Conceptual Modeling of Life: Beyond the Homo Sapiens

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Abstract. Our strong capability of conceptualization makes us, human beings, different from any other species in our planet. We, as conceptual modelers, should apply in the right direction such fascinating capability to make it play an essential role in the design of the world to come. What does it mean that "right direction" requiresa challenging discussion. Halfway between the need of having a sound philosophical characterization and an effective, practical computer science application, conceptual modeling emerges as the ideal discipline needed for understanding life and improving our life style. This keynote explores this argument by delimiting the notion and scope of conceptual modeling, and by introducing and discussing two possible scenarios of fruitful application. The first one is oriented to better understand why conceptual modeling can help to manage the social challenges of the world of the emerging information era, and how this world that comes could benefit from it. The second one focuses on how understanding the human genome can open new ways to go beyond what we can consider "traditional Homo Sapiens capabilities", with especial implications in the health domain and the new medicine of precision.

Keywords: Conceptual modeling · Conceptual models · Applications of conceptual modeling

1 Introduction

I live Conceptual Modeling (CM) with passion. For a person with this working passion, conceptualizing—as the basic process of CM—is present in almost every aspect of life. How to use it successfully becomes a challenge whose analysis is the objective of this keynote paper. The selected title is the first consequence of the faced topic. Conceptual modeling of life because behind any section of the paper there is always a concrete goal: to analyze how CM could be seen as a scientific approach to understand and improve life.

This covers a too open spectrum, and as time and space are limited, two main perspectives are going to be explored. The first one (Sect. 3) is a so-called "social perspective", intended to discuss how CM could help to better design the world to come, the world that in the information and hyperconnectivity era is already approaching. The second one (Sect. 4) is a so-called "biological perspective", which is closer to the scientific meaning of life, focused on arguing on how CM could help to understand

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the human genome transforming us, the current Homo Sapiens "version", into an evolved species able tomanage and transform life in our planet.

To make this discussion meaningful, the first aspect to be studied is necessarily to determine as much precisely as possible the scope and the definition of CM. It is a concept largely discussed but without a universally accepted definition, and the second section will be dedicated to this problem. Based on this positioning, the two previous perspectives will be then analyzed. Conclusions and references will close as usual the work. The idea of this paper is to introduce the guidelines of the keynote, in which more concrete details and examples will be given.

2 Conceptual Modeling Fundamentals: What Are We Talking About

The capability of conceptualizing is essential for human beings as it makes us different for any other species in our planet. It should then be massively accepted as an essential tool in the scope of software engineering (SE) and information systems (IS) engineering. This is not the case, and programming (as the act) and programmers (as the actors) are frequently socially recognized as their main roles. Conceptual models should be the key artefacts to make true that "the model is the code" instead "the code is the model". Unfortunately, this does not appear to be the case… yet! In current practice, software production methods are mainly code-centric, and it is the latter statement the one still guiding traditionally a software production process.

In a world heavily influenced by "doers", just doing something without understanding with a sound conceptual basis why to do it and how to do it better, appears to be too often the selected approach. Working as a Conceptual Modeler, or being nowadays a participant in a Conceptual Modeling conference, could be seen in some way close to the famous call for participation done by Shackleton, British explorer and adventurer, when looking for candidates for his expedition to cross the Antarctic (see Fig. 1).

MEN WANTED

for hazardous journey, small wages, bitter cold, long months of complete darkness, constant danger, safe return doubtful, honor and recognition in case of success.

Ernest Shackleton 4 Burlington st.

Fig. 1. Conceptual modelers wanted to face the challenges of the world to come: an analogy with the famous Shackleton call to cross the Antarctic.

In practical terms, conceptual modeling-based software production tools should be widely used and conceptual programmers should be the basic actors of any sound, well-defined software production process. As said before, even if a significant set of concrete proposals already exist (i.e. the conceptual programming manifesto presented in [1], the fundamentals of a conceptual model compiler introduced in [2]), this does not appear to be the case. Any discussion around this fact should start clarifying the definition and the scope of CM to try to envision scenarios of fruitful use. In this context, this keynote has three main goals:

- to discuss the notion and the scope of Conceptual Modeling,
- to analyze how conceptual modeling can help us to understand the world that comes (within what we could call a "social perspective"), and
- to analyze how conceptual modeling can open promising and challenging scenarios in the domain of the genome understanding.

2.1 Definitions for Conceptual Modeling/Conceptual Model

Teaching conceptual modeling since the early nineties, I have faced many times the very simple question of "what is conceptual modeling" and "what is a conceptual model". While some common, basic understanding could be said to be shared by many conceptual modelers, it is amazing to realize that so many years after the introduction by Chen of the seminal ER model [3] as a widely recognized conceptual model, the discussion for providing a universal, widely-accepted simple definition is still an open problem. Let me analyze some basic definitions to understand how CM is perceived commonly, and to explore the commented, shared understanding of the two notions.

Starting from a so elementary source as Wikipedia, we can find this first definition: "a conceptual model is a model made of the composition of concepts, which are used to help people know, understand, or simulate a subject the model represents". If a conceptual model is a model, the problem is transferred to the definition of "model". If we want to find what is a "model", what we have is that a model may refer to a conceptual model, a physical model, a scale model or a scientific model. Loop and back to the beginning…

Probably, Wikipedia is not the best option from a formal point of view. But if we look at some of the most well-known definition of "model" [4], we find that a model is defined as a simplification of a system built with an intended goal in mind [5], as an abstraction of a system to reason about it (either a physical system [6] or a real or language-based system [7]), as a description of specification of a system and its environment for some certain purpose [8], … One main conclusion that we can reach is that the distinction between "model" and "conceptual model" is not always as precise at it should be. As stated in [4], "while much has already been written on this topic, there is however neither precise description about we do when we model, nor rigorous description about of the relations among modeling artifacts". Looking for a kind of universal definition, it appears to be true what JochenLudewig states in [9]: "nobody can just define what a model is, and expect that other people will accept this definition: endless discussions have proven that there is no consistent problem understanding of models".

I would not agree with such a statement as a major conclusion. As said before, conceptualizing provides the key notion to characterize a modeling process. As a "conceptual" process, it is difficult to imagine a "model" that has not behind its essence a process of conceptualizing. This is why in this keynote we will explore the use of the "conceptual model" term assuming that a conceptual model is a model where the main components are concepts resulting from a process of conceptualizing a part of reality.

Back to Wikipedia to understand how CM is defined in non-formal contexts, more complexity arises. Exploring the definition it can be immediately discovered that there is another different proposed definition for conceptual model in the context of computer science: "A Conceptual model in the field of computer science is also known as a domain model. Conceptual modeling should not be confused with other modeling disciplines such as data modelling, logical modelling and physical modelling. The conceptual model is explicitly chosen to be independent of design or implementation concerns…". We see that the distinction between modeling and conceptual modeling is again unclear. What it is interesting is how an ontological perspective is introduced: "the aim of a conceptual model is to express the meaning of terms and concepts used by domain experts to discuss the problem, and to find the correct relationships between different concepts. The conceptual model attempts to clarify the meaning of various, usually ambiguous terms, and ensure that problems with different interpretations of the terms and concepts cannot occur. Such differing interpretations could easily cause confusion amongst stakeholders, especially those responsible for designing and implementing a solution, where the conceptual model provides a key artifact of business understanding and clarity". This ontological perspective will be explored in more detail later.

Another important aspect in this context is the connection between the conceptual model and the corresponding software product that materializes it. Once concepts of the domain have been modeled, the model becomes a stable basis for subsequent development of applications in the domain. The concepts of the conceptual model can be mapped into physical design or implementation constructs using either manual or automated code generation approaches. This is the basis of any model-driven development approach.

At least, this "computer science" perspective of CM—that I will prefer to refer to as SE/IS perspective—opens a more precise way to define CM, where we can find a significant agreement. Let me first refer to the John Mylopoulos's seminal paper [10] that defines the discipline of conceptual modeling as "the activity of formally describing some aspects of the physical and social world around us for purposes of understanding and communication. Conceptual modelling supports structuring and inferential facilities that are psychologically grounded. After all, the descriptions that arise from conceptual modelling activities are intended to be used by humans, not machines… The adequacy of a conceptual modelling notation rests on its contribution to the construction of models of reality that promote a common understanding of that reality among their human users…"

Back to the conceptualization human capability, we can conclude that a conceptual model is then the result of making explicit a conceptualization process applied to a part of the world considered relevant for the conceptual modeler purpose. This idea is clearly developed by Olivé in [11]: "In the information systems field, we use the name conceptual modeling for the activity that elicits and describes the general knowledge a particular information system needs to know. The main objective of conceptual modeling is to obtain that description, which is called a conceptual schema. Conceptual schemas are written in languages called conceptual modeling languages. Conceptual modeling is an important part of requirements engineering, the first and most important phase in the development of an information system".

This statement raises an interesting concern: how the terms "conceptual model" and "conceptual schema" are traditionally mixed up probably incorrectly. As an example taken from the database field, this mistake does not appear when we distinguish between "relational model" and "relational schema". Even it is frequent to see that these terms are used in a undistinguishable way, we have to be at least aware that what it is frequently referred to as a "conceptual model", it is really representing a particular "conceptual schema".

In the considered SE/IS context, we can then conclude that conceptual modeling is about describing the semantics of software applications at a high level of abstraction. Specifically, conceptual modelers have to (1) describe structure models in terms of entities, relationships, and constraints; (2) describe behavior or functional models in terms of states, transitions among states, and actions performed in states and transition; and (3) describe interactions and user interfaces in terms of messages sent and received, information exchanged, and look-and-feel navigation and appearance. Conceptual model diagrams are high-level abstractions that enable clients and analysts to understand one another and enable analysts to communicate successfully with application programmers. An immediate challenge is to facilitate the long-time dream of being able to develop information systems strictly by conceptual modeling, to be able to say that conceptual modeling is programming.

If behind a conceptual model there is a conceptualization process, the ontological perspective of conceptual modeling becomes a first-order issue to understand what CM is. Let's develop this aspect in the next section.

2.2 Foundational Ontological Background

Recovering Olive's ideas [11], in the field of information systems we make the fundamental assumption that a domain consists of a number of objects and the relationships between them, which are classified into concepts. The set of concepts used in a particular domain constitutes a conceptualization of that domain. The specification of this conceptualization is what conforms a particular conceptual model of the domain (sometimes called an ontology of the domain, although to see the conceptual schema as anontology-based representation of a domain provides a more precise picture). Note that in this context, the term ontology is used—in computer science terms—as a specification of the basic conceptual primitives used in the process of conceptualization. There may be several conceptualizations of the same domain and thus several possible conceptual schemas, all of them based on the same ontological primitives. Additionally, an ontology provides a concrete view of a particular domain. Therefore, it is also an ontological commitment for the people who observe and act on this domain.

In the field of information systems, ontologies are the basis for creating conceptual schemas, and the languages in which they are written are called conceptual modeling languages.

This perspective provides a solid basis to link ontologies and CM, through the use of a foundational ontology. Conceptual models provide a precise definition of structural knowledge in a specific field that can be instantiated across different application domains in the corresponding field. Such a conceptual model should always be built based on a foundational ontology that must determine the basic conceptual building units to be used to specify any concrete application domain.

The notion of foundational ontology is essential. A foundational ontology can be defined as an ontology that "defines a range of top-level domain-independent ontological categories, which form a general foundation for more elaborated domain-specific ontologies" [12, 13]. Rephrasing Guizzardi in [14], on the basis of a foundational ontology "a domain ontology is constructed with the goal of making the best possible description of the domain in reality". It can be represented as a conceptual model, as an engineering artifact with the additional requirement of representing a model of consensus within a community. Once users have already agreed on a common conceptualization, operational versions of the reference (foundational) ontology can be created. Selecting a foundational ontology determines the kind of conceptualization that must be performed.

Contrary to foundational ontologies, operational ontologies are designed with the focus on guaranteeing desirable computational properties. This makes a clear distinction between the foundational ontological perspective of conceptual modeling, and the operational perspective of ontologies represented by OWL, that it is not then a good choice for representing "foundational" ontologies. As a representation of a foundational ontology, a particular OWL ontology could consequently be seen as a conceptual model for the considered application domain.

In this context of ontology-driven conceptual modeling it is very important to characterize the different sets of meta-ontological choices that can produce different types of conceptual models. As analyzed in the OntoCom workshop series [15], "the effects of these differences resonate further into the overall information systems (IS) development lifecycle, with potentially significant economic impact on the evolution and integration of information systems. This especially affects the intended quality of the conceptual models that are generated to represent a given domain". It is important to know and to understand what methaphysical choices are taken when a given foundational ontology is proposed, because these choices characterizes the type of conceptual models that can be generated. In some sense, these metaphysical options determine what kind of conceptualization is applied to elaborate a specific conceptual model and not another one. As it is stated in [15], "sound knowledge of a foundational ontology's metaphysical choices better enables the IS modeler and practitioner to assess the consequences of selecting one foundational ontology over another, including the effects on the quality of the conceptual models underpinning the requirements and design of information systems".

Examples of meta-ontological choices were discussed in [15] and include [16–18]:

- Realism vs. idealism: there exists an objective reality (realism) or reality is individually constructed by one's own concepts (or ideas) resulting from one's subjective interpretation (idealism).
- Endurantism vs. perdurantism: individual objects are fully present at any given time and do not extend temporally (endurantism) or individual objects extend spatially and temporally, therefore, an individual is never wholly present at a specific instant in time (perdurantism).
- Physical vs. abstract objects: all individual objects are physical and no abstract objects exist (physical objects) or not all objects are physical therefore some objects are abstract (abstract objects).
- Higher order types: types can instantiate other types.
- Possible worlds: Our actual world is one of many possible worlds.

These different dimensions can help to classify different types of conceptualization supported by different proposals of foundational ontologies. Since the application of meta-ontology to conceptual modeling and IS development is still relatively underexplored and with a scarce literature, this perspective can really help to conduct comparative analyses of two or more foundational ontologies (and their subsequent conceptual modeling languages). This would allow to, for example, make explicit their theoretical differences, understand the different expressiveness of the resultant conceptual and investigating the implications of such differences on conceptual modelling within information systems development.

3 Conceptual Modeling and Life: A Social View and a Biological View

After emphasizing the link between conceptualizing and conceptual modeling, and the subsequent importance of conceptual modeling for human beings, let's explore in this section how we could benefit from recognizing and improving our CM capabilities. Understanding how our process of conceptualizing works in order to better understand our world and how to adapt it to our purposes, would allow us to go beyond the current, conventional "Homo Sapiens" rational capabilities. CM should be the basic tool of a future, evolved human being, able to use a level of knowledge never reached before, based on the rational use of universal information and advanced technologies. We are going to develop these ideas from two points of view:

- a social one, intended to analyze how CM can help us to look at the world to come as a better world, and
- a biological one, oriented to discover the secrets of life in our planet through the detailed understanding of the genome language, in order to profit this knowledge in the right direction.

3.1 The Social Perspective: Conceptual Modeling for Understanding the World That Is Coming

Understanding the world to come can be seen as a challenge whose solution should be CM-based. The sequence of social and technological advances that we are witnessing in the last decades is the source of a new era for the humanity. A CM-based exercise is required to understand those big changes and their immediate consequences. Once more, conceptualization is the key activity to guide adequately this new world that comes. This conceptualization process should be oriented to identify the basic issues that lead the change, to understand how they affect the current social context and to develop strategies to implement an accurate transformation.

Many works study this attractive social perspective. For instance, in [19], the basic issues whose continuous development is creating the context for the new world to come includes:

1. Hyperconnectity: the global net platform that has been created gives a big power to individuals and it allows the whole world to be more and more connected, having immediate access at any information and knowledge in the planet. This also blurs geographical barriers and it creates world of total, open competition.
2. Technological acceleration: the technological improvement is following an exponential growth. This technological explosion opens the way for a technological revolution whose intensity and social implications have never seen before.
3. Raising of world-wide emerging citizens, coming potentially from any country of the world and ready to consume and compete. The emergence of this new actor will impact economics and politics.

What role can CM play in this context? The combination of these three issues requires to perform an intense CM exercise to understand how they interact among them and to analyze the possible scenarios that could be generated as a result of these interactions. "Just doing it" does not appear to be an adequate approach.

A precise understanding of the concepts that participate in those potential scenarios is strongly required. Beyond its conventional use in the design and development of IS, conceptual modeling should provide a solid basis to discuss and materialize the opportunities demanded by this new world that is coming. The IS that must support this human evolution should be conceptually well-founded, and concepts as relevant as context, adaptability, decision, luck, user experience, satisfaction, sustainability… should have a strong conceptual support to represent them appropriately in those ISs.

Educating conceptual modeling skills will be the essential challenge to form citizens whose capabilities are expected to go beyond the Homo Sapiens traditional behavior. To do it, the role of a conceptual modeler is to understand the mental models used to abstract and represent the concepts that are relevant for a given domain. Identifying concepts and their relationships should guide the conceptual discussion intended to elaborate the most adequate solution.

An interesting conceptual starting point to characterize the types of knowledge that must be considered are proposed by Gervasi et al. [20] and explored in by Sutcliffe et al. [21] from a RE perspective. A Tacit Knowledge Framework is introduced, using the properties of expressible, i.e. known knowledge; articulated, as documented known knowledge; accessible, which is known but not in the foreground of the stakeholder's mind and therefore a memory recall problem; and relevant to the project and domain. As a result this work defines:

- Known knowns: expressible, articulated, and relevant.
- Known unknowns: not expressible or articulated, but accessible and potentially relevant.
- Unknown knowns: potentially accessible but not articulated.
- Unknown unknowns: not expressible, articulated or accessible but still potentially relevant.

While conventional CM focus on identifying "known knowns", these definitions provides an attractive taxonomy to be used in the conception process of a conceptual model. Conceptual modelers should act as the knowledge architects of those relevant data and the information generated by this hyperconnected world, composed by last-generation technologies in continuous evolution and reached by virtually all the human population.

One of the most appealing and challenging applications of this advanced technologies are those that focus on understanding the Human Genome. In the next subsection we are going to discuss another perspective of conceptual modeling of life: a biological one centered around facing the problem of how conceptual modeling can be applied to the never-answered question of understanding why we are as we are, and how the challenge of managing life could be faced.

3.2 The Biological Perspective: Conceptual Modeling for Understanding the Human Genome

Philosophers are for centuries trying to answer the question of why we—human beings—are as we are. Why do we behave as we behave? What is our origin and our destiny? Understanding and manipulating life has historically being out of our scope, and considered closer to religion than to pure science.

But again a new world is coming where CM can play an essential role. From a SE/IS perspective software products can be generated from a conceptual schema following a binary, silicon-based execution model based on 0s and 1s. Using an analogy, from a biological point of view we have the programs—any living being—executing an execution model that is carbon-based and instead uses four letters (A, C, G, T, the four nucleotides that conforms the basic elements of a DNA sequence). In this case we have the program instances, but we don't have the models. Analyzing this as a reverse engineering model-driven problem, we have the program and but don't know—yet!—the conceptual schema that a given program represent. This analogy is represented in Fig. 2.

A huge amount of data is generated continuously in the genome domain. While the sequencing technologies are making more feasible and accessible to obtain our genome sequenced, what do we do with a data file that contains approximately 3,200,000,000 nucleotides of DNA whose meaning is mainly unknown for us? We could go further in our analogy with conventional code, wondering what we would do with a huge

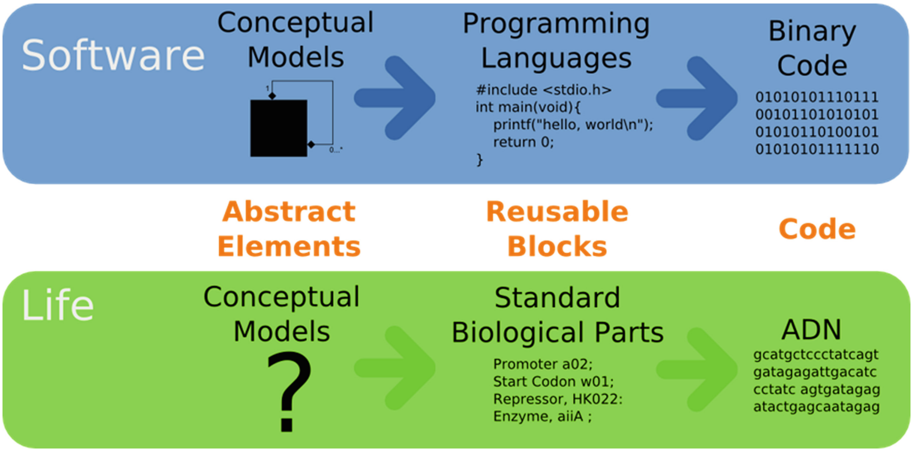

Fig. 2. Conceptual models for software versus conceptual models for life

sequence of 0–1s of an executable program if this sequence of millions of 0–1s were our only documentation of the program.

The technologies that are sequencing DNA improve at an impressive speed, Converting the initial sample of blood or saliva in a final sequence requests a sophisticated process where again the data perspective is essential. The so-called bioinformatics pipeline (see Fig. 3) follows a precise process where firstly, after a raw data capturing step the initial physical sample is converted into a given file visualization format (usually technology dependent). Secondly a sequence estimation process and an alignment to a reference sequence process generate a set of files with a de-facto, widely accepted data file formats (FAST, FASTQ, SAM, BAM). Finally, a comparative report with the relevant genome variants is generated using another text file format especially created for the case (VCF).

Fig. 3. The bioinformatics pipeline: sequence of actions, each one generating a type of file with a particular data format.

The problem is that this is just one concern of the problem. Beyond this technological perspective, once we have for instance the VCF file with the reported variants, the other concern of the problem is how to interpret the semantics of these variants in terms of what phenotype implications they may have. In clinical terms, we want to know what variations are related to what diseases. Considering the big number of diseases and the short amount of knowledge that we currently have, it is easy to conclude how much work is still to be done in the next decades.

To improve our knowledge of DNA variation and the consistency in variant classification will require a massive effort in data sharing. As we will discuss next, this data sharing implies a CM exercise to identify the relevant concepts and their corresponding relationships. Only having such a CM-based background, an efficient data analysis can be done and assessed. For instance, a recent analysis of the ClinVar data source on variant interpretation comparisons concluded that 11 % (12,895 up to 118,169) of variants had two or more submitters, and 17 % (2229 up to 12,895) were interpreted differently [22, 23]. Increasingly, genetic tests provide ambiguous results, leaving doctors and scientists searching to make sense of these “variants of unknown significance”. Clinic genetics may have a big problem that is affecting people’s lives. One again, CM can provide the required answer. Designing the correct conceptual models, the genomic community could come together to develop its own standards to ensure safe and effective use of genetic and genomic medicine.

Interestingly, we could talk not only about diseases. In terms of facing the problem of understanding the human genome, the final challenge is to understand any characteristic related with our way of living: physiognomy, personality features… The capability of being able to know and manipulate this type of properties opens scientific and ethical challenges that we have never faced in our history. Never in the past the Homo Sapiens has been able to understand how life works in order to manage this knowledge to transform life according to his interests. This is a strong, cultural revolution, that justifies why in the title of this keynote the term “beyond the Homo Sapiens” has been introduced. A Homo Sapiens with the capability of transforming herself appears to conform an evolved Homo Sapiens. Without any doubt, an interesting topic for a rich, long discussion!

Bioinformatics and CM. If we wonder what it is the role of CM in this context, the answer is immediate. More and more data are generated every day. Just for the human case, the size of a complete genome for an individual person is approximately 2.5–3 GB, but the data involved in the process is ten times bigger. We can imagine the Big Data problem related to the setup and maintenance of a sort of Genome database where we could for instance store the genomes of all the humanity. The most similar experience, the 1000 Genomes database, stores several TB of data. Still worse, it is not just a problem of data loading, it is a problem of data management. We should be able to “read” any particular genome, to compare different genomes, to edit a genome as we do with a conventional program… Genome editing technologies start to be a reality and the practical implications of all these facts are anticipating a revolution in our human concept of medicine, leading to the medicine of precision, a personalized medicine where any treatment will be dependent on the personal “genomic” code of the patient.

Additionally, we do not should forget that life in our planet is not only limited to humans! Any life as we understand it on the Earth is genome-based. This means that whatever we are saying for the human genome could be generalized and could be applied to any genome of any kind of species. Giving a unifying data treatment to the problem of representing life as a whole is a problem whose dimension is even hard to delimit.

This context provides a challenging working environment for the CM community. It is surprising to realize that in such a complex context, where data management and data understanding is a first-order problem, CM practice is ignored too frequently. To make things worse, current data are spread over a very diverse set of heterogeneous data sources, where data consistency is not warranted and data integration is tremendously complex - when just not possible.

The only feasible strategy to provide a sustainable solution should be centered around the use of the well-known IS principles, using CM techniques and proposing a kind of Genome IS approach based on a precise conceptual schema of the human genome (CSGH). While steps in this direction are already under development [24], much more work is to be done to assess that a sound conceptual background is provided to make possible an effective and efficient genome data management policy. This CSHG will act as conceptual repository designed to include all the knowledge accumulated around the human genome, and unifying the management of that heterogeneous set of data sources from a holistic perspective. Only with such an "oracle" of valid, well-designed data, a sustainable progress can be performed, based on storing and managing more and more right ("curated") data to be obtained as research in the domain progresses and to be provided to the community in the form of accurate results.

The steps towards a successful and reliable universal medicine of precision are fully dependent on the success of this IS and CM perspective, and this is probably the most promising scenario for CM practices in the next future.

4 Conclusions

This keynote emphasizes the intended importance of conceptualizing from two perspectives: from an Information Systems/Software Engineering perspective on the one side, and from a social, human being-oriented perspective on the other side. The world to come is plenty of social and technological challenges, and the discussed approach is that its fruitful development should be CM-based.

Assuming that CM is the essential discipline to develop such an evolved, better world where technology and information were properly used, conceptual modelers should play a central role. To understand this role, what CM is and what its scope is has been analyzed, focusing on the ontological background that such a sound definition requires.

An initial analysis of practical implications is discussed, If we want to build a better world, we must know what we are trying to build. The hardest part for most designers of complex systems is not knowing how to design such a complex system, but what it is what they are trying to design. This is where CM can provide the needed answers and tools. Using CM to understand and manage life—from both those social and biological points of view—will help us to use adequately our rational power of conceptualization, going beyond the capabilities traditionally attached to human beings and opening the door to an improved version of our species: beyond the Homo Sapiens, for developing a challenging, improved world that is already coming, with a sound CM background as the essential strategy to make it viable and real.

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