# On the Nature of Innovation: Towards a Structural and Behavioural Characterization[1]

Claudia Diamantini[1], Michele Missikoff[2], Domenico Potena[1]

[1]Dipartimento di Ingegneria dell'Informazione
Università Politecnica delle Marche - via Brecce Bianche, 60131 Ancona, Italy
{diamantini, potena}@diiga.univpm.it
[2]Institute of Analysis of Systems and Informatics,
National Research Council, Viale Manzoni 30, Roma, Italy
missikoff@iasi.cnr.it

**Abstract**. In its essence, innovation is commonly perceived as a process, i.e., a set of activities that are able to intervene and change for better one or more business elements. However, an innovation process is different from a usual business process. Innovation belongs to the category of creative endeavours that exhibit loosely structured processes difficult to be modelled and managed with the 'usual' methods. For these reasons, the present paper proposes a process reification method and develops the concept of innovation as an evolving entity. Such an entity, referred to as Innnogothci, is structured and managed according to a knowledge representation method, Topic Maps, that exhibit a number of convenient features for our purpose.

## 1 Introduction

Time passes but the attention to innovation is not showing any sign of decline, probably the opposite is true. But innovation is an elusive term that is often used in an imprecise way, or seizing only part of its substance. In fact, if we consider largely accepted definitions, it is easy to see that they are able to capture only part of the essence of the term innovation. For instance, consider the initial definition given by Wikipedia that reports: "innovation generally refers to the creation of better or more effective products, processes, technologies, or ideas that are accepted by markets, governments, and society." It is very schematic. Reading further, the text offers other perspectives. For instance: "innovation is the catalyst to growth", is the definition from an economic point of view; then, from an organizational point of view: "innovation may be linked to positive changes in efficiency, productivity, quality, competitiveness, market share, and others".

Another important aspect, in seizing the essence of innovation, is represented by the 'source of innovation', i.e., where the innovation originates. According to the literature, if we focus on technology-based business innovation, there are typically

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three modes to push forward innovation: (i) market pull, when it originates to respond to a specific market need; (ii) technology push, when new technological solutions offer the opportunity to improve a given business; (iii) co-creation, when innovation stems from a combined effort of the two above.

Another dimension is represented by the scope and impact of the innovation. Where its influence is it impacting? Among the most important target we have: production processes and means, products (goods, services, or both), markets and marketing strategies, organizations and business models, to name a few.

In its essence, innovation is commonly perceived as a process, i.e., a set of (partially ordered) activities that are able to intervene and change (for better) one or more business elements. But an innovation process is different from a usual business process we find in an enterprise. The latter is (supposedly) well defined and specifies to a good level of detail the activities, their sequencing, who is expected to perform them, what are the required and committed resources, etc. Innovation belongs to the category of creative endeavours that exhibit partially structured processes (if we can still call it a process), difficult to be modelled and managed with the 'usual' methods and tools (i.e., Business Process representation methods, such as BPMN, EPC, and related tools.) This is because innovation belongs to the categories of 'wicked problems'[1].

For the above reasons, in proposing a method aimed at supporting business innovation, we intend to abandon the traditional process-oriented approach to adopt an entity-centred perspective [2]. In our approach, innovation is seen as a complex structure that progressively evolves, growing from an initial seed, e.g., a creative intuition, through successive stages, such as a proof of concept or a prototype, until it reaches the final stage of an industrial-strength product (or process, or marketing strategy, etc.), where each stage can be more or less defined. At each stage, the innovation process requires the acquisition of new knowledge in order to proceed forward and reach a new stage. But, given a stage, what are the successive stages is not deterministically specified. So, we will have a fuzzy membership function to determine what is the stage that an innovation structure has reached and, when moving ahead, the next stage is non-deterministically reached.

## 2 A structural approach to innovation modelling

As anticipated, innovation concerns the entire process of moving new and valuable ideas into the enterprise, having an impact (direct, e.g., on the commercialised products, or indirect, e.g., on the production processes) on the marketplace [3]. Here we introduce a method that adopts an entity-oriented approach able to specify the structural nature of an innovation and, starting from the latter, its operational nature according to an underlying computational model. To represent the 'innovation entity' we adopt a Topic Maps modelling method.

## 2.1 Reification of an Innovation Process

A business innovation process consists in a (non deterministic) sequence of activities aimed at gathering and organizing a rich knowledge structure. In our proposal we will concentrate on the knowledge structure that is progressively built rather than in the process that is necessary to activate in order to achieve it.

The knowledge about a new business innovation case typically starts to be created moving from a creative idea, i.e., a preliminary innovation embryo. Then it is necessary to activate further investigations to understand the feasibility, the cost and benefits, if the market (and which market) is ready for absorbing the innovative product, etc. There are several studies in the literature that propose different variants of business innovation processes. For instance, [3] proposes the following steps: (1) discovery, (2) invention (3) development, (4) product, (5) market, and (6) profit. Another proposal, due to SAP, includes the following steps: (1) invent, (2) define, (3) develop, (4) deploy, (5) optimise. Both proposals are very sketchy specifications of a business innovation process; getting more specific, we discover that an innovation process is much more intricate, far from exhibiting the linearity reported above. However, despite their differences, they all exhibit a common trait: all the reported activities are tightly connected to the acquisition, understanding, organization, integration, enrichment, distribution, validation of a large amount of knowledge, typically organised in a predefined set of documents.

Our objective is to make such knowledge structures explicit. In our perspective, innovation is seen as a complex object that starts rather minimal (e.g., representing a creative idea or an intuition, a business opportunity or need) and then needs to progressively grow acquiring additional elements by means of specific studies, data acquisition, engineering investigation, etc. In essence, the 'innovation entity' is like a sort of artificial creature that once conceived needs to be fed with knowledge to progressively grow until it reaches the maturity, i.e., an industrial strength. To better fix the ideas, we wish to use the Tamagotchi[2] metaphor, adopting the name Innogotchi for our case that concerns business innovation.

We will consider the Innogotchi as a knowledge entity that, in order to grow and successfully develop in all its parts, needs to be fed, and the food is essentially knowledge. As an example, assume we are considering a fragment of a product innovation process, where the knowledge to be 'fed' to Innogotchi is represented by the following list:

- **Innovative idea**, that includes an idea description.
- **Feasibility study**, providing a preliminary account of objectives, technical and financial viability, IPR, etc.
- **Business model**, defining the economic sustainability and the way by which the novel product will be delivered to customers.
- **Technical specification**, structural layout and components (Bill of Materials), materials, building methods, standards, etc.

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[2] *Tamagotchi* is a Japanese term that refers to a digital creature and an electronic game that requires one to take care of the creature, feeding it to make it evolve to more mature forms.

- **Business plan**, including market analysis, cost-benefit analysis, financial viability (including break-even analysis), critical risk factors (including SWOT and PEST analysis), an exit strategy.
- **Marketing and sales strategy**, including selling modes, pricing, warranties, after-sale services.
- **Production planning**, including manufacturing, testing and QA methods, sourcing, logistics and delivery strategies.

As an example of non-determinism in the innovation process, a business model is typically defined during business plan definition, but often it is taken into consideration at earlier phases, for instance when a feasibility study is performed. In turn, a (preliminary) feasibility study can be started as soon as the innovative idea is sketched, or it can be delayed until the technical specification is given. The above points can be structured according to the knowledge they need to gather and, in addition, the specific methods and procedures that need to be adopted to collect it; all this is reported in the Innogotchi structure. As anticipated, the above knowledge cannot be acquired in any possible order since there are dependencies and priorities: also those represent knowledge that must be fed to the Innogotchi.

### 2.2 Innovation as a Topic Map.

Our objective is to capture, model, and organise the knowledge necessary to develop an innovative idea until it reaches the maturity and completeness of an industrial strength stage (be it a product or a process.) There is a great variety of knowledge modelling methods, graphical, such as E-R or UML, rather than in linear form, such as Prolog, RDF, or OWL, that may be adopted. But here we need to create a rich knowledge repository that includes the structural representation but also constraints, and procedures to acquire the needed knowledge, with also the possibility to easily connect instances and information resources, like documents, URLs, images, and so forth. For our purpose, a suitable approach is represented by the Topic Maps [4] that, in addition to a powerful modelling paradigm, offers a good choice of management tools. Topic Maps is a standard for the representation and interchange of knowledge. It is based on a sound mathematical basis (Common Logic) and has been defined as an ISO standard (ISO/IEC 13250:2003). Basic elements of a Topic Map are:

- **topics**: representing any subject of discourse, from people, countries, and organizations to software modules, individual files, and events. (E.g., The graduate student Aldo.);
- **occurrences:** representing information resources relevant to a particular topic. (E.g., Aldo's Facebook page.)
- **associations:** representation of a relationship between one or more topics, (E.g. Aldo is enrolled at Stanford University).

Topics, occurrences and associations can be categorized according to their kind. (E.g. the topic "Aldo" belongs to the category "graduate student"). Categories are named *types* in the Topic Maps notation. In practice, the set of topic, occurrence and association types form the conceptual or ontological level of the topic map, typically organised according to a super-type/sub-type relation. Then, an instance-class relation is established between a topic and its type. The capability of a Topic Map to simultaneously represent concepts, instances as well as information resources related to instances, within a unified frame, is one of the most powerful features of its knowledge representation paradigm. Topic Maps can be associated to graphical representations where topics and information resources are represented as nodes while occurrences and associations are represented as arcs. Fig. 1 reports a simple rendering of a Topic Map.

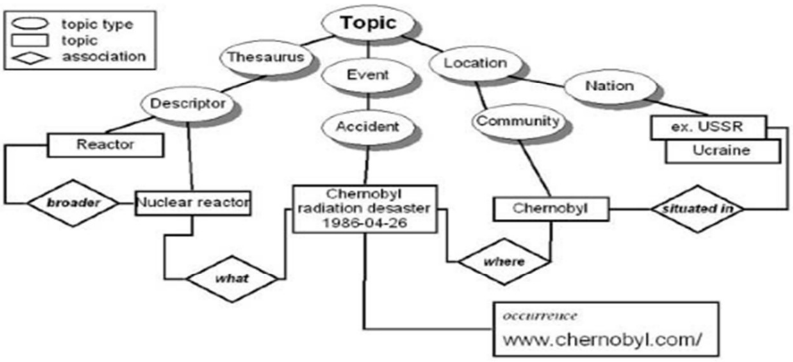


**Fig. 1.**. An example of Topic Map for the Chernobyl Disaster [5].

## 3 Innogotchi: an evolving knowledge structure for innovation

Here we elaborate the knowledge structure, sketchy reported in Section 2.1 in the form of a bullet list, as a fragment of a Topic Map. It is conceived as a core structure that progressively evolves, capturing the knowledge gathered in the different stages of development of the initial idea. The proposed method consists in the *Innogotchi* knowledge structure that needs to be progressively fulfilled, by providing the required knowledge. Each component, besides the structure (e.g., the information that needs to be provided) is also associated to one or more procedures (i.e., subprocesses) that can be activated in order to collect and/or produce the required knowledge. Such procedures are very diverse, depending on the kind of knowledge, and may require skilled people (e.g., market analysts), specific tools (e.g., PEST analysis tool[3]), and/or the access to dedicated information resources (e.g., web sites with figures on the market of interest). Furthermore, dependencies among *Innogotchi* sections are also reported. This structure is represented in Fig. 2, where the reported map has been drawn by using *Ontopia* (http://www.ontopia.net), one of the most widespread Topic Maps management tools.

Due to lack of space only the ontological level is rendered, and a single instance (the innovative idea “Massage chair”) and its properties are reported as an example. In particular, the broken line represents an *instanceOf* relationship between a topic and its topic type, hence de facto this kind of lines divides the conceptual level of the

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[3] See for instance: http://www.businessballs.com/pestanalysisfreetemplate.htm

Topic Map, from the level of instances. Also note the panel, which describes the properties of the instance, and in particular a pair of occurrences: the URI of the document describing the idea specification and the URI of the sketch of the new chair.

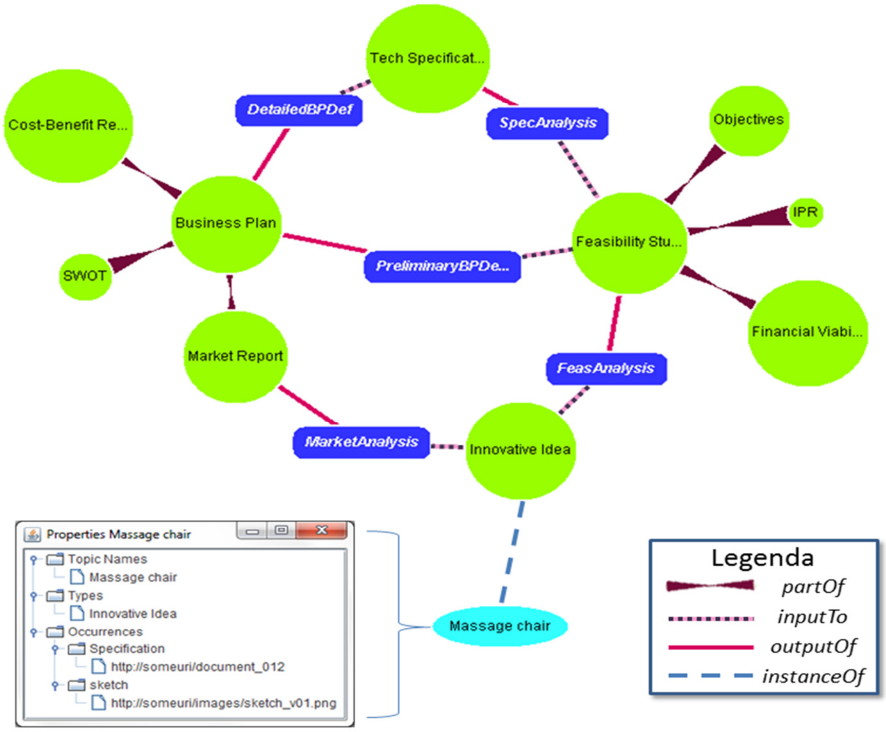


**Fig. 2.** A fragment of the Topic Map for Innovation Knowledge.

At the ontological level, green circles represents knowledge types, whereas blue rounded boxes represent activity types. Arc shapes represent different association types. Bowtie arcs represent *partOf* relationships among knowledge types, while straight and dotted linear arcs respectively represent the *output_of* and *input_to* associations between a knowledge type and an activity. The definition of these associations is a crucial design choice since it allows to define constraints in the growth of the *Innogotchi*, showing what knowledge is needed to produce another. Although a similar dependency constraint could be represented by directly linking two different knowledge types, the explicit use of activities serves two goals: (i) it allows a richer description of activity features, for instance the fact that two or more knowledge types are needed to perform the activity and (ii) it allows to recognize and represent the existence of different instances of same activity type, that is of different modes to move to the next stage, with different efficiency and effectiveness levels. This represents also the non-determinism inherent in the innovation process and, besides being a support for the incremental evolution of a specific *Innogotchi*, it also provides different "ways to innovation".

## 4 Conclusion

In this paper we presented a few preliminary ideas aimed at addressing the problem of business innovation from a declarative knowledge representation perspective, instead of the more traditional Business Process approach. Innovation is widely recognised as a complex loosely defined process and it shares the difficulties typical of the wicked problems: when you start you are unable to foresee how the process will evolve in its later stages and if eventually it will successfully end. Furthermore, each innovation endeavour is different from its predecessors, although it is possible to identify a number of ‘knowledge invariants’, i.e., elements that need to be acquired in order for the focused innovation to progress and mature towards an industrial and/or commercial result. In this paper we proposed to see an innovation as an entity, referred to as *Innogotchi*, which is fed with the knowledge necessary to evolve along a successful innovation path. So our specification is concentrated on the structural aspects of the *Innogotchi* and its components, represented according to the Topic Maps standard, rather than the process necessary to achieve it. The growth and achievement of an *Innogotchi* can be performed according to a computational model driven by its structure with the objective of *Innogotchi* completion. The future of this work will focus on a better definition of an example of *Innogotchi* and the specification of the computational model.

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