Adaptive Application for Complex Systems Modeling

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Abstract

The paper presents a formal system for presentation and measurement of applications adaptability, and describes an original methodology for building adaptive applications from various fields of activity/research, including for computer modeling of complex systems in physics.

Keywords: adaptive application, adaptability criteria, personalized adaptive application, complex system.

1 Introduction

Agent-based models (ABM) represent a relatively new methodology designed to study complex systems whose properties synergistically show the individual states of the component subsystems, and can not be deduced through a simple extrapolation of the evolution of components properties from a lower structural level to the higher one, but represent qualitatively new qualities of self-organization. These models can be also developed with adaptive computer applications.

2 Adaptive Applications

An *adaptive application* (*AA*) integrates: hardware, software, methodical approach, design and organizational tools that perform the general automation aspects of defined classes of problems characterized by unique data processing technology, information processing regimes, and conditions for unique operation of hardware and software (adapted after [1]). *AA* are available on workstations of researchers, connected to computer networks and associated in scientific research laboratories. The *Researcher's application* (*RA*) is the hardware and software of *AA*, designed to solve the researcher's concrete problems.

Applications (*A*) *can demonstrate the following types of adaptabilities*: (1) *adapting the computer network* (*CN*) *by adding/ excluding a CN node* (A_{CN})*;* (2) *improving computer speed (CS) to solve research problems in a certain CN node* (A_{CS})*;* (3) *adding/excluding a scientific research laboratory* (*SRL*) *in the application* (A_{SRL})*;* (4) *adding/ excluding an automatic post work* (*APW*) *in SRL* (A_{APW}); (5) *expanding the power of the application* x_i *to solve a new research problem* $p \in \Pi$ (A_{Π})*;* (6) *building the knowledge base* (*KB*) *for a new CN node* (A_{KB})*;* (7) *building a new CN node* (*NCN* - A_{NCN})*;* (8) *modifying the operating system, system and application software in one or more nodes of the CN* (A_{Soft}).

Adapting an application to the advanced field of application requires the following resources: *of staff* (*S*), *of time* (*T*) and *financial* (*F*). In this context, the dimensions of the adaptability of each application are shown in Table 1.

Table 1. Application adaptability dimensions

		A_{CN}	A_{CS}	A_{SRL}	A_{APW}	A_{Π}	A_{KB}	A_{NCN}	A_{Soft}
		1	2	3	4	5	6	7	8
1	*F*	$A_{F,CN}/a_1$	$A_{F,CS}/a_2$	$A_{F,SRL}/a_3$	$A_{F,APW}/a_4$	$A_{F,\Pi}/a_5$	$A_{F,KB}/a_6$	$A_{F,NCN}/a_7$	$A_{F,Soft}/a_8$
2	*S*	$A_{S,CN}/a_9$	$A_{S,CS}/a_{10}$	$A_{S,SRL}/a_{11}$	$A_{S,APW}/a_{12}$	$A_{S,\Pi}/a_{13}$	$A_{S,KB}/a_{14}$	$A_{S,NCN}/a_{15}$	$A_{S,Soft}/a_{16}$
3	*T*	$A_{T,CN}/a_{17}$	$A_{T,CS}/a_{18}$	$A_{T,SRL}/a_{19}$	$A_{T,APW}/a_{20}$	$A_{T,\Pi}/a_{21}$	$A_{T,KB}/a_{22}$	$A_{T,NCN}/a_{23}$	$A_{T,Soft}/a_{24}$

The degree of adaptability of the AA to the family of research issues (FRI) is characterized by three indicators:

- ✓ the ratio between the average cost of achieving a new issue in the *FRI* in *a specific application SA* using *AA* and the average cost of doing the same problem without using *AA*;
- ✓ the ratio of the average staffing requirement ($man \times days$) to the achievement of a new *FRI* problem in an *SA* using *AA* and the average staffing requirement ($man \times days$) of the same problem without using *AA*;

- ✓ the ratio of the average time needed to achieve a new issue in the *FRI* in an *SA* using *AA* and the average time required to achieve the same problem without using *AA*.

Measuring the degree of adaptability of applications and/or comparing the adaptability degree of different applications uses one, several or all of the adaptability dimensions of the applications integrates 24 adaptability indicators of the applications (see Table 1). This adaptability measurement system is universal. Each indicator represents a dimension for assessing the adaptability of applications.

Adaptive applications offer the following benefits: (1) time diminishing, average staffing and average cost of solving problems in an *FRI* in an *SA*; (2) a high degree of standardization of the *SA*; (3) high quality of *SA* and *AA*, and so on.

Each A_i application demonstrates, according to Table 1, the following adaptabilities: $Adapt(A_i) = \{a_{i,1}, ..., a_{i,24}\}$. Let the end-user requirements for application adaptability are specified by the set of adaptive requirements $Criteria = \{c_j | c_j \geq 0; j=1, \ldots, 24\}$.

The *Criteria* reprezents a customized criteria system of the beneficiary to evaluate the adaptability of applications. The end user's interest $Interes(A_i)$ in the A_i application, measured by the customized adaptive assessment system, is as follows: $Interes(A_i) = \sum_{j=1}^{24} c_j \times a_{i,j}$.

Thus, each beneficiary can build a customized application adaptability assessment system specifying the adaptability criteria.

3. Life Cycle of the Adaptive Application

The fact that an adaptive application produces additional software qualities for the user needs, requires a technique for building adaptive applications that includes [2]: (1) definition of the *AA* requirements; (2) *application domain* (*AD*) description; (3) building a *formal (axiomatized) theory of AD* developed at the step (2); (4) elaboration of the *AD language* of the formal theory developed at the step (3); (5) specifying *families of the AD problems* required by the beneficiary for computing; (6) building the *AD* computer platform; (7) elaborating the adaptation components of

the computer platform developed at the step (6) (*Adapter* and other auxiliary modules); (8) generating customized versions of the adaptive applications by end users applying the components developed at the steps (6) and (7); (9) exploitation, maintaining and developing personalized applications built at the step (9) by the end users.

4. Conclusion

In this paper, an original development methodology for adaptive applications and a system for measuring the adaptability of applications have been exposed. The presented methodology was applied to the development of several adaptive applications, including an adaptive-parametric application for modeling complex systems in physics [3].

Acknowledgments. Part of the research presented in this paper has been supported by the Moldova State University project no. 15.817.02.38A "*Intelligent Information Systems Development for Families of Decision Making Problems with Application in Education and Research*".

References

[1] *Methodical materials on Problem-Oriented Complexes and Consumer Complexes.* Materials of the Section of Specialists No. 1 of the Council of Chief Designers of Small Computer Systems. - Moscow, 1981. - 133 c. (in Russian).

[2] Gh. Căpăţână. *Sisteme informatice adaptive*. Studia Universitatis, Nr. 5 (15), - Chişinău: CEP USM, 2008, p. 49-59.

[3] V. Ciobu, F. Paladi, Gh. Căpăţână *Sistem informatic adaptiv „Determinarea stărilor proprii ale moleculelor de fullerene*”, Studia Universitatis Moldaviae (seria Informatica), Nr.2(82), - Chişinău: CEP USM, 2015, p.10-15.

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