Goal dynamics: from System Dynamic to Multi-agent systems

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Abstract. This paper presents the work have been conducted during the first year of my PhD degree in management of science and information systems in business and economics school, Loughborough University, also it describes the research design and plan for upcoming years, including literatures review, methodology, aims and objectives and research design. The research aims to provide a methodology for capturing, and understanding complex and dynamic problems, focusing on a thin line from human mind and intention to complex agent systems, thus will open new horizons toward designing new generation of information systems. The research composed from two parts. First aims to understand the goal creation process "Goal Dynamics" in social and cognitive context then to provide a methodology for understand it and model it with an intention of building information systems. The second part aims to understand the configuration of agent that allows information system interact with the change in the environment "social and business", the contribution result should present the conceptual and logical framework for the agent information system.

Keywords: Goal Dynamics, Requirements Engineering, System dynamic modeling, multi-agent systems, and agent oriented modeling.

1 Introduction

From long time, the researchers trying to analyze complex situations occur in our world by following different theories and assumptions. Examples for these situations: including behaviours, unexpected event, up-normal status and many others social or ecological phenomena. This is not the end, the new socio-economic and socio-technical systems led to increase efficiency, speed and accuracy but in the same time increasing in the complexity in our life, to such an extent emerged from the need to manage and control these creative new systems; Even the most optimistic design initiatives finding the rhetorical moves unwieldy or struggling with the software tools to express and manage things as they would like. Since the complexity considered as a problem need to be solved, many researchers adopt creative thinking methods to solve such as complex problems. Boden and Gero (J. S. Gero, 1994), (M. Boden, 1991) argued that moving from one conceptual space to other conceptual spaces is essential for creativity, which is important for problem solving process. Furthermore,

they argued that building a space from an idea should not be related to personal perception to enhance the creativity. The previous assumptions are a justification to how transformation from a model to model can give different knowledge perspective about the phenomena or the enterprise in the business domain, while the knowledge network growing it will be easy to reflect the new knowledge on business activities by linking different models together, which help in transforming the knowledge from tacit level to execution level (Hori K., 2000). The need of using memory and experience is very tricky, while it is important to use memory for building trust, learning and reflecting. The memory should be ignored when we talk about creativity, this is explaining what many researchers declare " if you want to get different results, change the way of thinking or the process" , "if you follow the same procedure to solve an equation you will get always the same result". This statement contains advice for both learning and creativity, where we need to use and ignore memory continually. Usually one model or space is not enough to solve all kinds of problems, for instance: business process model can't describe everything in the business domain and can't provide a full solution; business needs more models to describe the different kind of ontologies and knowledge, rules, vocabulary, processes, data, complex calculation and operations. Integrating several spaces and models is not an easy task, transforming the instances and parameters should be accurate to provide successful integration, the development in information system aims to provide a one single problem solving point, the model should be filled by all available knowledge capable of give the ability to perform knowledge mining in other spaces, the process is to search the solution in one space model once the search fails in discovering the solution should be able to jump to the next space model and explore the solution.

The space model is a creative structure built by designer/thinker to provide suitable structure to investigate the solution. Domain space shouldn't be static and this requires to be connected to several knowledge sources and should be able to link the knowledge from previous model spaces to the current investigated one. This multi-space model should provide two important contributions: 1) to be able to simulate the current state and the solution "presentation"; thus will give decision support answers. 2) Should be able to provide an implementation platform for the solution in enterprise information systems "implementation". Metamodeling concept is one useful and widely adopted technique address this issue by creating a schema of abstraction has instances to the more details model. Basically, Metamodeling started with branch in computer scinese called conceptual modeling, which is also belong the software engineering, with goal to use abstraction and modeling to solve complex problem in a new way as presented in model driven development. Metamodel allow creating schema for the subject to be fulfilled by domain knowledge once required, it is also helping in simplifying the complex models of the real world while keeping valid the model execution capability. The other concept is the model transformation it helps to jump from space models to other space models to increase the comprehension and instances validity. Moreover, model transformation help in integrating knowledge spaces where the knowledge represented in one space models not available in other space models, thus will increase problem solving capability and data validity. The both concepts are highly considered in the research as they are current and future research trends still not fully potential capabilities have been used.

The figure 1. Below describe a conceptual design for a visionary solution to solve complex and dynamic problems, this solution is based on the concepts have been mentioned before. Multi-space integration model can technically be implemented based on model integration, were set of models will work as a comprehensive solution, for instance, the ERP system is composed from different modules. These modules specialized and cover some set of activities and functionalities in the business domain. You can buy the solution as a whole or a part depends on business needs, whenever the problem is more complexes will require adding more spaces. In the end, you have a single access point "interface" and multi integrated models, the single model should be dynamically developed reconfigured and its metamodel should be automatically readapted to match and fit the new situation. Such as framework still far away, though something similar have been proposed by OMG call, called "The concept of the problem-specific views" (OMG, 2010), this research will be a step toward adopting such as complex multi-space modelling framework.

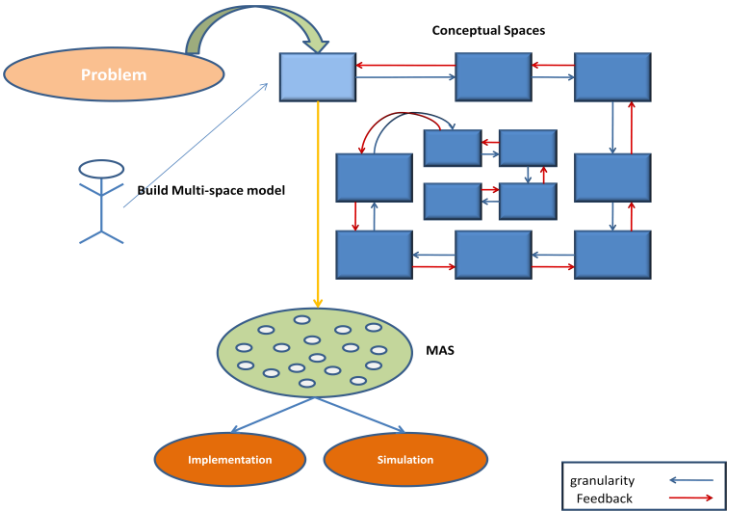

Fig. 1. Solution concept

This paper organized as the following:

Section Two: literature review and state of the arts related to the problem domain, related disciplines and solutions. Section Three: research problem and gap. Section Four: research objectives and questions and Section Five: research methodology, followed by tools and conclusions.

2 Literatures review

Two of the complex variables influences business environment and not fully considered by researchers and current techniques, are the goal creation process (configuration) and the agent configuration, the research will be conducted based on

only those two variables which contain diversity of methods and research disciplines where it will not be easy to realized, in other side it will bring comprehensive and expensive research value.

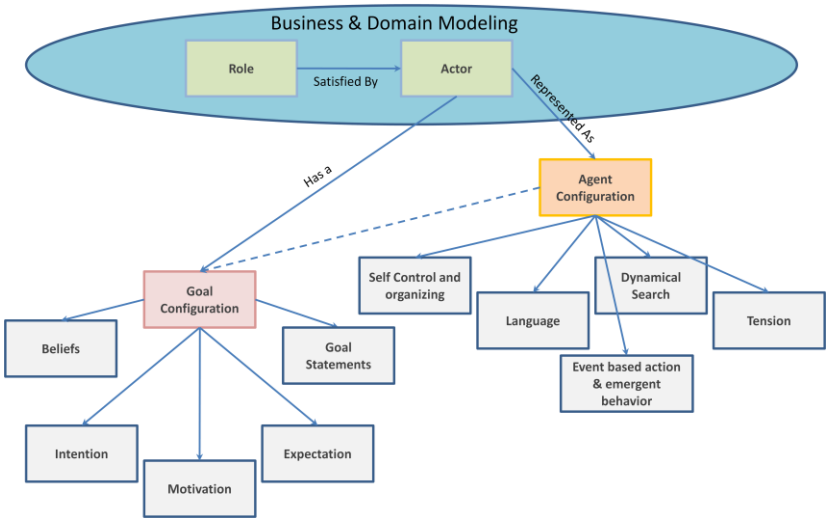

Fig. 2. Research Components and Variables

2.1 Goal Configuration

Goal modeling technique has been proposed in many frameworks. However, the semantic based intentional modeling approach is that the representation of behavioral and intentional aspects of the stakeholders' goals (Samavi, 2009) is not considering the dynamic aspects of the modeled goals. In (E. Yu, 2009) the author argues that goal-oriented RE frameworks (such as KAOS or NFR framework) employ ontology, which is intentional but not social. Semantic-based intentional modeling (E. Yu, 2009) is representing the behavioral and intentional aspects of the stakeholders goals, intentions and motivation may be used to design processes and rules in information systems. The change in goal and motivation also is influenced by the representation of the time as a dynamic dimension, thus will trigger the business processes and business rules systems to change the behavior and constraints based on previous assumptions. It is important to represent and link the dynamic intentions of the stakeholders, which will be represented as attributes in the goal configuration. Thus will lead to formulate semantic content of the goal, considering the evolutionary aspects of semantic contents, which make research in this area a real challenge, also it is important to find the semantic map between intentional model of stakeholders and their roles and processes design in IS's, however, possible solutions available such as (event management system, and rules engine) triggered by changes occurred from ecological environment factors and stakeholders mental model (Sterman, 2000). Prof. J. Gero

discussed. The development of the Function–Behavior–Structure (FBS) ontology has provided one robust ontology that has been applicable to both designs (the results of designing) and designing (the process of designing), this ontology can be used to describe the learning and reflecting process for goal creation. However, in this part the research will investigate the causal relationships among intentional aspects of the goal in the process of trying to describe social ontology and to be integrating with the second part of the research in "Agent Configuration".

In (E. Yu, 2009) it's clearly mentioned that intentional ontologies have been emphasized goal and goal-based reasoning but beliefs have not been so well investigated. Beliefs appear in the NFR framework in a form of claims and subject to the same evaluation propagation producer as softgoals.

The aim of this part of the research is to understand what is the Goal creation process, how it formulated and what influence its change and dynamics by intentional ad social aspects, how we can relate to strategic business goals and objectives, how these variables will look in detailed requirements' models (semantic mapping) and how it will contribute in building/generating IS specifications. It is high potentially to use System dynamics modeling technique presented by the tool iThink in describing the complexity phenomena and relation among variables. As well as studying i* framework is essential since it is the most advance framework for describing social relations and intentions in the early requirement engineering domain, finally ontology development tools to use maximum capabilities of ontology. The tools may be extended or build a model up to them to extend their capabilities in progress of developing and testing research assumptions.

2.2 Agent Configuration

Agents characterized as Autonomy, Adaptation, Interactive, Heterogeneous, Flexible, Scalable, Distributed and Robust. In requirement engineering Agent have been proposed in i* framework only.

The Language is one of the complex aspects to understand social and domain knowledge as well as researchers working from long time trying to transfer language to the systems in a form that can be understood from the systems as understood by human and to be used efficiently in enterprise applications. SBVR is an OMG standard represented as formulation of natural language; agents interact with other agents (and possibly humans) via some kind of agent communication language. SBVR is an ontology describing business vocabulary and business rules in business level. Using SVBR to extract knowledge from the organizational and business level to IS level will be extremely valuable for agents in different purposes, 1) it is possible to use the SBVR ontology as a communication language among agents, 2) it is possible to write agents governing rules and behavioral rules by SBVR formulation, 3) extract the knowledge from computational level to IS and handle it as an input to our Agent systems (fayoumi, 2009).

In complexity science Self organizing as described by Cilliers (1998) p. 97 “the system organises itself towards the critical point where single events have the widest possible range of effects”.
For instance, Sand piles; forests; heartbeats: Under constant tension of some kind (gravity, ecological balance, delivery of oxygen), some systems reach a critical state where they maintain stasis by preservative behaviors—such as sand avalanches, forest fires, changing heartbeat rate—which vary in size of effect according to a power law (Bak et al., 1987; Drossel & Schwabl, 1992; Bak, 1996).

In computer science Self-organization is an attractive way to handle the dynamic requirements in software. It refers to a process where a system changes its internal organization to adapt to changes in its goals and the environment without explicit external control. Self-organization often results in emergent
behaviour that can be either desirable or undesirable. Due to the dynamism and openness of contemporary agent environments and the ever increasing distribution, complexity and dynamic changes in application requirements, understanding the mechanisms that can be used to model, assess and engineer self-organizing behaviour in MAS is an issue of major interest.

In the early 1900s, a French physicist named Bénard conducted an experiment which is widely quoted in complexity literature due to its neat demonstration of self-organisation and emergence. The experiment is simple. Heat some liquid from below. At first convection currents from keeping the system in equilibrium. As the heat increases these convection current's morph into clearly recognizable hexagonal cells, these cells appear to be efficient at dissipating the energy from the liquid. Prigogine, a complexity science pioneer, called this type of phenomena, ‘adaptive tension’.

Complexity science aim to describe how order emerges from self organizing agents' interactions (McKealvy, 2004), agent it may be automated “artificial agent” or not automated”actor”.
Adaptive tension is required for the self organisations, such as the formation communities of practice. Nevertheless, what does this mean in the organisational context? Well, 3M created an adaptive tension by mandating 30% of revenues must derive from products introduced in the last four years. GE created adaptive tension when Jack Welch made it clear that each division must be 1st or 2nd in the marketplace of it will be fixed, sold or closed down. Adaptive tension can be negative or positive in an organizational setting, it is important for learning, innovation, strong control and fat adaptation.

In this case, agents should have the ability to perform a dynamical search in the real time scale, agent learning and adaptation will be based on the knowledge that will be received from input tools (text to SBVR model), and it’s the agent responsibility to extract the required knowledge from the model repository or DB then to use it according to it is role and governance rules, agent implementation could take advantages of Belief-Desire-Intention software model and Roles, Norms, sanctions approach.
The following some examples describe how social mechanisms work for self-maintenance, stabilization and change:

- By understanding what is the best configuration that insures achieving super-organism company by maximizing distributed intelligence and knowledge handling between human-system and multi-agents interaction.
- Time concern, space and location, how business influenced by ecological phenomena to be taken in consideration as well.

3 Research Goal

To find a proper method to analyze, model and support business dynamics and complexity by merging complexity theory applied in inter-disciplinary topics with requirements' modeling. Requirements' defined artifacts contribute in building modeling framework for IS development, using the model driven development for automatic models simulation and implementation. The unique in this research that it explores the configuration of cognitive business and human mental tasks to be taken in consideration, while the previous methods doesn't support this level of causality and configuration details, the research importance relay on considering two parts, those parts presents a full analysis cycle from the human/social mind until artificial agent components in the information system platform. Moreover, the aim of high detailed complexity components is to provide high and detailed models of system configuration ready to be simulated and implemented, the development of concept "prototyping" is required to prove the assumptions.

3.1 Research Questions

The aim of the research to develop intelligent enterprise framework contribute in the following:

- Provide dynamic method to analyze and capture goal dynamics: as the fuzzy goal is a result of changing state of cognitive process, or in other case result of environment change. (How it could be defined and measured for rapid IS design?) using requirements engineering methods.
- Provide intelligent agent capture the change in enterprise information environment: Since little work has been done to develop characteristics that can be applied to identify the individuals and multi agents capability for handling complex and dynamic business situations

4 Research Methodology

In such as multi-disciplinary research I am trying to apply theories from several sciences like design science and complexity science in requirement engineering and

information system modeling for solving complex and distributed problems. It is important to prove that the acquired theories can work efficiently in the requirement engineering for software and information system development by developing a prototype brings a value to the information system modeling domain. The results should present a different approach to solve and improve handling complex situations in the applied domain or environment.
The design science research methodology for information system research [Peffers K., 2007] is an ideal notion for a methodology to be used in such a research environment, the methodology considers the use of interpretive research paradigms, but the resulting research output is still mostly explanatory. DS research is not part of the dominant IS research culture. No such commonly understood mental model exists. Without one, it may be difficult for researchers to evaluate it or even to distinguish it from practice activities, such as consulting.

The methodology provide a commonly accepted framework for successfully carrying out DS research and a mental model for its presentation; It also help with the recognition and legitimization of DS research and its objectives, processes, and outputs, and it should help researchers to present research with reference to a commonly understood framework, rather than justifying the research paradigm on an ad hoc basis with each new paper.

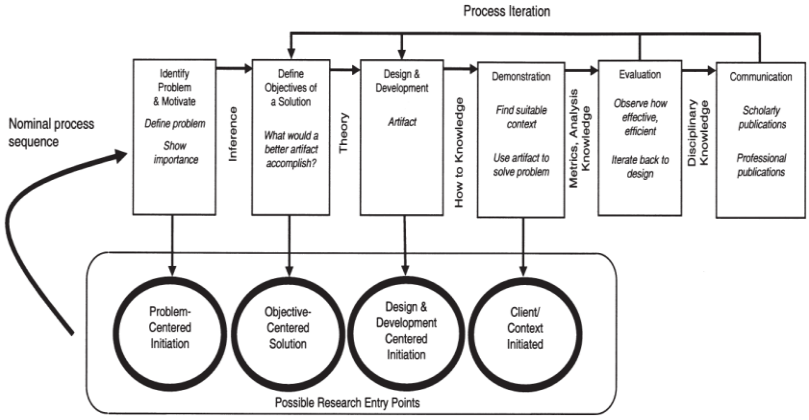

Fig. 3. DSRM process Model

PEFFERS K, TUUNANEN T, A Design Science Research Methodology for Information Systems Research, 2007.

Activity 1: Problem identification and motivation.

Define the specific research problem and justify the value of a solution. Because the problem definition will be used to develop an artifact that can effectively provide a solution, it may be useful to atomize the problem conceptually so that the solution can capture its complexity. The both research questions present the limitation in the current methods/tools to be fulfilled by the research.

Activity 2: Define the objectives for a solution.

Infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible. The objectives can be quantitative, such as terms in which a desirable solution would be better than current ones, or qualitative, such as a description of how a new artifact is expected to support solutions to problems not hitherto addressed. the objectives of the solution are the answers of the research questions, however, the research will consider the current modeling techniques capability and the new development paradigm MDA advantages.

Activity 3: Design and development.

Create the artifact. Such artifacts are potentially constructs, models, methods, or instantiations (each defined broadly) or "new properties of technical, social, and/or informational resources" [Peffers K, 2007]. Conceptually, a design research artifact can be any designed object in which a research contribution is embedded in the design. This activity includes determining the artifact's desired functionality and its architecture and then creating the actual artifact. This research will study Modeling Goal Dynamics, goal creation process and goal configuration taking advantages of design science theories for cognitive process.

Activity 4: Demonstration.

Demonstrate the use of the artifact to solve one or more instances of the problem. This could involve its use in experimentation, simulation, case study, proof, or other appropriate activity. Resources required for the demonstration include effective knowledge of how to use the artifact to solve the problem. This research will consider a case study to demonstrate example for how the process will work, many modeling techniques to be used in the research such as using system dynamic modeling, requirement engineering methods and model driven development.

Activity 5: Evaluation.

Observe and measure how well the artifact supports a solution to the problem. This activity involves comparing the objectives of a solution to actual observed results from use of the artifact in the demonstration. It requires knowledge of relevant metrics and analysis techniques.

Activity 6: Communication.

Communicate the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences such as practicing professionals, when appropriate.

To match the methodology steps with my research purpose, the following figure (figure 4.) shows that the processes should be fulfilled in each phase in the research methodology.

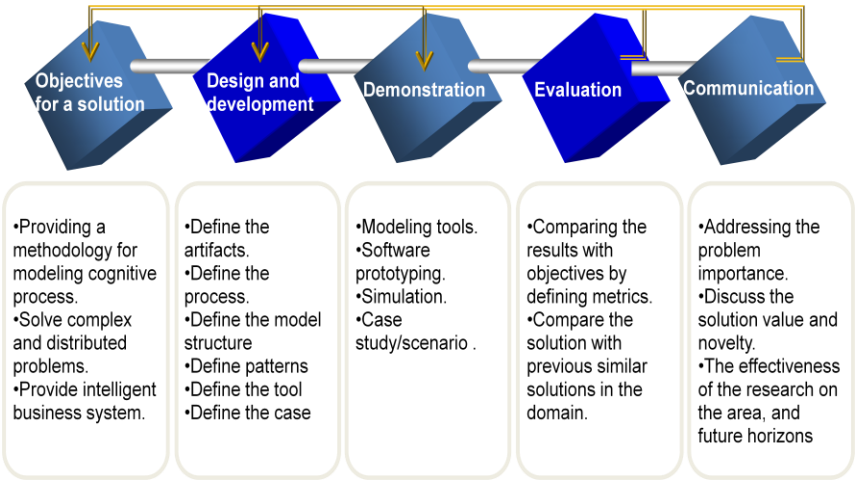

Fig. 4. Research methodology

In (Figure 5.) show the research structure with all of the sub-components and how they will work together to achieve dynamic framework to handle complex and dynamic situations as the following:

- Dynamic modelling and goal oriented modelling to be applied in modelling dynamic goal configuration in order to use it for agent design.
- Ontology to be built and extracted from knowledge domain "if the environment still not semantic web" since the semantic web is already based on ontology structure.
- Ontology to be transferred to SBVR structure to support automating rules and definitions in business environment.
- Rules to be constructed as SBVR to govern agents' behaviour.
- Change in domain knowledge to trigger the event management system to change agents behaviours based on the new knowledge or situation in the domain.
- Rule engine to execute the SBVR rules for business activities.
- Workflow to orchestrate business activities and agent roles based on specific tasks.

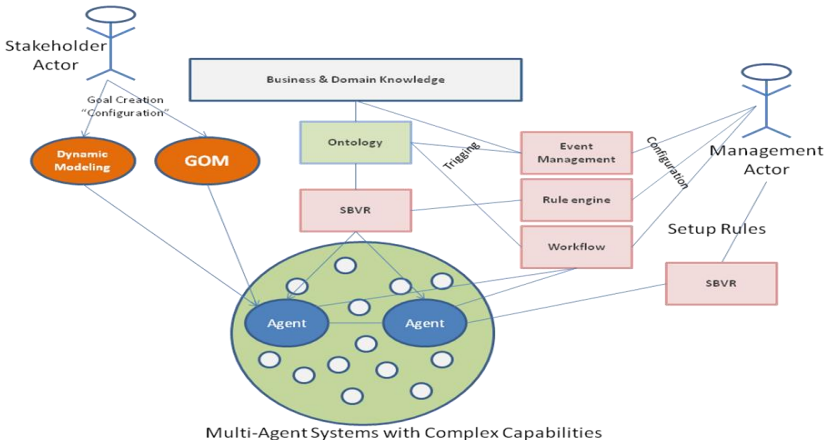

Fig. 5. Research technical structure

5 Research Tools

As mentioned before the aim of the research to develop intelligent enterprise framework contributes in the following:

1) Provide dynamic method to analyze and capture goal dynamics: fuzzy goal is a result of changing state of cognitive process, or in other case result of ecological change. (How it can be defined and measured for rapid IS design?)

2) Provide intelligent agent capture the change in enterprise information environment: Less work has been done to develop characteristics that can be applied to identify the individuals and multi agents capability for handling complex and dynamic business situations

The following is a list of the tools initially considered to be used to reach the research objectives:

- Protegé: ontology development framework.
  Will be used to build ontology map for developing agents prototype handling these ontology.
- ODMatcher: ontology matcher.
  Ontology learning and matching for knowledge acquiring.
- SBVR compiler:
  Build SBVR statements (rules and definition) for business and agents rules.
- OME 3. (Organization Modelling Environment) or Si* Tool, I*framework for agent and goal oriented modelling:

Tools for social goal oriented modeling and social interaction based on i* framework.

- Eclipse framework:
  Eclipse is an open source framework with hundreds of open plug-ins for agent modeling, UML, SBVR, ontology,...etc. will be used to develop the prototype.
- Vensim and IThink/Stella for system dynamic modeling:
  System dynamic modeling tool will be used for modeling goal and social dynamics.
- Qualitative research tools:
  Case study, cognitive and social analysis, hypothesis, design rationale.

6 Research Strategy

- Modeling Goal Dynamic, goal creation process and goal configuration using system dynamic modeling.
- Map the instance from dynamic modeling structure to requirement engineering modeling techniques.
- Social modeling framework and detailed architecture design using (BMM, i*, SBVR, ontology).
- Define the methodology and architecture for models' integration.
- Writing Rules using SBVR Form to describe high level Agent Rules.
- Using SBVR to write negotiation and communication between agents.
- Build technical architecture for agent configuration with advance capabilities.
- Build agent prototype with advance capability for dynamic architecture.

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