A Survey of Ethical Reasoning Methods, Their Metamodels, and a Discussion on Their Application to Conceptual Modelling

Sergio España[1,2(✉)], Chris van der Maaten[2], Jens Gulden[2], and Óscar Pastor[1]

[1] Valencian Research Institute for Artificial Intelligence, Universitat Politècnica de València, València, Spain
[2] Utrecht University, Utrecht, The Netherlands
{s.espana,j.gulden}@uu.nl

Abstract. There is wide acknowledgement of the benefits we reap from information and communication technology (ICT) in many facets of our lives. But there is also an increasing concern over the negative ethical, social and environmental impacts it sometimes has. This leads many stakeholders, such as conceptual modellers, programmers, users and policy makers, to situations where they need to reason about the ethical implications raised by ICT engineering or usage. This paper offers a survey of ten ethical reasoning methods suitable for the ICT domain. We present the method metamodels we have authored and then validated through expert interviews. We also reflect about the application of such methods within conceptual modelling. We expect to pave the way for further research on reasoning about the ethical implications of ICT, in general, and conceptual models, in particular.

Keywords: Conceptual modelling · Ethics · Ethical reasoning · Sustainability assessment · Method engineering

1 Introduction

Nowadays, there is awareness of the range of positive and negative impacts of information and communication technology (ICT) in business, society and the environment [40]. It is increasingly common to reason ethically about the implications of a specific ICT [10], to incorporate value management during ICT design (e.g, Value Sensitive Design -VSD- [31]), or to compare two or more designs as part of a trade-off analysis of their impacts (e.g. [43,99]), motivated by intrinsic (e.g. engineers' moral values) and extrinsic (societal pressure) factors. In the last decade, several methods have been proposed to perform such ethical reasoning, some specifically targeted at the ICT domain and others adapted

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for or demonstrated to be applicable to the ICT domain (e.g. we have been using these in higher education [44,50,70]). For many ICT engineers, conceptual models play a pivotal role in the analysis and design of ICT, given their potential to be subjected to quality assessments [16,49], different sorts of analyses [68], simulations [75], and transformations or code generation [36,65]. In this paper, we claim that conceptual models can be the subject of ethical assessments. However, to date, there has been no comprehensive survey of existing *ethical reasoning methods for ICT* (that is, methods that aid in ethical reasoning, aimed at the ICT domain), nor a discussion on how they can be applied to conceptual models to discover the ethical implications of ICT conceptualisations and designs.

This paper applies a multivocal literature review to collect a set of such methods, and makes the following contributions:

- A description of each ethical reasoning method, including the method metamodels using Process Deliverable Diagrams (PDDs) [94].
- A discussion on how ethical reasoning methods can be applied to assess conceptual models, along with an example.

We first explain the research method in Sect. 2. We review the literature in Sect. 3. Section 4 presents the ethical reasoning methods we have found so far, and their metamodels. Then, in Sect. 5, we discuss the application of ethical reasoning methods to assess conceptual models. After a discussion of the results (Sect. 6), we conclude the paper and anticipate some future work (Sect. 7).

2 Research Method

Multivocal Literature Review (MLR). We opt for an MLR [32] because grey literature can report valuable methods. We have searched IEEE Xplore, ACM Digital Library, Web of Science, Scopus, and Google Scholar for scientific literature, and Google for grey literature. The search string is constructed from Table 1. We retrieved the first 100 results from each engine. After removing duplicates, we applied inclusion criteria that checks whether it indeed presents an ethical reasoning method for ICT (C1-C3) that is up to date (C4):

- **C1.** As a method, it prescribes a specific way of thinking, consisting of directions and rules, structured in a systematic way in activities with corresponding products [13].
- **C2.** It aids in ethical reasoning, that is the ability to identify, assess, and develop ethical arguments from a variety of ethical positions [88].
- **C3.** Regarding the ICT domain, either of these subconditions holds true:
  - **C3a.** It is specifically aimed for use in ICT-related situations.
  - **C3b.** It comes from a different discipline, but earlier research projects have empirically proven its applicability to the ICT domain.
- **C4.** In the case of method versions, we kept the most recent one.

Table 1. Concepts defining our unit of analysis, along with related terms

Concept	Related terms
Ethical reasoning	Moral reasoning, ethical decision making, moral decision making, moral dilemma, ethical dilemma, ethical impact, ethical evaluation, ethical assessment, incorporating ethics
Method	Methodology, modelling, framework, tool, approach, guideline
ICT	Information and communication technology, IT, ICT ethics, digital ethics, computer ethics, information ethics, cyber ethics, technology ethics

This resulted in 10 studies with their corresponding methods to be analysed. For each study, we performed forward snowballing [97] to collect additional method manuals and studies reporting extensions or validations.

Method Analysis and Metamodelling. For each of the methods, we have performed a perspective-based reading [4] of all sources in order to identify the method background, purpose, process and product descriptions, and applications or validations. We then have metamodelled the methods with Process Deliverable Diagrams (PDD), consisting of a UML Activity Diagram (representing the flow of activities prescribed by the method) and a UML Class Diagram (representing the information structure of the input, intermediate and final products of the method), interlinked with output relationships [94].

Validation of Method Metamodels. The resulting PDDs were first subjected to peer reviewing. Then we conducted expert assessment semi-structured interviews [96, p. 63] with the method creators (i.e. authors of the studies) where we verified the completeness of our method documentation, we validated our understanding of the background and purpose of the method, and we guided the method expert through the PDD, asking whether it represented the method well. We elicited improvement points, asking for explicit changes they would suggest and the rationale behind those changes. Find the detailed protocol in the technical report [24]. We then updated the PDD accordingly, keeping track of the changes in a PDD validation matrix, inspired by [19].

Reflection on the Application to Conceptual Modelling. Some of the reviewed studies discuss assessments of ICT-related products and research. These, along with the analysis of the methods, and our own first-hand experience in teaching and applying the methods, have allowed us to hold a few discussion sessions about the role of ethical reasoning methods within conceptual modelling. Herein, we elaborate on our thoughts, illustrate the application of one method, and include conceptual model sketches and rich pictures [6].

3 Review Results

The review has yielded ten ethical reasoning methods for ICT, summarised in Tables 2 and 3. The *Method* column shows its name and main reference;

Background lists disciplines or theories the method builds upon; we express the method *Purpose*; we summarise its *Process*; *Empiricism* indicates reported endeavours to test or validate the method. For the sake of brevity, we select a couple of methods which have a graphical notation to elaborate on them and offer an example; the technical report provides longer descriptions and examples of each [24].

Architecture Decision Maps [50] are part of the Sustainability Assessment Framework Toolkit [51], and allow framing ICT architecture design concerns around four sustainability dimensions (technical, economic, social and environmental), ascribing these concerns to impact levels (immediate, enabling and systemic, which are equivalent to those in the LES model [40]). The map also expresses positive (+), negative (-), and undecided (unlabelled) cause-effect relationships from the ICT towards the concerns and among concerns, in the fashion of Causal Loop Diagrams [37]. To create the maps, the engineers should engage the stakeholder, ideally in a participatory modelling workshop. Figure 1 shows a decision map depicting the trade-off analysis among the impacts that a mobility as a service (MaaS) system might have, from the perspective of the system users. On the one hand, the `MaaS system` offers a `Flexibility of mobility means` that enables citizens to shift from the `Possession of personal cars`, to relying on other means to ensure their mobility (e.g. public transportation, shared cars and bikes). This is likely to produce the beneficial effect of having less `Cars on road`. On the other hand, since a greater number of people will have access to cars owned by others through the car-sharing feature of the system, they will likely be used more often (meaning more `Cars on road`); but it is unlikely that this would cancel out the overall beneficial effect. During system design, the model represents the stakeholder concerns and agreements elicited during the workshops, but the model assumptions should be supported by earlier empirical evidence or be validated by the engineers.

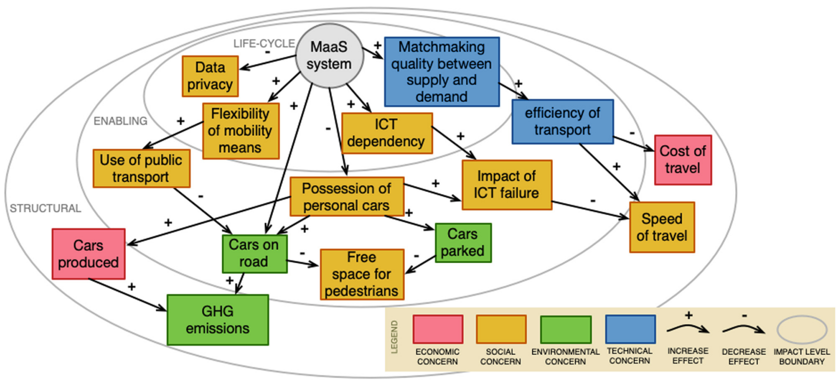

Fig. 1. Example of an Architecture Decision Map of a mobility-as-a-service (MaaS) ICT (own re-creation of model from [50])

Table 2. Summary of ethical reasoning methods (part 1)

Method	Background	Purpose	Process	Empiricism
Architecture Decision Maps [50]	• Sustainability as a software quality [52] • Impact levels of ICT [7,40]	Make sustainability-driven ICT design decisions, despite trade-offs	**1.** Determine sustainability concerns **2.** Determine impact levels of concerns **3.** Relate effects.	• Expert assessment [23] • Action research [50,61]
Design Solution Matrix [44]	• VSD [31] • Virtue Sensitive Design [89] • Regulative ideas as the best possible solutions [45]	Structuredly comparing different ICT designs decisions, from an ethical point of view	**1.** Identify norms ICT should abide by **2.** Identify design fragment affected by each norm. **3.** Define regulative idea **4.** Agree on best feasible solution	• Action research [44]
Square of Values for Business Informatics [70]	• Values as guiding principles [39,86] • Aristotelian virtues [76] • Value synthesis framework [38]	Modelling ethical dilemmas and alternative designs using a quadrant	**1.** Model initial and sister values **2.** Model exaggeration values **3.** Describe current, alternative and negative designs **4.** Discuss options and agree on design	• Action research [70] • Expert assessment in participatory workshop [71]
Ethics Canvas [73]	• Business Model Canvas [64] • Science and Technology Studies [2,27,42,67,78,91] • VSD [31]	Identify and discuss ethical impacts of technologies and come up with countermeasures.	**1.** Identify stakeholder groups **2.** Consider potential ethical impacts on them **3.** Consider non-stakeholder-specific impacts **4.** Discuss actions to overcome impacts	• Student testing [57] • Action research [41,57,62].
Ethical Dilemma Scenarios [98]	• Scenarios in strategic management [34] and policy making [17]	Collaborate in describing plausible futures where emerging technologies raise ethical issues requiring discussion among stakeholders.	**1.** Create matrix ICT applications⊥ ethical values/issues **2.** Fill in cells **3.** List *sunny*, *dark*, *popular push-back* and *unintended consequences* scenarios. **4.** Agree on story line, write scenarios.	• Participatory workshop [98]

The **Square of Values** guides analysts and engineers in visualising, discussing and resolving interests between conflicting values. Each corner of a rectangle represents a different value. Values in the upper corners represent positive intentions and are desirable. However, because they are conflicting, they cannot be achieved at the same time. Values in the lower corners should be avoided and are undesirable. This defines a space where system design options can be geometrically positioned and compared with respect to their proximity to the four values. Figure 2 shows the example of a healthcare management system (HMS). The HMS should allow the healthcare provider `Control` over the patient records,

Table 3. Summary of ethical reasoning methods (part 2)

Method	Background	Purpose	Process	Empiricism
MEESTAR [56]	• Developed during industrial project	Identify ethical issues caused by a socio-technical arrangement (i.e. an ICT in its context of use)	**1.** Interdisciplinary groups reflect from social, individual, organisational perspectives **2.** Identify ethical issues in 7 ethical dimensions **3.** Assign stage 1–4 to each dimension	• Action research [48, 83, 99]
Techno-Ethical Scenarios [11]	• Moral principle of *prudence* [84] • NEST-ethics [85]	Enhance techno-moral imagination to anticipate coevolution of technology and morality	**1.** Analyse current moral landscape **2.** Envision controversies by ICT introduction **3.** Determine plausible resolutions **4.** Write scenarios	• Method demonstration by authors [11]
Strategy Mapping for ICT [92]	• Strategy maps in Organisational Management [46]	Give stakeholders common understanding of human value tensions in project, and how to estimate, measure and validate. [26, 92]	**1.** Model elements and relationships: (i) ICT owner goals, (ii) customer values, (iii) intended ICT effects, (iv) existing/alternative processes/ICT designs **2.** Specify indicators for each element **3.** Design monitoring cycle **4.** Validate empirically causal relationships	• Action research [18, 63, 92, 93]
Ethical Framework in Information System Decision Making [12]	• Stockholder theory [30] • Stakeholder theory [25] • Social contract theory [20]	Provide framework to examine the ethical dimensions of ICT professionals decisions	**1.** Define dilemma **2.** Adopt the ethical lens of each theory consecutively **3.** Combine results.	• Method demonstration [12, 54]
Ethical Matrix in Digital Innovation [80]	• Ethical Matrix for biotechnology [59] • Value-Sensitive Design [29]	Provide structural framework to examine the ethical dimensions of ICT professionals decisions	**1.** Value investigation (e.g. literature review, interviews, workshops) **2.** Create matrix of stakeholders⊥values **3.** Workshops to identify positive, neutral, and negative impacts of existing, alternative or final ICT designs	• Action research [80, 82]

while respecting the `Privacy` according to legal and social standards. Both are considered desirable, but cannot be fully achieved at the same time. Without the balancing tension between both values, the values can easily degenerate into exaggerations; that is, when taken to the extreme, the system could run into `Heteronymy` due to over-control, or `Negligence` due to not storing any data to avoid privacy concerns. The engineers have generated four design scenarios in yellow boxes and placed them close to the values they realise. Two negative scenarios are associated with undesirable values, shown in red boxes. And the main scenario is deemed to find a balance between the two positive values

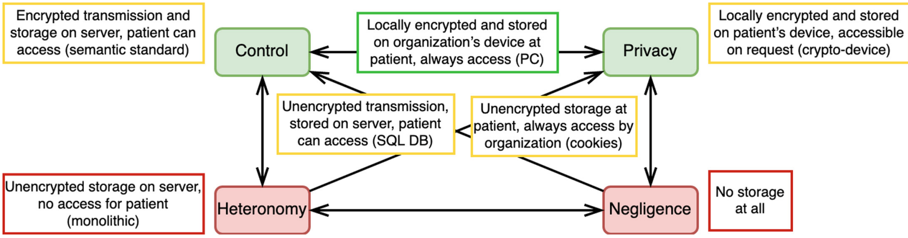

Fig. 2. Example of a an application of the Square of Values method to a healthcare management system (own creation, adapting a model from [70]).

(i.e. locally encrypting and storing while allowing the organisation to access the information), shown in a green box located between the two desirable values.

4 Metamodelling the Ethical Reasoning Methods

4.1 Process Deliverable Diagrams

We decided to create rigorous metamodels that provide a unified view on the examined methods. Process Deliverable Diagrams (PDD) [94] allow us to describe each method in detail and make them comparable among each other, as shown in Fig. 3 and Fig. 4. While metamodelling the process dimension we had to make some assumptions, such as the (total or partial) ordering of activities. With respect to the deliverable dimension, we had to find a balance to the following trade-off: accurately describing the information infrastructure of the method while keeping the elements in the diagram recognisable to method creators. At this point of our long-term research project, we are not yet attempting to develop tool support for the methods, so we made some concessions (e.g. specifying the Ethics Canvas as an aggregation of specialised blocks, rather than modelling it as a single class). To offer a complete method specification, PDDs need to be accompanied by tables that explain each activity and deliverable. For the sake of space, we include these in the technical report [24].

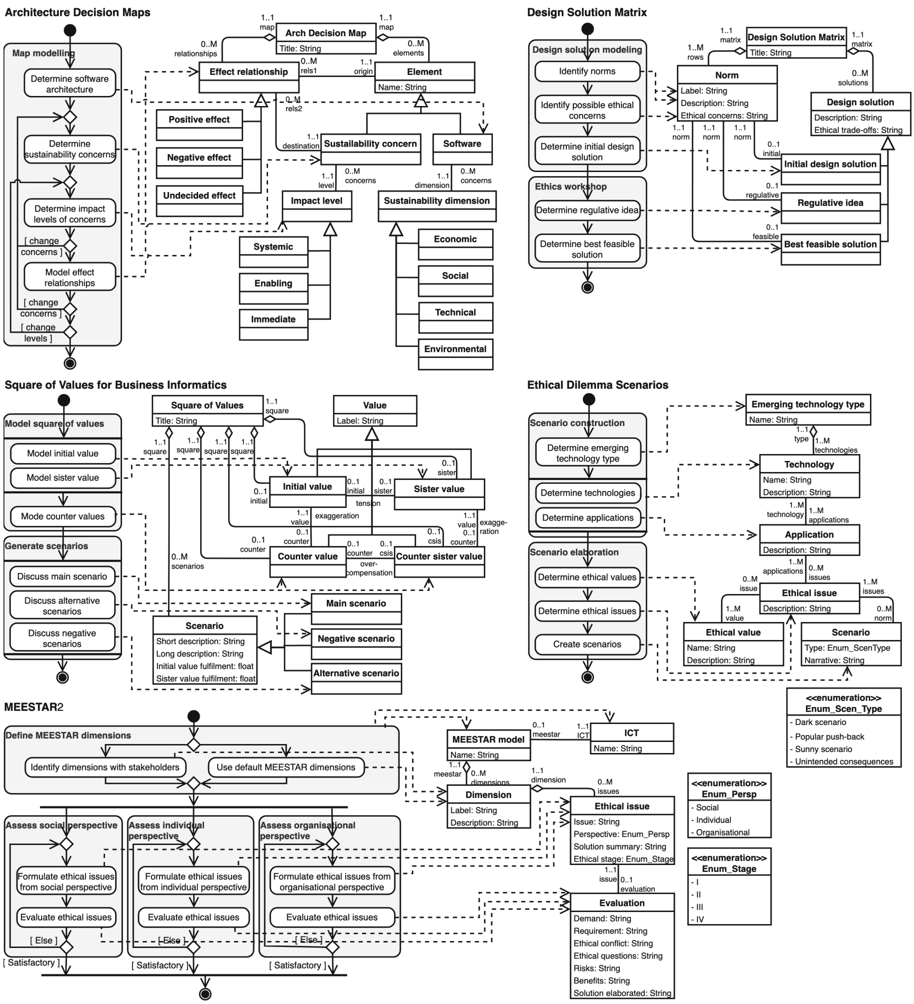

Fig. 3. Process deliverable diagrams of the following methods (left-right and top-down): Architecture Decision Maps, Design Solution Matrix, Square of Values for Business Informatics, Ethical Dilemma Scenarios and MEESTAR. Final versions after validation (own creation).

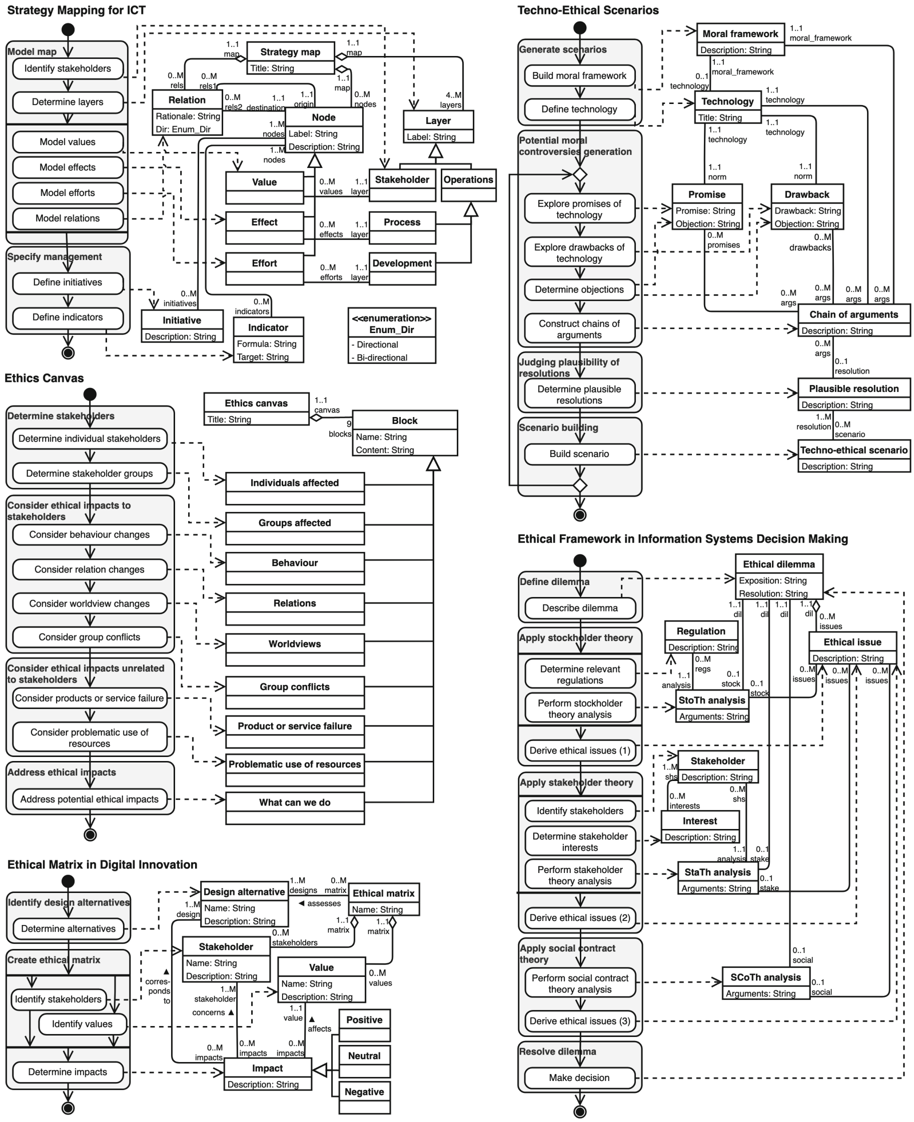

Fig. 4. Process deliverable diagrams of the following methods (left-right and top-down): Strategy Mapping for ICT, Techno-Ethical Scenarios, Ethics Canvas, Ethical Framework in Information Systems Decision Making, and Ethical Matrix in Digital Innovation. Final versions after validation (own creation). We expressed *many* cardinalities with `M` because earlier experience interviewing non-ICT professionals showed us that they understand it better than `*`. We keep this notation consistent throughout the paper.

4.2 Validation

We peer-reviewed the PDDs several times within the research team, improving the layout and structure by following good practices for process [58] and information modelling [22], changing the names of some activities, classes and relationships, revising cardinalities and adding role names. Then, we conducted eight interviews with method creators, to validate the PDDs of eight methods, along with their tables. In the case of MEESTAR, we interviewed an experienced method user. Overall, method experts stated that the PDDs reflect the methods well. Some pointed towards slight inaccuracies or proposed concrete changes, such as adding process loopbacks, or improving activity and deliverable descriptions. We revised the diagrams and tables accordingly. The changes are summarised in Table 4. For instance, the PDD of Architecture Decision Maps was not revised after the interview, since the creator deemed it accurate. In turn, the validation of the PDD of Strategy Mapping for ICT led to adding three activities to the process (to reflect the specialisation of a deliverable), changing two flows to make sequential activities unordered, changing tha name of one activity, creating three specialised classes, along with their three specialisation relationships, adding three relationships, changing the name of two classes to more appropriate ones (i.e. `Perspective` to `Layer` and `Objective` to `Node`), and changing two cardinalities. Overall, the number and nature of the changes make us confident of the accuracy of the metamodels.

5 Application to Conceptual Modelling

Earlier research has demonstrated the utility of conceptual (general-purpose of domain-specific) modelling languages to analyse or design ICT for ethics-related purposes, such as environmental management [47], corporate social responsibility [15], sustainable building design [33], ethical machine learning [100], social-ecological systems [1], and social impact [9]. During our MLR we have not found

Table 4. Matrix indicating how many elements were created (C), updated (U) or deleted (D) in each method metamodel artefact, after the expert validations.

Method	Process			Deliverables			Tables		
	C	U	D	C	U	D	C	U	D
Architecture Decision Maps									
Design Solution Matrix							1		
Square of Values for Business Inform.					4				
Ethics Canvas									
Ethical Dilemma Scenarios		2	2		2		1	2	
MEESTAR2	1	2	1						
Strategy Mapping for ICT	3	3			4				
Ethical Matrix in Digital Innovation			1	1				7	

any evidence of an application of ethical reasoning methods within conceptual modelling. Nonetheless, it is plausible that modellers do sometimes reason about the ethical consequences of their models. Perhaps such reasoning takes place indeliberately or in an unstructured way, triggered by situations where a conceptual model fragment elicits feelings of dissonance or ambivalence in the modeller, when the human values instantiated in the model are incongruent with the human values important to the modeller. Social and experimental psychology has explained the mechanisms by which value incongruence produces feelings of ambivalence [90] or dissonance [81]. Ethical reasoning methods give modellers the opportunity to plan the assessment of the models they are responsible for, or assess them contingently upon a feeling of discomfort. Herein, we further reflect on the role of ethical reasoning methods within conceptual modelling.

Let us define a fictional, illustrative case. A Dutch research institute is developing a software named Cancer Research Management Information System (CaRMISy), to support a research project investigating genetic and contextual factors that increase the probability of developing several types of cancer, using patient samples and clinical data from hospitals. Part of the project studies the prevalence of certain cancers in families. As a result, one fragment of the conceptual model underlying CaRMISy represents a family tree (see Fig. 5). Karin has joined the project recently and is extending the conceptual model with classes devoted to genetic mutations based on the current state of the art [8], when she feels that there is something 'wrong' in the way families are modelled. Apart from finding that the minimum cardinalities of the roles `father` and `mother` do not account for situations where the biological parents are unknown, Karin feels that the model does not match well with some of the families around her. Two of her best friends are a gay couple who have two children: one that was born from one of the fathers with a previous woman partner, and one that the couple have adopted recently. Also, a niece of hers does not feel represented by neither the man nor the woman labels.

Karin decides to apply the Square of Values method (see Fig. 6). Since her husband has recently conducted research on the Theory of Basic Human Values [79], she decides to frame the ethical dilemma in terms of this theory. She selects `Self-direction` as the initial value, representing that CaRMISy should perhaps accommodate to the gender expressions of the research subjects, and `Conformity` as the sister value, since most database designs she has seen in the healthcare domain conformed with binary genders. As an exaggeration value, she opted for `Anarchy`, representing that data would be impossible to analyse properly if

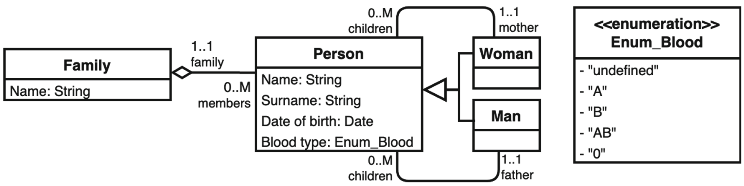

Fig. 5. Controversial fragment of a conceptual model of the illustrative case.

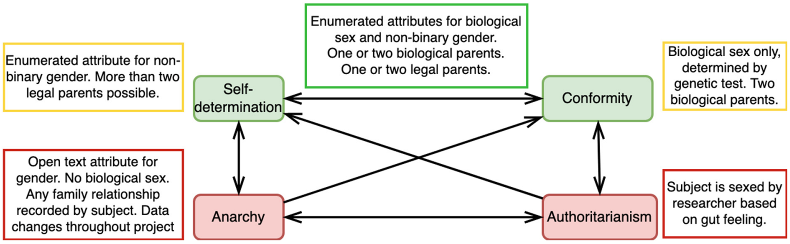

Fig. 6. Application of the Square of Values method in the illustrative case.

subjects were given the chance to describe their perceived gender in an unconstrained open text field. For the other one, she chose `Authoritarianism`, and she entertained the idea that the researchers themselves would sex the subjects based on gut feeling. She did not spend much more thought on negative scenarios, and instead concentrated on alternative scenarios, in search for some balance among the positive values. After considering what scenarios would embody the `Self-direction` and `Conformity` values and even drafting some conceptual model fragments realising such designs, she came up with a solution that felt like a reasonable trade-off: (i) including attributes for biological sex and non-binary gender, which would have enumerated data types, (ii) the model would include relationships to express both the biological and legal parents. She considered whether to open the model to the possibility of more than two legal parents, given that the Dutch government had been recommended to reform the law to recognise plus-two-parent families [14]. But she left that for an alternative scenario; she also did not want to push too far before getting to know her project colleagues better. Afterwards, Karin revised the conceptual model (see Fig. 7) and presented it to the CaRMISy project manager, who agreed to the changes. It became clear that the research team was not willing to do genetic tests to determine the biological sex during the intake process, but rather rely on the subjects self-reporting; only in the case when phenotypic traits did not match the reported sex, they would politely inquire the subject further. They agreed that including gender information would make subjects more comfortable than merely asking about sex, since it would offer some chance for gender expression. The conversation with her manager went on for one hour and they ended up agreeing to further revise the model and (later) the user interface designs, to account respectfully for transgender situations [3].

The example shows a conceptual modeller resorting to an ethical reasoning method for ICT, when confronted with an ethical dilemma, during conceptual modelling activities. We propose to distinguish the moments, relative to conceptual modelling, when the methods are applied, adopting categories from [74]:

– **Ex ante.** Before starting the conceptual modelling (e.g. when just a vision for the ICT is available), as a way to detect potential value conflicts, impacts, or ethical dilemmas of the envisioned ICT, then informing the conceptual modelling activities in the form of requirements, constraints or just warnings.

- **Intra.** During or right after conceptual modelling or right after producing the pre-final version, as a one-time or recurrent reflection where versions or fragments of the conceptual model are assessed. It likely results in changes to the conceptual model and in rationale for some modelling decisions.
- **Ex post.** Assessing the system already in use. If relevant impacts or ethical concerns are detected, a feedback loop towards conceptual modelling allows correcting the issues and reengineering the ICT implementation.

The example above relates a case of an *intra* application. Figure 8 provides an overview of these different contexts of use. Stakeholder groups and other elements in the domain provide knowledge that is key to the processes depicted below. Ethical reasoning methods enable a cycle safeguarding the ethical integrity of the conceptual model.

Figure 9 shows a draft of the conceptual model that underlies Fig. 8. As research in this area progresses, the community will propose or discover more concepts, details and relationships. For instance, it is likely that the results of applying a method in a (fragment of a) conceptual model will point directly to specific elements of the model, either highlighting them as ethically problematic or expressing a sustainability or ethical trade-off among two or more elements (or fragments). Some methods are clearly judging designs (e.g. the Design Solution Matrix); in such cases it is probably easy to assign (fragments of) a conceptual model to cells of the matrix. Some methods assess the ICT as a black box

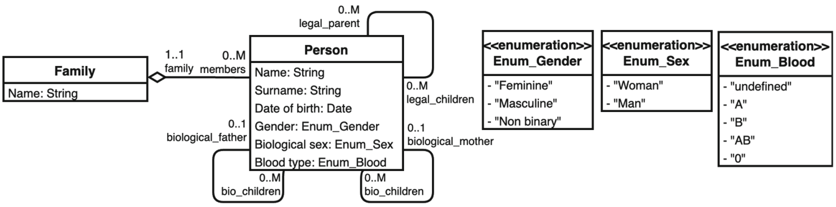

Fig. 7. Conceptual model fragment, after the main scenario of the Square of Values.

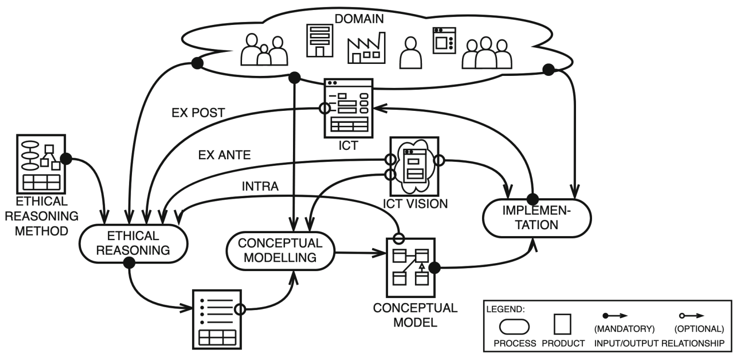

Fig. 8. Contexts of use of ethical reasoning methods within conceptual modelling.

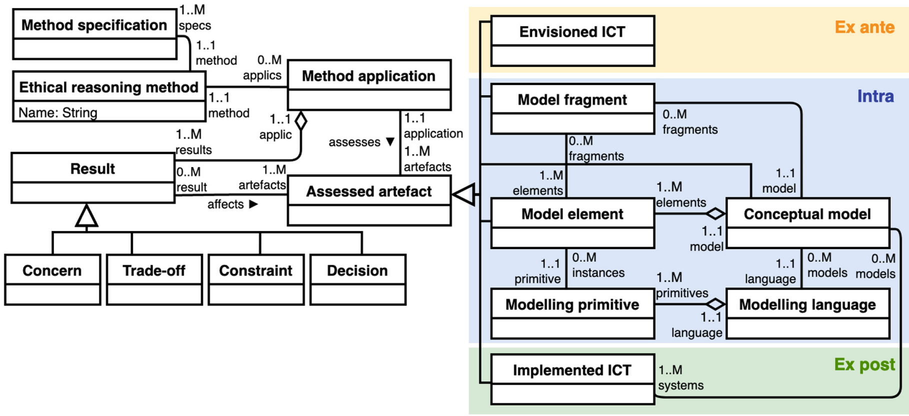

Fig. 9. Conceptual model of ethical reasoning methods within conceptual modelling.

(e.g. Techno-Ethical Scenarios); then it might be necessary to build a bridge between the results of the method and the conceptual model. This will perhaps require an extension of the method in the form of an activity that elicits and documents the requirements or constraints that will affect the conceptual model (in *ex ante* situations), or that performs a change impact analysis identifying the elements of the model that are affected (in *intra* or *ex post* situations). We expect traceability and model evolution analysis to play a role here [77].

6 Discussion

6.1 Interpretation of the Results

This research is located at the cross-point of ICT ethics and conceptual modelling, involving a method engineering approach. The foundation for reasoning about ethical consequences of ICT was laid by Wiener in the book "The human use of human beings" [95]. In 1978, Maner [55] defined the field of Computer Ethics and developed curriculum materials and pedagogical advice for university lecturers. The information revolution sparked interest on this field (e.g. [60]) and there has been an increase in such research during the last decade [10]. Reasoning about the ethical consequences of ICT is a subdiscipline of applied ethics, the application of ethical principles in practical situations [10,66]. When defining the scope of our method survey, we opened it to sustainability reasoning methods, such as Architecture Decision Maps, based on the widespread regard of sustainability either being a field within applied ethics [5, p. 18] or being linked by important conceptual and operational relationships to ethics [87].

Most of the studies we collected during the MLR present methods that have been specifically engineered to assess ICT, with the exception of the Square of Values and Strategy Mapping, which were nonetheless included thanks to condition C3b (Sect. 2). The studies described the methods textually, with some diagrams representing aspects of the method (e.g. MEESTAR is often represented as a cube). We only found a metamodel for Architecture Decision Maps [51], which covers just the deliverable dimension. During the expert interview, the method creator expressed that our metamodel is equally valid.

Different methods refer as *value* to different things. In the context of Value-Sensitive Design, human values refer to "what is important to people in their lives, with a focus on ethics and morality" [28, 4]; Design Solution Matrix focuses on norms used to refer to ICT behaviours ought to be considered valid by project stakeholders; within Strategy Mapping for ICT, values also encompass stakeholder goals such as "Quicker response" of the ICT [92]. Similarly, the focus of the ethical issues and values differs across methods, some embracing sustainability more explicitly (e.g. Architecture Decision Maps) than others (e.g. MEESTAR2). However, all methods fall within the realm of ethical reasoning by offering guidelines to elicit such concerns from the affected stakeholders or by putting the method user in the skin of the stakeholders, guiding a reflection on the effects of the ICT, and spotting where there is a need or a space for improvement. Some methods also offer means to propose design solutions.

6.2 Limitations and Threats to Validity

As in any structured literature review, we can claim that we have followed a rigorous procedure but we are careful not to make strong claims concerning the completeness of our results. In fact, we are aware that some methods have fallen out of our radar. We discovered a couple while writing this article. For instance, the Ethical OS toolkit, which intends to help ICT practitioners to reflect on the possible unintended consequences of their work [53], especially regarding dark user experience patterns [35]. In future iterations of this research, they shall be considered in order to provide a more comprehensive method repository. There are also methods which allow for ethical reasoning which, even when they are not specifically designed for the ICT domain, they could in principle be applied. This of course, requires validating such assumption. Among them we find Consequence Scanning [21] and the RRI Roadmap [69].

To validate the method information and PDDs, we approached method creators because we expect them to have the most detailed and accurate knowledge about the method, including the goals and method design rationale, which may not be described in the paper. The creators of two methods declined or ignored our interview invitation. Finally, when determining the extent to which the methods have been investigated empirically, we have considered that an application of a method by researchers in the context of a real project is action research, without judging the quality of the protocol they applied.

7 Conclusions

This paper presents a survey of ethical reasoning methods for the ICT domain, that we collected through a multi-vocal literature review. Their metamodelling offers opportunities to incorporate them within conceptual modelling practices and research.

We have placed a foundation stone upon which other projects can be defined. We now outline a few. The method base can be extended with additional ones that have escaped our review or might arise in the future. Some authors might be interested in modifying our definition of ethical reasoning methods for ICT to expand or shift the scope. Also, studying the characteristics of the methods might help discover which are more suitable to *ex ante*, *intra* or *ex post* situations, which are scalable in terms of participants, which facilitate trade-off analysis among the concerns of several stakeholder groups or which focus on ethical dilemmas confronting just two concerns. We plan to adopt a situational method engineering approach to investigate the situational factors that make one method preferable over another one when confronted with a given ICT engineering or ethical assessment, so as to guide engineers, analysts and other stakeholders in selecting the method that better suits their context.

It will be insightful to empirically evaluate ethical reasoning methods for ICT under controlled circumstances or in actual practice, with a single or multiple users, applying them to different ICT artefacts (e.g. visions, requirements, conceptual models, beta versions, deployed systems). Comparing the performance will allow discovering their strengths, weaknesses, trade-offs and sensitivities. It is also relevant to investigate the loopback cycle that conceptual modellers enact in cases where the model is subject to ethical reasoning while being created. Similarly, we find it relevant to investigate situations in which more than one method is applied simultaneously or sequentially over the same or different versions of a conceptual model, how to do this efficiently, and study the strengths and weaknesses of such method combinations. This can be addressed by applying situational method construction approaches [19,72]. Lastly, the development of tools that support these methods might facilitate their integration with conceptual modelling. We are interested in investigating whether engineering domain-specific language editors and other supporting technologies influences the applicability of the methods and the performance of the method users.

Such empirical research will eventually lead to developing a theory on the application of ethical reasoning methods within conceptual modelling, which should probably be grounded on complementary disciplines (e.g. Philosophy, Cognitive Psychology, Ontology). We are hopeful that these research avenues will contribute to assisting conceptual modellers in conducting their professions with greater commitment to ethics and sustainability.

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