitcoin ecosystem. In eCrime Researchers Summit (eCRS), 2013 (pp. 1-14). IEEE.

Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system.

Noorman, M. (2012) "Computing and Moral Responsibility", The Stanford Encyclopedia of Philosophy (Spring 2018 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/spr2018/entries/computing-responsibility/>.

Rip, A., Misa, T. J., & Schot, J. (Eds.). (1995). Managing technology in society. London: Pinter Publishers.

Van de Poel, I., & Royakkers, L. (2011). Ethics, technology, and engineering: An introduction. John Wiley & Sons.

Verbeek, P. P. (2006a). Materializing morality: Design ethics and technological mediation. Science, Technology, & Human Values, 31(3), 361-380.

Verbeek, P. P. (2006b). Persuasive Technology and Moral Responsibility Toward an ethical framework for persuasive technologies. Persuasive, 6, 1-15.