Ontological and Knowledge Emergent Engineering of Systems and Meta-systems based on General Schemas Theory

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Abstract. In this paper we will consider the role of Ontological Engineering in Emergent Engineering of Systems and Meta-systems based on the understanding of General Schemas Theory.

Ontological Engineering in relation Systems Engineering Architecture

Baseline Understanding. Ontological Engineering is the study of what kinds of entities have being and their inherent relations to each other. Systems Engineering concerns the production of Systems that are created out of these existing entities. Normally we think of producing an architecture for the system which would give a template for what kinds of entities need to be in the system and their basic relations to each other at a high level of abstraction. Then as we continue design we specify more and more entities that need to be part of the system and more and more of their relations to each other, until there is a complete delineation of all entities within the system and all their relations, especially those relations that cross interface boundaries of different kinds within the system. Usually we start with some combination of requirements and a concept of operation in order to set the stage for the design activity at both the Architectural and the detailed design levels. The conventional wisdom is that we do various levels of requirements documentation, and then we do functional or object oriented designs that produce images the functional architecture for the system. That functional architecture is a decomposition of the system into objects or functions that will achieve the goals described by the requirements. This is a synthetic stage where we combine various requirements together to produce a vision of what might fulfil the intention of the requirements. Then after we have a functional architecture then we transform that into a physical architecture based on performance needs which is the design. That design is normally a single point in a design landscape and there is a trade off of different architectures and different designs that will fulfil the same requirements and their functions. We do trade studies to determine which of the possible designs are most likely to give the performance, and contain the other necessary qualities specified by the specialty engineering sub-domains, which will meet the customer's needs. The various standards like IEEE 1220-2005, EiA632, and IEEE 15288-2002 and other materials like the INCOSE Handbook flesh out this brief sketch giving the conventional wisdom on how Systems Engineering should be accomplished. After design there is of course implementation, verification, validation and other lifecycle phases as specified in these standards and others such as the CMMI version 1.2 and ISO/AS9100. These are a series of stages of synthesis. In fact synthesis is used as a term in some of the standards for the design activities.

But it is only recently that Systems Architecture has become a point of emphasis within our discipline, and we are just now realizing, especially when we consider Systems of Systems that Ontological Engineering is also a significant part of the types of systems we are building, especially when we hope to move from an information to a knowledge level of manipulation and transformation of data within the systems we build. Thus the question of the relation between Ontological Engineering and Systems Engineering needs to be considered more carefully. We mostly run into Ontological Engineering in the context of Web 2.0 or the Semantic Web, but its genesis is in Artificial Intelligence. A part of Artificial Intelligence is how the intelligent agent understands its environment. There are many tacit or implicit facts that we all know about our environments that are never written down anywhere. Artificially intelligent agents need to know these facts explicitly in order to be able to reason about situations. Thus there has been a push to try various means of writing down these facts in a way that would be useful for intelligent agents to use in their reasoning. But ontological engineering expanded from this role to attempt to produce systematic sets of primitive concepts and their relations from which other more complex concepts can be produced. And as such it specifies for a particular domain what are the fundamental entities and their possible combinations and relations. Architecture then takes over from there to say given the possible relations between entities how should they be put together to achieve the particular emergent effect desired by the customers. Architecture looks at the requirements and attempts to synthesize them into a set of intentions, i.e. functions that the system would fulfil. Then it attempts to find a structure of architectural components that could be built and put together that would achieve those intentions and embody those functions. Object Oriented Architecture tends to do these two things at once. It specifies at a high level of abstractions what kinds of objects that would need to exist and what their relations should be to accomplish the goals set out in the requirements. The functionality and its hierarchy that used to be separated from the physical architecture is represented in the inheritance hierarchy and becomes part of the abstract description of the objects rather than being seen as a separate functional architecture. But sometimes both functional and object hierarchies are produced and are mapped to one another. There are still many different approaches to the work of synthesizing and architecture that will meet a synthetic set of requirements for an emergent system.

This, then, is the baseline understanding. The Ontology supplies the background understanding of what entities exist, or can exist and their relations with each other which the requirements use to talk about the intended system with emergent properties, and the Architecture also takes things that already exist in various domains and puts them together in novel ways to produce the end result. Sometimes new objects need to be created in order to fulfil a particular function in a design. So Ontologies must be inherently dynamic to accept the production of new things which produce new relationships which then would lead to the production of emergent real effects in the world through the mysteries and magic of systems engineering and other disciplines like Software, Hardware, and Human Engineering.

We says the mysteries and magic of Systems Engineering because in many ways it does not know how it produces the results it produces. And this is due to the fact that it does not yet have firm foundations that many other disciplines have which might give it a scientific basis for its work. Systems Engineering is a craft, and many times we fail to produce the emergent effects we desire to produce for various reasons. But the fact that we cannot put together things that exist into new configurations to produce emergent properties does not mean that we did not know what does exist and how those things that do exist relate to each other in their current environment which is what Ontological Engineering tells us. As we try to produce knowledge based systems rather than just information systems, and we attempt to fuse not just data into information but information into knowledge, then we are raising the stakes in some sense, because Ontological facts are not just the description of the things that exist and their relations but this very knowledge becomes what is being processed by the systems we build. And so in a sense our systems are becoming reflexive in as much as we use ontologies to describe the requirements and to specify the things in the architecture, but then the systems we build use this information and other ontological information like it to produce knowledge from information about things given in ontologies. And so we are in effect striving for a higher level of synthesis which is a synthesis not just of information but knowledge in the output of systems. Such knowledge systems interact with humans on a level of knowledge not merely just supplying information when and where needed but rather when the system itself is dealing in concepts and synthesizing concepts from information and then presenting configurations of concepts to the users then we think of such a system as operating on the higher emergent level of knowledge, where what flows though the system are semantic entities rather than mere representations of entities in terms of information. Of course, object oriented design was itself a big step in this direction in as much as it produced entities that had functions but also carried data. The transformation between objects and concepts is a difficult one which has not been totally bridged as yet. But this is the goal, to have systems with artificial intelligence operating at the level of knowledge and interacting at humans in terms of knowledge rather than merely taking in and putting out information about entities. But of what we think of as semantic has to do with the understanding of how entities function in their context, or situation and the inherent relations things have in the world. So ontology rather than being merely a part of domain analysis that tells you want exists so you can build a system out of those kinds of things, moves into the heart of the system when they reach for this knowledge level. In some sense those knowledge systems have to become reflexive in as much as they know about their own parts and their relations as well as knowing about the parts and relations of other systems.

Thus, ultimately Systems Architecture and Ontological Engineering are becoming entangled at the cutting edge of the systems we are trying to build. Architectures need to accommodate ontologies and be able to use them not just in order to know what pieces are available to build systems but in order to operate on this higher emergent level we are striving for in which the systems are operating with concepts and display an understanding of knowledge rather than mere information. So the baseline understanding that we are tending toward in our discipline is a merging with artificial intelligence and Web 2.0 ideas which need to be integrated and synthesized with our concept of how Requirements and Architectures of Systems are produced in the future.

And this of course leads to the question as to whether this synthesis that is done in Systems Engineering of complex systems with emergent properties could some how be done by Artificial Intelligent Design applications rather than humans. And so this is another level of accommodation and synthesis that is necessary for systems engineering to understand and embrace ontological engineering. Ontological Engineering would be the basis on which Systems that do Emergent Design would be built. But that would mean that such Artificial Emergent Design applications that would do systems engineering would have to have all kinds of knowledge not just about the world they were designing for, but about the systems engineering process itself, and about how emergent systems are synthesized. And example of such work is that of Koza who has been synthesizing antenna designs using Genetic Programming. The question becomes whether Emergent Design can be done by some sort of Genetic Programming technique that understood Ontologies sufficiently in particular domains to do design of complex systems rather than humans.

From all this we can see that where we are heading is probably some sort of assimilation between Ontological Engineering and Systems Architectural Engineering. We concentrate on Architecture because it is in the architecture that the essence of the system is projected that would have the emergent properties that are desired and that appear in the requirements when synthesized into the intended functional system that might be translated into objects that when they are embodied and interact properly actually have the emergent properties that are projected. We hypothesize that in the future at least for some kinds of Systems Engineering there will be no difference between the architectural view and the ontological view of a system. The architecture would draw on the ontology as a basis for building the emergent properties and the emergent properties would be at the knowledge level and would thus use ontologies as a key component of the architecture. It is this merger and synthesis between Ontological Engineering and Knowledge Engineering that we would like to consider as our baseline understanding of the relation between the two disciplines. The further we look into this the more we see that there needs to be a new sub-discipline which is something like Ontological Systems Engineering which uses ontologies to synthesize designs with emergent properties and which builds those systems with ontologies as an integral part of the system which operates at the knowledge level with concepts rather than information. Of course, building such an artificial intelligent system that operates with concepts and interacts with humans on the basis of understanding concepts has traditionally been called knowledge engineering. And so the combination is really something like Ontological Systems Knowledge Engineering. Systems really connect the Ontologies with the Knowledge processing. If there was not the production of an emergent capability that could link ontologies with knowledge processing then there would be no systems that had this artificially intelligent capability.

Transforming the Baseline Understanding. Now that we have established this baseline understanding of the relation between Ontological Engineering, Systems Engineering and Knowledge Engineering, we can begin to question how our discipline will get to that goal. One problem with our discipline is that it has no foundational scientific basis as other disciplines do, which could sustain the combination with these other disciplines. But these other disciplines although they have existed longer than Systems Engineering, are in some ways no further along than we are in establishing their own scientific foundations. So we are really confronted with a dilemma that all three disciplines are somewhat nascent and that there approaches to their work though rapidly evolving are still only in the formative stages, and so we are really talking about combining disciplines that are equally unfounded and obscure from a scientific point of view. In fact there is no reason to believe that Artificial Intelligence is possible, and it could be that both Ontological Engineering and Knowledge Engineering are in fact pipe dreams as some like Dreyfus have said.

But perhaps what is necessary is some sort of paradigm change or even some deeper change such as that which Foucault calls an Episteme Change, is necessary to realize the fruit of the merger of these disciplines. My goal here is to sketch such a transformation of our understanding of not just

Systems Engineering but also Ontological and Knowledge Engineering, where we will change the basis of understanding the basis of all three, and thus effect the synthesis of these disciplines by transforming them all to a new level of understanding. I propose to do this by introducing a new type of Theory called General Schemas Theory. Schemas are merely the various types of projections by which we organize our experience. For instance, some schemas are patterns, or forms, or systems. But there are also other higher schemas like meta-systems, domains, worlds. These are the six schemas that relate to experience according to S-prime, the most rudimentary and primitive conception of schemas theory developed by the Author. What we need to realize according to General Schemas Theory is that there is something that comes before the identifications of the kinds of things that exist and their relations, or before the configuration of those things to produce emergent effects, or before the understanding of those things in situations through concepts based on knowledge. What comes before all these approaches to the study of things and their relations, is the projection of the spacetime configurations and embodiments of the things themselves prior to knowing what they are. Notice that Ontological, Systems and Knowledge Engineering all are based on distinguishing things in terms of What they are. What exists in what relations, then how can we configure what exists or might exist in such a way to produce emergent effects, then how can we manipulate our concepts of what exists to have deep knowledge about them by which we can effect transformations on the knowledge level. General Schemas theory is a prior discipline which only worries bout the way that human beings project the break-up of spacetime embodiments prior to deciding what something is. Because it is prior to the deciding of what exists, what can create emergent effects, what can be understood by concepts as knowledge, it is a foundation, part of the missing foundation of all three of these disciplines. As such it becomes a possible basis for integrating these disciplines and their different viewpoints. And better yet, it becomes a possible basis for helping them achieve their perhaps now dubious goals.

General Schemas Theory studies all the schemas that exist and their relations to each other. But it posits that there is a relation between the organizational templates for understanding that are the schemas and the break-up of spacetime into dimensions. It says that from the point of view of humans spacetime is not a homogeneous plenum as science imagines it, but instead it sees it as chunked or quantal in relation to the human scale. Protagoras said Man is the Measure of all things, of what exists that it is and what does not exist that it is not. The schemas are how we measure things at a fundamental level in our experience as an automatic projection that we place upon spacetime and our experience of things in spacetime unconsciously. But this prior or a prior projection has big effects in shaping our world. Of course, we do not notice it because for us it is like water to the fish or air to the birds, it is our medium as human beings in which we live the existential finitude of our lives, so most of the time it goes un-noticed. However, it determines what we isolate in order to determine what something is, or it determines how we imagine the structure of the things we build and how they will display their emergent properties, and it also determines what we will conceptualize and call knowledge and how we will transform it. Emergence is taking something from the status of what is not to what is and Protagoras' *Man as the measure* plays a key role in this transformation which we call an emergent event.

The basic idea that we wish to put forward here is that by defining General Schemas Theory as the foundation for Ontological Engineering, Systems Engineering and Knowledge Engineering then we provide a human cantered basis, i.e. as part of Human Engineering, for the integration of these now disparate disciplines. And also we provide some foundation for our understanding how they might work together to achieve the production of Emergent Knowledge

Transformation Systems based on Ontolgoies that might operate in the world, and also perhaps perform emergent design to produce such systems in the future, making it easier for us to design and build the very complex systems we are contemplating in the future, if we can actually make it up to the knowledge level with the systems we build and make artificial intelligence more than a play thing of academics.

So first of all it is necessary to understand all the Schemas that humans project together, and to understand how we cut up spacetime and organize as a natural outgrowth of our cognitive processes. Once we understand that then we will have produced the building blocks for our ontologies, our emergent architectures, and our knowledge systems. As an example I will mention one fundamental transformation that General Schemas Theory calls upon us to understand better, and that is the transformation from Systems to Meta-systems. These are two fundamental types of schemas. A system is as we know the relations between things with emergent characteristics. But a meta-system is the inverse of the system. The meta-system is the context, situation, milieu, ecosystem, environment, media of the system. And right away you can see how this relates to semantics. Normally it is thought that semantics comes from context. Syntax can be closed, by a a particular expression of syntax points beyond itself to the diacritical system of signs and those signs point toward their environment as a whole, and somehow in that pointing beyond significance is produced. So immediately we see that Ontology is an understanding of what exists and the inherent relations between those things that exist which we can build upon to produce architectures, or to give our information a knowledge background. Knowledge processing would use this ontology to understand conceptually what the significance of a certain state of affairs was to produce decisions that lead to actions that are relevant, and cogent. So it is clear that the meta-system is relevant to Ontology and Knowledge Engineering. But what is perhaps not as clear what the connection of meta-systems might be to architecture. But when we realize that architectures are the fundamental conceptual arrangement of the system to produce an emergent effect, and that effect will be a gestalt, i.e. a whole greater than the sum of its parts. Then, we must consider what is the opposite of that system with its emergent effects. That is called a proto-gestalt, it is a whole less than the sum of its parts, a whole full of holes like a sponge, that the system fits into in order for its emergent effects to have causal efficacy. The meta-system is the inverse dual of the architecture's emergent effects. It is the responsive environment in which those effects will have meaning and results. We already have a set of ideas similar to this in Architecture which we refer to as the architectural framework, when we produce a product line in which we hope to have reuse. In the architectural framework we are building something that mediates between the system and the meta-system. The system when it is produced such that it will fit into many different environments needs to be structured differently in different cases, but there are some things that can remain the same and others that must change as we adapt the architecture of the system to various environments. We call that common part the architectural framework, it allows architectures to be more than just point solutions within the design landscape. Rather it says that the design landscape can be navigated and so certain aspects of the architecture will remain the same as other parts change, and that way we get greater leverage out of our design. So the environment that appears in architecture that gives significance is the design landscape out of which we pull the efficacious emergent design. Ontology Engineering deals with the meta-system for the system and says what kind of things exist in both. Knowledge Engineering deals with the meta-system of a system in operation and allows conceptual processing based on an ontology so that it can make decisions and interact with its users at higher cognitive levels. Systems Architecture deals with the environment of the design landscape and Architectural frameworks allow architectures to be produced in such a way that we can move though the design landscape of possibilities easily, and also we can build systems so that their architectures can be changed to cover a larger area of the design landscape and produce their emergent effects in a broader range of environments.

We have proposed in other papers presented to INCOSE that there needs to be a theory of Meta-systems and not just that but a complementary discipline of meta-systems engineering for the production of meta-systems. Systems and Meta-systems are complementary theories and engineering approaches to the same problems. One looks at how I can draw a functional boundary that achieves an intended emergent effect, and the other looks at the environment in which that emergent effect is operating and looks at the effect of that set of emergent characteristics on the environment and the receptivity to that emergent effect in the environment. It looks at the unexpected side effects and the unintended consequences of the emergent effect in the environment. But also we can understand that Meta-systems have their own special ontology. Where as system ontologies say what kinds of systems exist and what their relations and transformations might be, so it is that meta-systems ontologies say what kind of environments exist and what their relations and transformations might be. A formal ontology would concentrate on the kinds of forms or objects that exist and what their relations and transformations might be. It is clear that we need ontologies at all these levels. But normally ontologies concentrate more on formal and systems issues and less on meta-systems issues. But meta-systems issues are those that produce significance, and it is those which conceptual understanding is aimed at. Knowledge is not just about what kinds of things exist, but it wants to understand systems of things, and the relations between things in those systems. But also it wants to know about the effects of environments on those things in those systems. Ultimately knowledge wants to know about domains which have multiple perspectives on those things, and the worlds of interrelated meanings in which those things, systems, environments and disciplines function. Ontologies are in fact structured by the nested hierarchy of the schemas. And the meta-system level of nesting is crucial to understanding what kinds of situations can arise and what their significance is conceptually in terms of our knowledge. So it seems crucial that we have a Meta-system theory and that we be able to do environmental engineering based on such a theory. But at this time no such discipline independent theory exists. Thus there is no theory to give a foundation not just to our aspirations to design meta-systems, but for our wanting to understand the meta-systemic level of ontologies or of knowledge and conceptual understanding and processing that we might want knowledge based systems to do in the future. When we talk about producing systems that will understand ontologies and do conceptual knowledge processing we are really talking about systems that understand their meta-systems and can very agilely and robustly adjust to those meta-systems. If we were talking about human organizations that were like this we would perhaps call them intelligent enterprises. Human enterprises currently design the complex allopoietic systems that we build using traditional systems engineering methods. But eventually we would like those systems engineering enterprise to show some signs of intelligence beyond that of their individual human actors. Our gage for that will be when the organizations facilitate human creativity and innovation rather than stifling it. But eventually we would like such an intelligent human enterprise to design a system that produces complex systems and meta-systems as their products. That way the human work would be to create the means by which systems and meta-systems engineering is done rather than doing it themselves manually as a craft. That would show a higher level of intelligence at the meta-system level.

As is said by Barney Pell[1] in gaming most of the intelligence goes into creating a program that will play the game in a way that appears intelligent. What is needed is something that does this meta-analysis to create the intelligent acting agent. This he invented the idea of meta-game design and rasied the whole question of intelligent behaviour to a new level of problematic. Similarly we need to design those systems that design new emergent systems and meta-systems. So rather than engaging in Emergent design directly we are instead engaging in emergent meta-design instead. But that goal is far away, and first we will have to understand what emergent design is and how it works when ever we create something that has emergent properties. How can we do that? We don't understand it ourselves. But though ad hoc and some traditional means we approximate that behaviour as humans. And part of the possibility of that behaviour for us is the built in, perhaps somewhat culturally modulated projection of schemas on which we base our designs of things with regard to quantal spacetime embodiment. It is on that basis that all our ontologies, emergent design and conceptual knowledge of things is built. So it stands to reason that this should be part of our attempt to merge these various disciplines as we strive to produce systems and meta-systems with emergent knowledge and conceptual manipulation characteristics in the future.

Architectural Design Knowledge Engineering based on Ontologies. As we talk about this whole area of future research it becomes clear that when we create architectures for systems and meta-systems we use concepts to do that, and our knowledge of how the world operates both implicit and explicit. So in some sense we need to understand better the relations of Design, Concepts, the kinds of things in the world and the multiple perspectives of various disciplines that view these same things so differently. Systems Engineering must constantly bridge the difference between Software, Electrical, Mechanical and Human Engineering perspectives in order to produce a system that works and combines the best of what all these disciplines have to offer. Part of the research of the Author has been into the nature of Emergent Design. Emergent Design can be understood as a Quadralectic between Concept, Essence, Perspective and Design at the Hyper meta-level of Being. There is a complex meta-dialectic between design and non-design elements in the process we call design. In Systems and Meta-systems Architectural Design we concentrate on the Design moment of this quadralectic. But for instance in the ontological part where we identify what exists to contribute to our design that might help produce emergent effects in the end result we concentrate on the essences of the things that exist and how they hold together attributes of particular kinds of objects. In the knowledge processing part we concentrate on concepts and the manipulation of those in relation to situations we are trying to understand based on sciences and rules of thumb based on past experience as well as much tacit and implied knowledge of how the world works. And finally we know that in design many different people look at the same thing based on their training in different disciplines differently and we need to bridge between these disciplines and their languages and their modes of understanding in order to synthesize an understanding of the entire systems and how it should work when it gets into its end use environment. So in many ways we can see that the differences between Ontology engineering, Knowledge engineering, Architectural Design of Systems and Meta-systems and the various Disciplines such as Systems, Hardware, Software, and Human Sciences and Engineering, all work together in the quadralectic of Design and Non-design elements that determines the structure of Emergent Design itself in relation to other cognitive structures and abilities. Thus we can say that the disciplines we have mentioned do not have an

[1] http://satirist.org/learn-game/projects/metagame.html

external relation to each other but rather an intrinsic relation such that they show up in the moments of the quadralectic of emergent design itself. We need to design ontologies each of which have a different architecture. We need to use ontologies to inform our design. We need to conceptualize architectures so we can explore the design landscape more broadly and in greater depth to avoid point designs. But we also need to understand how to architect conceptualizing systems. We need to apply various scientific and engineering viewpoints to our architectures so that the emergent end product can be as robust as possible. But also we need to know how to design systems that are aspect oriented as well as object oriented so that the system can view its environment from different aspects and respond appropriately even in adverse circumstances. Thus we see that the separation of Ontological Engineering, Systems and Meta-systems Engineering, Knowledge Engineering and the various Scientific and Engineering disciplines is only so that they can interact to make Emergent Engineering possible at all the various schematic levels at which we might want to design products. Design is not something isolated but more and more it is going to become integrated with other disciplines so that the quadralectic between design and other human cognitive capacities becomes more and more apparent. This tells us that the fusion of these disciplines is something intrinsic to them and they do not have merely extrinsic relations to each other.

Deep Background. Once we realize that Knowledge informs Architecture which informs our Ontological Understanding by creating new emergent things which informs the various disciplines that participate in design which study those new things, then we realize that it is necessary to understand knowledge better as well as Being. When we go back and look at philosophy Ontology and Epistemology are key parts of Meta-physics. Ontology tells us what exists in the world and Epistemology tells us what we can know about what exists in the world. Of course, down though history there have been many theories of Ontology and Epistemology. But they have always been considered together like two sides of the same coin in philosophy. And philosophy itself was considered meta-physics because it is seen as what goes beyond physics, i.e. beyond the description of what exists in the world from the viewpoint of the various disciplines. Of course, Metaphysics and Physics have to deal with the fact that existence is dynamic and that new things are continually being produced in the world, some of these are discoveries, but most of them are new artificially created things with emergent properties. Thus, in some sense we have learned that meta-physics and physics have to be cognitively dynamic and adaptiable to the introduction of new things unexpectedly which may cause us to understand everyting else differently once the emergent event has occurred. What I am trying to say here is that the disciplines that we have been considering up till now in terms of their fusion into a single discipline, are in some sense merely an image in a particular domain of a more general structure specific to the Western worldview and its scientific and philosophical tradition. Ontological Engineering is an extension of the question of ontology as to what exists or can exist, or might have just been discovered to exist. Epistemology is about how concepts form knowledge constructs and how those change over time, especially how they transform by the production of new facts, theories, paradigms, episteme, ontos, existents and absolutes. Physics traditionally the opposite of meta-physics covered our study of things from various points of view, which eventually produced though history different disciplines and eventually different practical applications of those disciplines in engineering which occasionally produced an emergent product setting off a cascade of an emergent event that fundamentally changed the way we looked at the world, i.e. the worldview. Emergence Engineering is about how we produce those new, innovative, and novel objects that perhaps change radically the way we live, or the way we die in the case of new weaponry. Emergence is about the changes to Ontology, Epistemology, and Physics or what other disciplines study with regard to what is in the world. So these four elements were there from the beginning of our tradition in Aristotle, if not prior to that. The quadralectic has something to do with the structure of our metaphysical worldview. And we are merely seeing how it impinges on a particular aspect of our endeavours where we are attempting to produce systems and meta-systems with emergent or de-emergent properties. Normally these include information systems, but we are striving to extend that to the production of knowledge manipulation systems which understand things conceptually and can interact with us on a conceptual level. That hoped for move from the information level to the knowledge level is an emergent leap we are trying to bring into effect. And there is some hope that if we were to make such a leap and realize it that it could also transform how we design products themselves and allow us to engage in meta-design rather than the hard work of design itself.

Conclusion. We have a great deal further to go in our understanding of the relations between Design, Cognition of Concepts and Knowledge, Ontological understanding of what exists and their tacit relations, and the various perspectives of the sciences and engineering disciplines. To this we must add the exponential changes in technology, society and other factors that cause us to have to continually deal with emergent human production that shapes what is possible to design next. However, we have started the journey by pointing out the relations between these various approaches and General Schemas Theory which can serve as a basis perhaps for their integration. And we have mentioned that their relations are intrinsic to each other producing a quadralectic not very different from the quadralectic of Emergent Design. And finally we have mentioned how this pattern is deeply embedded in our tradition and shows up in the beginnings of the classification of the sciences and their relation to philosophy in the metaphysical era. This is merely meant as starting point for us to continue the integration of Ontological Engineering, System and Meta-system Emergence Engineering, and Knowledge Engineering based on General Schemas Theory a broad theory that can serve as the basis of our discipline, no matter how much it transforms from the integration of these various approaches in the future.

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