Knowledge and object phylogenetic production cascades - the TELOS case

Ioan Rosca
Information, instruction and telecommunication systems engineer
LICEF-Teleuniversity of Montreal, Canada
ioan.rosca@licef.teluq.uqam.ca

Abstract. In the unitary design of systems involving people, objects, processes and concepts, the engineering acquires a hybrid character, requiring the coagulation between the contributions based on diverse expertises and posing coordination and communication problems inside mixed design teams. The LORNET project federates research institutions from Canada for the construction of a “middleware” supporting technical and semantic inter-operation between campuses and repositories distributed on the Internet. It is a double challenge: an effort of concurrent research for instrumenting the instructional concurrent engineering. Observing the circle between "doing by learning" and "learning by doing", activity coordination systems can be enriched with a "semantic layer" (facilitating the procedures execution by alleviating their comprehension and learning). Reciprocally, the production and management of distributed pedagogical activities require collaborative procedure modelling and orchestration. This paper is addressed to those seeking different perspectives in dealing with complexity. I summarize it as follows: mixing the management of persons, objects, processes and knowledge; using the procedures' models for their orchestration; approaching a “4d” vision for extending the observation of short process (“ontogenetic” and “physiological”) to those of long-term evolutions; unitary management of phylogenetic cascades- reproducing structures and processes- based on metafunctions.

Keywords: instructional systems engineering, semantic indexed procedures, phylogenetic production cascades, LORNET, TELOS

Introduction

Although I do not actively take part in the scientific life of the CE community, the consulted papers enable me to see the connection between the problems that preoccupy this interdisciplinary domain and the problems I faced as an architect and coordinator… of teams producing systems and knowledge… usable for the production of systems and knowledge… usable for the production of knowledge and systems … I'm counting on the expressiveness of narrating my experience to point out intuitions and proposals - instead of launching myself in an analysis of the literature of a domain that I do not claim to master. For this reason, I will not resort to the usual bibliographical explorations (specifying only the last readings that influenced this paper - as, for example [1a, b] and signalling personal texts- which extend ideas briefly exposed here).

1. Between to do, to know and to learn

1.1. Procedure for knowledge… or knowledge for procedures?

The encounter between these two trends in fields like "pragmatic web" [2] is natural and I had been waiting it for a long time. I have realized the indissoluble link between information (learning) management and activities management for the first time - as coordinator of the vocational training system of a large electronics company (television sets, computers etc). Trying to organize an infrastructure for combining instruction, information and support, I found myself in a difficult posture. I discovered that the "technology of instruction" rises problems as: "With what strategies and tools should we equip the technologists A and methodologists B, which wish to supply (with composition and management methods and instruments) a public of authors C and managers D, which organize instructional systems, in which a group of assistants E can instruct a group of learners F so that they obtain an amelioration G of their competences in the knowledge domain H, necessary to accomplish the performances I in the contexts J- … all that optimally, according to criteria K, verifiable by the methods L".

In the meantime I have learned that the engineering of objects and knowledge cannot be untwined. Knowledge is produced in activities instrumented with objects. Their construction is accomplished through communication and coordination- which is based on semantic synchronization. At the base of this loop stands the relationship between "doing to learn" and "learning to do". In order to do, you must know. But for that, you must exercise, doing- learning, climbing up the "experience" spiral. Therefore, the concept of "assistance" - covers a large range of significations. It can mean to "inform" –delivering an opportune and intelligible message. When the understanding process meets difficulties- "clarifications" are required. If necessary, the beneficiary is helped to "learn" the information- in order to be able to reuse it anytime. In the place of explicative messages (what is to be done, how, with what instruments)- new tools can be provided ("equipment") or the use of the existent ones can be "facilitated".

After many years of practice and meditation, I have reached the conclusion that the concept of *explanation* can facilitate the fusion between instruction and assistance and that the foundation of the "instructive-productive management" should be a unitary theory of procedure modelling- including material and cognitive aspects. I have exposed the objectives and principles of such a science in my doctoral thesis [3]. I will only signal in this intervention the aspects related to the cooperative design of evolving systems implying evolving knowledge (embodied in evolving participants and referred in modifiable message supports).

The connection between knowledge and the entities that incorporate it must be correlated with the observation of dualities such as: structure/process, existence/transformation, adaptation/evolution, ontogenesis/phylogenesis. The physical and conceptual entities, tied by relationships, create systemic units and determine their behaviour (physiology). Conversely, the physical and cognitive processes sediment structures (entities and relations). A complete systemic vision must reveal the existence-becoming duality. The adaptation and evolution of a structure are intimately tied, defining its "life", as systemic entity. The ontogenesis of the being (of the individually experienced concept, of the object) and the phylogenesis of the species (of the collectively experienced concept, of the object production cascade)- are interlaced processes.

In the same way a cell's metabolism coexists and interferes with the metabolism of the organism it belongs to, the individual cognitive metabolism is "situated" in that of the community [4]. Explicative communication can be seen as a relationship between two distinct cognitive systems, but also as a manifestation of the cognitive physiology of the human species' system, ensuring knowledge reproduction.

What derives from these systemic considerations?

The proposal to replace the concept of “concurrence” with that of “coexistence” and "co-evolutivity". The perception of the “4d” character of systems moves the accent from “reengineering” to the longitudinal management of their evolution [5]. As for the continuous evolution of the participants, what can better highlight it than the observation of the "learning" phenomenon?

1.2. Semantic matching for co-action and explicative communication

The key to the coordination of (design) processes is the co-operation between participants. Sometimes, it can be solved by distributing the tasks, other times it asks the demonstrative sharing of certain operations. In any case, it supposes semantic consonance. The engineering of concurrent processes involving people cannot avoid the communication problem and the partition of meaning.

Although dealing intensively with modelling co-operation and negotiation (examples in [6,7]), domains like CSCW, DSS or CE have studied insufficiently the specific of explanatory cooperation- in which the expert does because he knows and the novice knows progressively- because he is helped to do. It isn't just about concatenating two operations, because the "pas de deux" execution draws its sense from the processes fusion.

What role can intermediary artefacts have in these bi-human processes? To what extent can they take part in to the dialogue (as "intelligent agents") or instrument it? As co-action and communication partner, the human assistant has intrinsic qualities - difficult to mechanize. The assistants' "artificialisation" is problematic - practically and ethically. But prior to cooperating or communicating, the partners must equip, find and agree themselves. And after, they must update the model that sustains their coordination. Instead of degrading the explicative dipole, the synaptic infrastructure based on the computer network can provide contact, contract and management services. Activity coordination systems (production, instruction, engineering) of CSCW type could be enriched with matching facilities: selection of participants that can perform (optimise) the ongoing operations' chain.

This requires the "indexation" of all elements (available persons and resources, actors and generic instruments specified in the activities' scenarios) relative to a "knowledge domain" K, used as a reference system [8]. In a support (instruction) system, the evolution of the subjects' understanding must be observed. We use "*competences*" C (descriptions of someone's position relative to knowledge): "mastering levels"- measured on a metric scale M or qualitative "abilities"- as *knowledge/ comprehension/ application / analysis/ synthesis / evaluation).* In order to observe the competence equilibrium around pedagogical operations [9] I have introduced "postures" as: (*knowK, aimK, explainK(x,y), describeK(x,y), evaluateK(x,y), recommendK(x,y)*)- where the parenthesis show a predicate depending on the detained (x) or aimed (y) "mastering level" of the person (learner etc) to which the described participant could explain the knowledge k.

The organization of the K-C layer stands at the foundation of the global physiology of the knowledge system involved by a project, an evolving system or a community. Semantic indexation (knowledge and competences) of participants and documentary resources will facilitate their retrieval (in the case of emergent activities) or their connection (when the activities are orchestrated through adaptable predefined scenarios).

1.3. Managing a project seeking project management tools…

I had the occasion to study the relationship between supporting learning and action in some research projects: SAFARI (an ITS authoring system), EXPLORA (a virtual campus management platform, MOT (a knowledge structure, pedagogical scenario and resource conception/diffusion editor - IMS-LD compatible), ADISA (Distributed Workbench for Learning Systems Engineering - allowing their complete planning according to the MISA method), SavoirNet (the transition of EXPLORA towards a service provider position), VAL-GEFO (a cooperative pedagogical workflow manager) [10]. But the fusion of this vast problem space was imposed by the task of conceiving the TELOS system (distributed pedagogical tele-learning operating system) in the LORNET (learning object repository network) project (launched in 2003 and holding until 2008).

My activity in LORNET (2003-2005) as conceptual architect has enforced my belief that the methods and tools used in the management of such complex projects should be perfected. An interesting (and somewhat paradoxical) engineering situation is created - in which the formulas and instruments produced in a project can be useful in the organization of their construction. The occurrence of this "vicious circle" can produce a certain epistemological perplexity, but it also opens the way of refined and fertile strategies for ascending the research-development-application spiral.

But I haven't found yet a satisfying theoretical frame to approach the matter of recursive management and meta-management (managing the process of conceiving a system for managing the evolution of the A-B pair formed by a system A and a management instrument B…). I also haven't assisted often to descriptions of projects envisioning management methods- that were organized by the proposed methods, of procedures for process modelling, modelled by their own formula etc. Why do we invite others to consume medication (instruments) that we do not use in analogue situations? Could it be that some profound causes are hidden here? Insufficient observation of costs involved by the management efforts hides optimisation paradoxes?

2. The loop between a procedural reality and its model

I have defined the TELOS conceptual architecture [11] so that it sustains the modelling and management of distributed instruction activities: from the emergent ones (searching human and material support and chaining operations freely) to the orchestrated ones (through rigid or adaptable scenarios). Sometimes, users prefer the freedom to choose the pertinent resources (support tools and persons, previously "published" in directories and repositories). In other situations, instead of loosing time to find resources or order operations, users can rely on already prepared "aggregates", edited by an author at a previous stage [12]. These combinations assemble the resources appropriate for solving a problem, according to various formulas. "The

Collection" - is a set of resources, equipped with management instruments (interfaces). "The Fusion" - composes a system from interdependent resources, forming a unitary whole. "The Operation" - aggregates an action, its executor, support actors and support or target resources. "The Function" - is a procedural aggregation, the required resources being connected to the operations decomposing the activity that it models or orchestrates [10,13]. The structural or procedural aggregation can continue recursively, leading to more and more complex resources.

A rising interest is manifested for the representation and instrumentation of procedures, both as design target and as its instrument [14,15]. The use of models can be a way for their management, orchestration or reproduction. The functions allow the representation of short processes ("events") but also of “longitudinal” evolutions. For instance, they can represent a resource (aggregate) lifecycle chain (edition, progressive concretisation, run-time adaptation and use, annotation and feed-back).

When the object pursued by such a model M is also a model m (for example a function)- we can emphasise the reciprocal influences between the modelled reality r and the model m (occurring for example during the model composition inspired by the reality or when the phenomena's model m is used as an instrument by the participants to an actual r process). The global physiology of the "reality-model" pair can be followed (managed) with the help of metafunctions (also see a similar approach in [16]). These ones capture the evolution of the relationship between an assisted system A and a supporting system B: the request, definition and construction of B (from A), the adaptation (particularization) of B for various versions (contexts) of A, the use of B (towards A) and finally the annotations and the eventual corrective reactions. The P(f(p)) process of managing such a f(p) "functional model" for a procedure p (from its edition to its use) - can at its turn be modelled and orchestrated with the help of a "metafunction" F(P(f(p))).

Figure 1 represents the global process of reproducing primary phenomena, modelling them and using these models to create more or less similar secondary phenomena (procedure "phylogenesis")- synthesizing the use cases of the GEFO function manager.

1 **Modelling.** A primary procedural phenomena P is observed (imagined) by the designers that edit its model.. 2 **Reproduction.** The primary phenomenon P is reproduced in a number of secondary phenomena S, through the execution of the model, which can mean 2a The model is used as an informational (explicative) guide, inspiring the actions, facilitating the sequencing etc. 2b The participants declare (annotation) and produce (trace) data relative to the exploration- memorized by the model and used for reactions (verifications, support etc). 2c The model is used as an interface for launching and controlling some resources, facilitating their manipulation (procedural aggregation) 2d In the case of cooperative use, the model can facilitate the participants' communication and coordination (floor-control, signalling, etc). 2e If it is semantically indexed, the model can provide retrieval, selection and alerting services, sustaining the run-time concretisation of the components (matching role). 3 **Meta-modelling.** Observing (imagining) the primary process 1 of the model's editing (or of the P-1-2-S chain of reproducing procedures with the model help), some process engineers can edit meta-models- useful for modelling, explanation or support. **4 Meta-reproduction.** Using meta-functions (in the: a,b,c,d,e sense), the primary process 1 of function editing can be reproduced (with variations) in secondary editing processes 1S-producing functions usable in the chain 2-S.

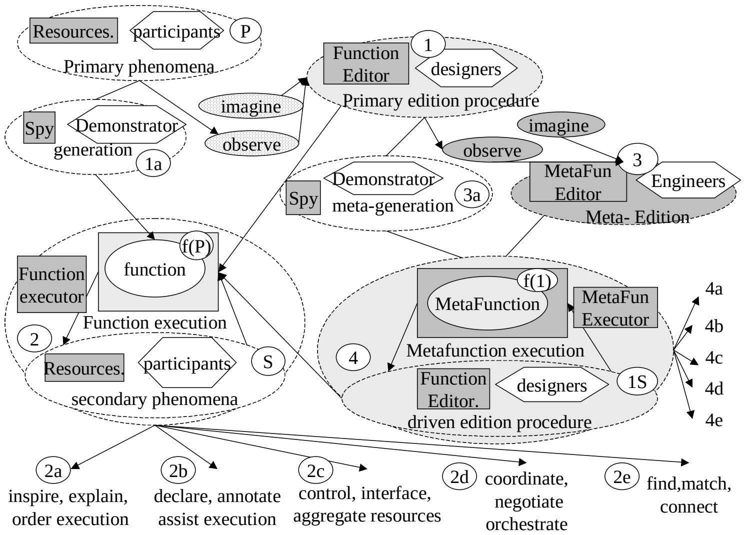

Figure 1. The procedures' phylogenetic reproduction chain

3. The meta-engineering of "phylogenetic" production cascades

The meta-process exposed above can explain (manage) the reproduction of processes and structures. But the “ontogenetic” operations can also be chained by “production cascades”: the resources resulted from a process being used (as raw material or instrument) in the other. The questions signalled in paragraph 1.1 have stirred my interest for the meta-engineering of the longitudinal chaining of "lifecycles", conforming to a "phylogenetical" approach: to prepare "grand-grand-mother" systems that can produce "grand-mother" systems with which "mother" systems can be conceived, able to generate the desired knowledge "children".

The ambition of the systemic approach is therefore paid by confronting complexity (perplexity). A rigorous resolution is problematic. Even when it is possible, the energy expenses can surpass what is gained from it. The impressive number of: elements and phases, aspects and dimensions, criteria and methods, contexts and versions – require the simplification of the models, strategies and instruments, according to a "pragmatic" orientation: get the most useful services through the most accessible means, seeking the optimisation of the effort/result ratio – when the resources are limited. I have orientated the TELOS conceptual architecture [6,9,10] on such pragmatic criteria, segmenting the following phases of the TELOS main production chain:

LKMA use - to produce knowledge and LKMP. The system's target-process is the use of learning or knowledge management applications (LKMA) by learners (eventually assisted by facilitators)- to improve their competences and eventually produce some material results- traces, notes, objects- (forming knowledge management products- LKMP, which can be managed in system libraries or in user portfolios).

LKMS use- for producing LKMAs (lessons, support tools etc). An important case of (functional) aggregate "ontogenesis" is the construction of an application scenario (LKMA) using an authoring tool (learning and knowledge management system - LKMS). The recursive situation shows up: the design procedure produces a model that will pilot the (re)production of another procedure. Thus, the participants to this phase can also learn, cooperate, produce traces and notes, receive support from specialized persons or use assistance tools.

Core use- for producing LKMS (instructional systems, authoring tools, etc) Another important ontogenetic chain is the construction of an LKMS with the instrument toolkit available in the TELOS core, its particularization for various beneficiaries (that will use it for the conception of LKMAs.) The LKMS design can be managed as a complex aggregate composition. Thus we can observe operations as: finding components, making notes, producing traces, receiving help, learning, cooperating etc.

Core modification and longitudinal management. Core administrators manage the content of system libraries and handlers: document and tool repositories, participant directory records (eventually enriched with person "interfaces"), aggregate repositories (fusion, collections etc), operation and function models (abstract, concretised or adaptable), LKMS, LKMA and LKMP areas. The *"genetic" character of the production cascades* becomes visible observing the object "circulation": a component produced by the system core engineers can be adapted and incorporated in an LKMS, then placed into an LKMA - from where it can finally get into an LKMP.

Figure 2 (extracted from the TELOS documentation)- illustrates the TELOS operations described above and adds the level of the LORNET research team, building the TELOS system: the educational researchers- establishing the project specifications and the evaluation scenario, the system engineer- producing the conceptual architecture and the scheduling, the technical architect- designing the architecture and piloting the development team, the technical evaluators- observing the system behaviour and the pedagogical evaluators- watching the qualities of learning experiences realized with the aim of the LKMA… produced with the LKMS… designed with the core tools.

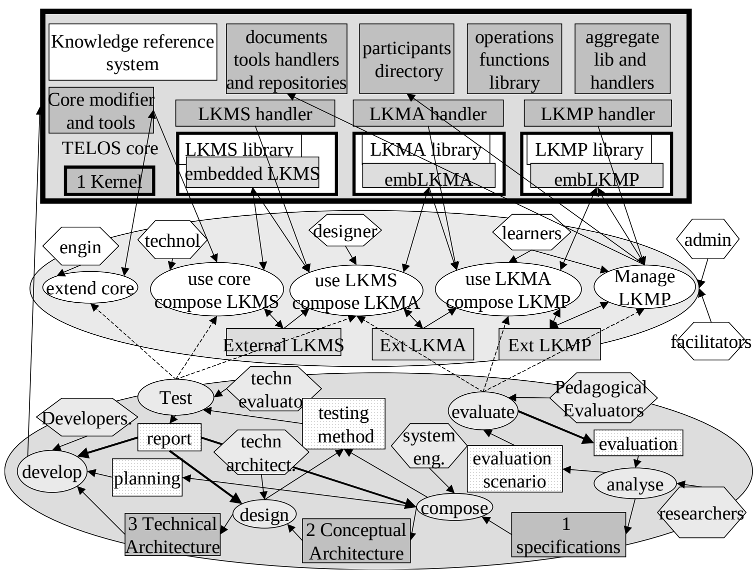

Figure 2. TELOS and LORNET blended physiologies

Organized as a "meta-function" (with connected resources, indexed on a meta-ontology and implementing ordering, coordination and assistance mechanisms) - this scheme could have become a dual-project management tool (instrument and proof of concept). That is why we have used [10] the GEFO manager to illustrate the desired behaviour of the TELOS system. That is also why we could adopt and enrich the RUP software engineering method [11] - axed on "use-case" management- during all development phases.

I hope that this succinct account will instigate the interest of the CE community for the instructional engineering. On one hand, this domain reveals similar problems to those encountered by the engineering of any complex system. On the other, any systemic metabolism implicating human protagonists involves an evolving distributed knowledge system. The physiologies of these two reality layers are too intimately correlated to justify their separate optimisation (engineering).

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