# HOW SIMULATION CAN HELP IN A PROCESS CONTROL MODEL

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**ABSTRACT**

Environment in which enterprises are doing their activities is currently subject to continuous changes. Therefore, enterprises have to do continuous improvement to stay competitive. This article focuses on control systems for enterprises having a process-based approach and presents OLYMPIOS model, which is dedicated to enterprise information system.
We consider that an information system is relying on a new system architecture. More precisely we consider that an information system could be described by a knowledge management system, a resource management system and a process management system. We present our control system model dedicated to control manufacturing systems. Moreover, the OLYMPIOS model considers that control should be described towards four phases: an initialisation phase, an evolution phase, an adaptation phase and a finish phase. This approach makes the control proactive because it allows to study possible drifts of a process in order to anticipate the appearance of dysfunction.
After this presentation, we present some works concerning simulation applied to controlled process model in order to help enterprise to control their processes. Simulation could help initialisation and adaptation phases to verify correctness of a process configuration at a given time. Furthermore simulation could help process evaluation.

## INTRODUCTION

Nowadays enterprises must stay competitive face to market pressure and increase of customers' requirements. This implies for enterprise a better control of their processes, to be able to quickly react to external events (customer requirements) as well as internal events (dysfunction). This article aims to present our work on control model and its integration in the information system of an enterprise.
The major problem in enterprise modelling is that each enterprise has its own strategy and/or control architecture. So this paper does not deal with specific control mechanisms but defines principal functions that have to deploy in a enterprise control system. This generic set of function has to be completed with specific functions for each particular enterprise.

Firstly this paper present enterprise control structuring which present on the one hand the complexity of a controlled system and on the other hand the reasons of our work. Then we present the main concepts of our control system relying on processes. At least, we show that simulation could help us in many ways.

## CONTROL STRUCTURE

Since R. Anthony's works in the 60's (Tardieu and Theys 1987), the enterprise control function is often structured in three layers (Orlicky, 1975) (Vollmann et al. 1988):

- The strategic layer deals with major decisions (investment, organisation) and enterprise policy (outsourcing, innovation). It defines long-term objectives as well as adequacy of enterprise resources.
- The tactical layer verifies if resources are used in an efficient and low cost way. This layer relies on long-term objectives (defined by the strategic layer) and has a medium term influence. In production terms, it means that the unit of production has to satisfy the market demands. This layer also verifies if the production system is able to realise forecasted production.
- The operational layer has to verify if production tasks are used in an efficient and low cost way. This layer manages the co-ordination of all resources, controls production activity and has a short-term decision influence.

This structure is important because it defines the scope objective of each layer. When the predicted performances are not achieved, the control activity is often put in the balance because it is the nearest layer of production system. However, a more precise analysis shows sometimes that some dysfunction appears because a resource is continuously overloaded or because raw material is often unavailable. In the face of these problems, control activity could almost do urgency corrections, which does not allow to reach expected goal. This acknowledgement shows that upper layers define the scope of correction of production activity control. Furthermore, accuracy of dysfunction is relied on a system model, which gives a good problem identification. So, it is necessary to have of a generic model on the one hand to take complexity of control mechanisms into account and on the other hand to build a representation of the controlled system that allows to take good decisions.
This presentation of control structure is completed by the definition of control architecture. Architectures describe the distribution of control activities in an information system.

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Based on different works, (Dilts et al., 1991) (Bongaerts, 1998), five different control architectures have been identified: Centralised, Proper hierarchical, Modified hierarchical, Heterarchical, Holonic.
So, a control model should take these different points into account:

- Good representation of the system.
- Complexity of control mechanisms.
- Control architectures.

## OUR VISION OF CONTROL SYSTEM

Most of results concerning system modelling consider that a system can be divided in three sub-systems: decision system, information system and operating system. The OLYMPIOS model considers that a system should always rely on well-defined processes. Consequently, the information system has to manage processes; it relies on a resource management system and a knowledge management system (Braesch and al 1995). In accordance with the modes of understanding of the real world, defined by H.A. Simon (Le Moigne, 1990), the model should:

- Take into account the physical structure, containing elements such as machines, persons, resources, environment, products, services, etc., in order to provide symbolic information that defines the enterprise states.
- Describe its own processes and execution conditions.

This vision induces a system architecture which splits information system into three different sub-systems:

- *resources management system* that handles resource access and manage resource diaries.
- *knowledge management system* that manages enterprise know how to fit with enterprise strategy.
- *process management system* that manages process execution to realise an expected goal.

OLYMPIOS is dedicated to information system modelling. To be able to represent a part of a system, OLYMPIOS considers three points of view:

- The *structural and functional* point of view, that allows to describe the considered part and to define all possible actions for it.
- The *management* view that allows to define the studied part objective and the way to obtain the result and to evaluate the performance.
- The *behaviour* view that defines the evolution rules of the considered part.

The control model defined in OLYMPIOS model relies on these three sub-systems. This modem is based on a process model which defines a process as a set of *executing activities* organised by a *control scheme* to reach a goal (Dindeleux 1998) (Braesch et al. 2002). This process allows to reach a expected goal. Based on this model, our control model defines required mechanisms used to detect problem and to define new process when a problem is detected.

### Process model

A process is characterised by an initial state, a final state, intermediary states and transitional functions between these states. The structural and functional view of a process is based on set theory. Dynamic aspects are described Furthermore, the formalism used to define the dynamic is based on a state diagram representation.

### Controlled process model

We consider that control model have to integrate anticipation and adaptation mechanisms to insure an evolution in accordance with environment constraints (Camman and Livolsi 2000) (Théroude et al 2001 a). Furthermore, we consider that control model should be able to detect local or global dysfunction and to correct it by using a referent model. So, a control model is based on four phases (*Cf. figure 1*):

- initialisation phase: reference process definition able to reach a goal,
- evolution phase: process evolution control through activities execution and performance check,
- adaptation phase: new referent definition when dysfunction are detected.
- final phase: goal process evaluation.

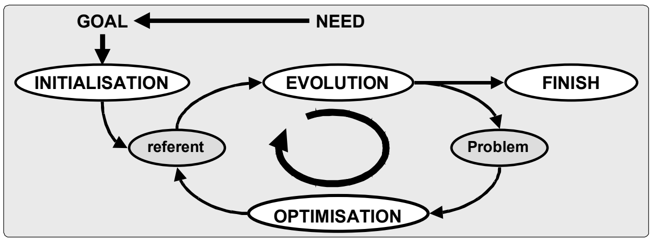


Figure 1. The four control phases

## CONTROL PHASES DESCRIPTION S

### Initialisation phase

The initialisation phase defines a reference process named referent. The referent execution allows to reach a given goal. This function is based on technical data and resource availability.

*The referent*
A process evolves in a restricted space define by an initial state and a final state (goal). Intermediate states exist between those two states. A reference process defines the projected evolution of a process from a state to another (*Cf. figure.2*).

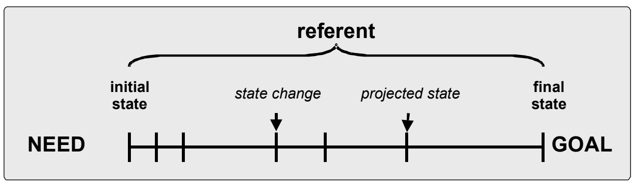


Figure 2. Referent

*Referent generation*
The construction of a referent implies a research space definition. This space defines all reachable states in respect of technical constraint (availability of resources, precedence constraint, etc) and objective constraint (Théroude et al. 2001b). A state is reached by activity execution.
The construction of a referent could be based on many different techniques such as Backtracking, Means and analysis, least commitment (Jain and Meeran, 1999) (Kolish and Padman 1997), Hierarchical task network planing, case based planing (Myers and Berry, 1998), user definition, etc.
In our model, we define generic processes which represent the whole processes of the enterprise. When a requirement is defined, the generic process (with a goal fitted with the requirement) is used to build a referent.

*Simulation and initialisation phase*
After defining a referent, it is necessary to verify that process execution reaches the expected goal. If a referent is built with a small number of activity, this verification could be done by an human actor. But, if referent contains a large number of activities, verification is more complex. That why, in this case, simulation tools could help. In this field, we have to make the connection between the simulation model and our controlled model in order to ensure the reference process correctness.

**Evolution phase**

Evolution phase should perform process activities and compare obtained results with expected objective defined by referent. In fact, this phase compares a current state to an expected state (*Cf. figure 3*).

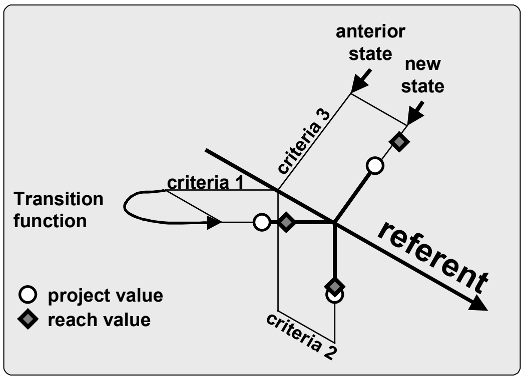


Figure 3. Expected state and current state to be evaluate.

This comparison is used to evaluate activity performance (local performance) and process one (global performance). It is important to take these two kinds of performance into account because a good performance at the local level does not mean the goal (global level) will be reached.. If this performance is not sufficient, the evolution phase stops process execution and release the adaptation phase to correct the referent (*Cf. figure 4*).

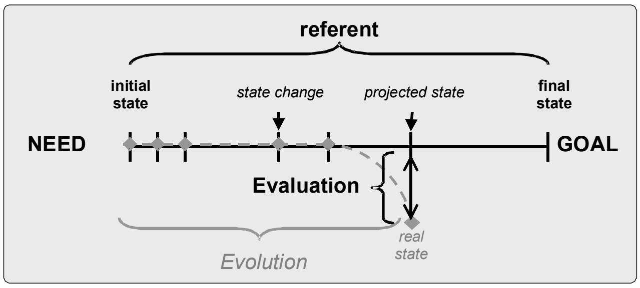


Figure 4. The evolution phase

The evaluation relies on performance formalisation which specifies the performance indicator. One definition of the performance indicator is "a variable indicating the effectiveness and/or efficiency of a part or whole of the process or system against a given norm/target or plan". In this sense, a model of performance indicator involves three following characteristics (Berrah 1997):

- expression of objective to be reached,
- acquisition and comparison of effected measure with objective,
- appreciation of acquired measure in accordance with context and know-how of an observer.

The evaluation given by performance indicators can be described through two aspects. The first one concerns flexibility in performance evaluation. It can be categorical (is or is not fully satisfied) or gradual (partly satisfied). The second aspect concerns uncertainty of performance evaluation. This problem is principally raised by uncertainty of the measure (Berrah et al.1998).

As we said in introduction, this work provides a set of functions that have to be defined for each particular process of an enterprise. Nevertheless, we consider that two types of global evaluation could be used to provide a process evaluation:

- The first type considers activity evaluation provides process evaluation. For this vision, activity performance indicator has to provide a good representation of the process evolution. The problem in this case is to define an indicator system that allows detection of a global problem.
- The second type considers that process evaluation has to take objectives and results of finished activities into account. In theory, this vision allows to study process drift. But the problem in this case is definition of aggregation functions for building an evaluation from objectives and results.

The choice between those kinds (or other kind) is a very important because in controlled process model because it is strongly relying on process evaluation.

*Simulation and evaluation phase*
As we have seen previously, evaluation is a crucial point in our model and it is not easy to specify indicator and global process evaluation.
Concerning those points, simulation tools could helps us in two ways:

- Firstly, simulation tools could be used to insure correct indicator specification. It means that we have to make connections between simulation model and our control model in order to ensure the correctness of new performance indicator.
- Secondly, simulation tools could be used in process evaluation. In this case, evaluation uses process simulation to calculate a simulated goal. In this vision, simulation calculates the goal that could be reached from a current state. The process simulation is based on referent. In this case, we have to translate the referent into a simulation model.

**Adaptation phase**

When dysfunctions are detected by evolution phase, the adaptation phase has to generate a new referent. This generation implies to understand the problem (specific to the enterprise) and has to propose a solution (Myers and Berry, 1998). We consider that this solution could rely on a set of corrective generic functions. This solution is then integrated (Casati et al., 1996) (Reichert and Dadam 1998) at the current state of the process (*see. figure 5*). This integration requires to build a new referent (*see initialisation phase*)

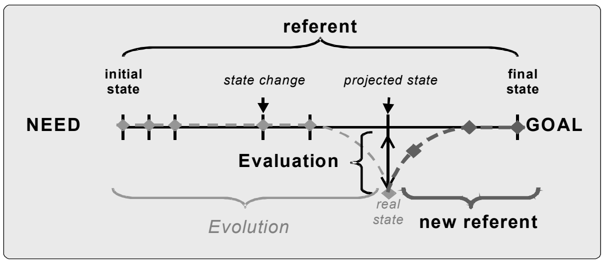


Figure 5. Adaptation phase

*Simulation and adaptation*
In this case, the simulation could be used to test correctness of the new referent. The tools used in this case could be the same as those used in initialisation phase. But in this phase, there is an additional constraint, which is time necessary to obtain a result because the adaptation phase needs to react quickly.

**Finish phase**

The finish phase performed goal process evaluation. This evaluation expresses the goal satisfaction expression.

## CONTROLLED PROCESS BEHAVIOR

The process behaviour is based on definition of activity states. We use a state diagram representation to define dynamic of an entity. This kind of diagram allows us to describe use of different functions. The behaviour of an activity is defined by the following figure (*see figure 6*).

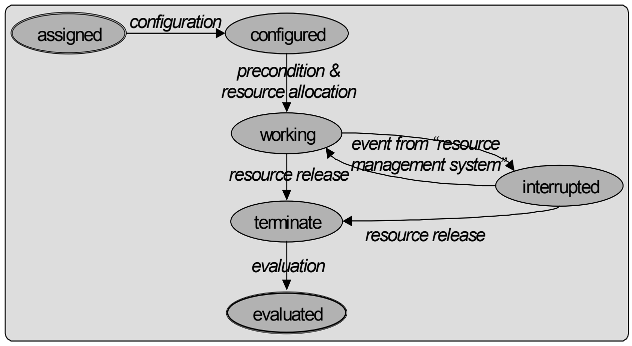


Figure 6. Activity state diagram

The transition function ensures process evolution. This function relies on reference process and process event to release activities of the process. For example, when an activity is finished (a specific event is triggered), the transition function identifies with referent the next activity that has to be released.

The figure below defines the four phases in a diagram state.

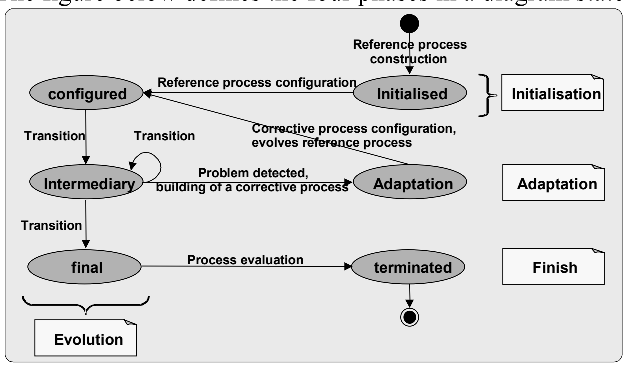


Figure 7. Process state diagram

The initial and configured states are reached by initialisation phase. Iintermediary and final states are reached by evolution phase. Adaptation state is reached by adaptation phase and the last state, terminated is reached by finish phase.

## SIMULATION AND CONTROLLED PROCESS SPECIFICATION

In the case of improvement of production system, the main problem is the definition of new processes. This definition induces following description:

- operation definition,
- stock dimension,
- number of mean and actors,
- objective definition,
- performance indicator definition
- Control function specification.
- Etc.

So, in order to help this definition, simulation tools could be used to check process descriptions. In this case, simulation can test different production system organisation, different evaluation functions and different control functions.

## CONCLUSION

This paper has presented an overall approach adopted in OLYMPIOS model to control process. This approach can be summarised in two points. The first one concerns the process model. The second point concerns the control model, which is relied on four control phases.

Furthermore we show in this paper possible links between process control model and simulation tools. These links concern:

- Evaluation using simulation.
- Verification of reference and corrective process correctness.
- Evaluation of process specification.

Currently, we work on a software platform to integrate different simulation tools in a process control environment.

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