

# Integration Framework for Complex Systems

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## INTRODUCTION

Information is seen as one of the main resources that systems analysts try to use in an optimal way. In this chapter we show how this resource can be used in integration issues. We introduce the problem of information-based integration, propose a solution, and briefly discuss future trends in this area. Systems become increasingly complex. Their decomposition into smaller units is the usual way to overcome the problem of complexity. This has historically led to the development of atomized structures consisting of a limited number of autonomous subsystems that decide about their own information input and output requirements, that is, can be characterized by what is called an information closure. In a real-world context, autonomous subsystems consist of groups of people and/or machines tied by the flow of information both within a given subsystem and between this subsystem and its external environment (Esteve, 2002; Szczerbicki, 2003; Tharumarajah, 1998). Autonomous subsystems can still be interrelated and embedded in larger systems, as autonomy and independence are not equivalent concepts. These ideas are recently gaining very strong interest in both academia and industry, and the atomized approach to complex systems analysis is an idea whose time has certainly come (Liu & Ling, 2003; Orłowski, 2002).

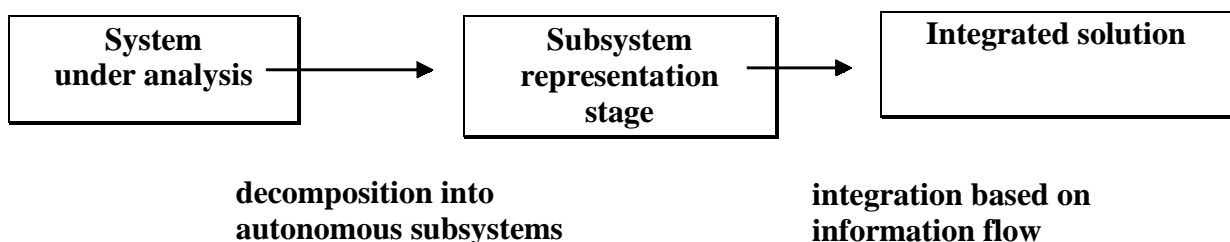
Complex systems (for example manufacturing) are often viewed as sets of components (agents, subsystems) supporting separate functions. Many organizations operate in this highly compartmentalized manner. It appears

that the general direction of systems in the future, however, is toward linking together function-specific agents into fully integrated entity. An integrated system is a system that consists of agents/subsystems that efficiently contribute to the task, functional behaviour, and performance of a system as a whole. It is believed that such an integration can be achieved through the flow of information. "Integration," as used in this article, should not be confused with integration at a physical level by means of computer networks or computer buses. Rather, the semantics of integration is addressed - the information that subsystems should share. While structuring the approach presented, the first consideration was to design some tools that could be easily implemented as components of an intelligent system supporting development of system configurations integrated by the flow of information. Due to the complexity and creativity associated with the early stages of such a development it is quite clear that the way a practicing analyst solves a system configuration problem cannot be easily implemented. This explains the need for new tools and approaches that solve the problem but at the same time can be supported by a computer. Elements of such an approach are presented in this article.

## BACKGROUND

We propose a three-stage approach for the development and analysis of complex systems. The involved stages are systems decomposition, subsystem modelling represen-

*Figure 1. Overview of a three-stage approach to complex systems integration*



tation, and integration at the level of information flow. Figure 1 depicts the general underlying idea behind this approach.

The essence of information-based integration problem can be formulated as follows and illustrated as in Figure 2.

Theoretical framework to provide support for systems integration as outlined includes the following fundamentals:

- the syntax for connections of autonomous subsystems,
- the mechanism for guiding the generation of such connections,
- the integration algorithm.

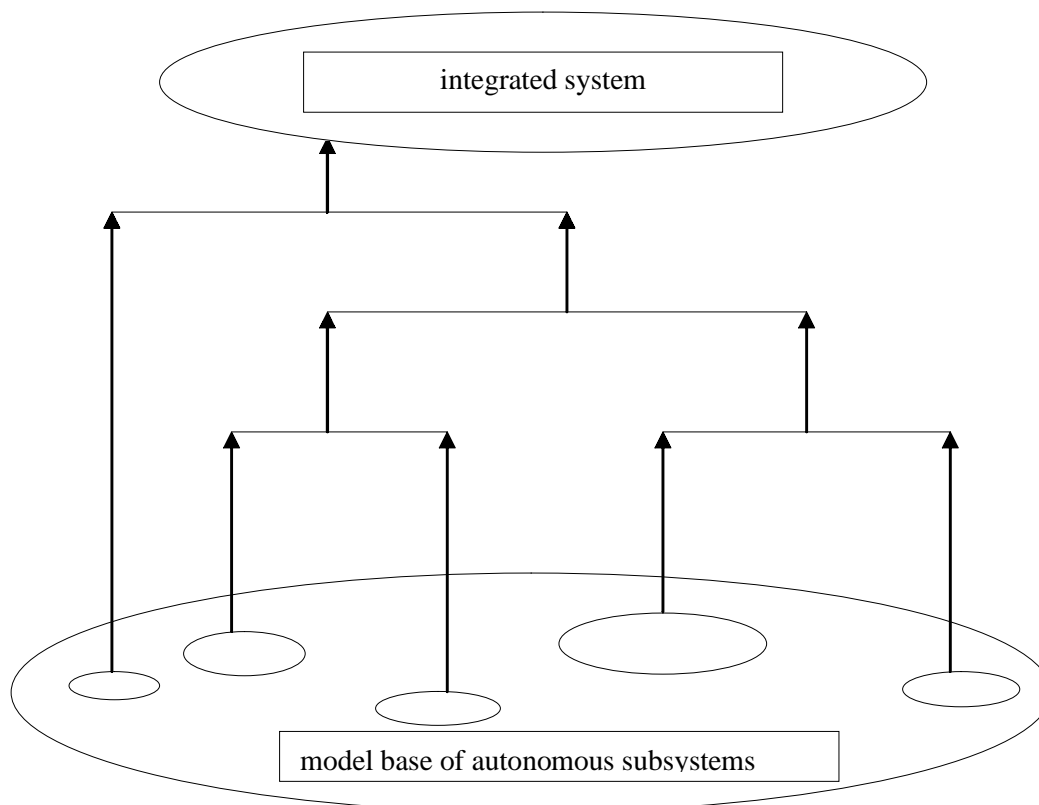
The aim of this article is to briefly outline these fundamentals.

The author, together with his collaborators, has been researching information-based integration issues since the early nineties, starting at The University of Iowa (Kusiak, Szczerbicki & Vujosevic, 1990, 1991), Iowa City, USA, continuing at The GMD FIRST, Berlin, Germany (Szczerbicki, 1994) and currently working on these issues at The University of Newcastle, Newcastle, Australia (Szczerbicki, 2003). The aim of this entry, which is based on previous research publications by the author, is to overview the integration problem from the perspective of the author's experience and to place it among the work of others.

Integration problem is recently gaining very strong interest in both academia and industry. This is particularly apparent in the area of design and modelling of manufacturing systems (O'Grady, 1999). Model development and synthesis (that resembles autonomous systems develop-

*Figure 2. Illustrative example of a three-level hierarchical tree of the bottom-up integration process*

Given the informational inputs and outputs of autonomous subsystems, find the overall system being designed that meets the desired functions and is integrated through the flow of information.



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