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ABSTRACT
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NLR'S CACE WORKING ENVIRONMENT ISMuS

by

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Abstract

This paper describes the NLR working environment for Computer-Aided Control Engineering ISMuS. ISMuS provides via a graphical user interface transparent access to a collection of CACE tools and information management tools on a network of computers.

Keywords: CACE working environment; CACSD support environment; controlled dynamical systems.

1. Introduction

The National Aerospace Laboratory NLR of the Netherlands develops information systems for aerospace and related applications. Software is developed, tested, and used on NLR's advanced general-purpose computing network. This network includes a vector supercomputer, several parallel computing servers, mainframes and workstations, distributed over 2 sites and all connected through a high-speed network.
NLR is involved in various activities from the broad field of applications which can be characterised by the keyword *controlled dynamical systems*. ISMuS, which originally stood for *Information System to support the development of digital simulation models for Multibody Systems*, is aimed at supporting the development process of controlled dynamical systems. It has evolved into a working environment for Computer-Aided Control Engineering (CACE). In ISMuS the computer network appears to the user as a single, virtual computer. A graphical user interface provides file manipulation and easy program activation through point-and-click and drag-and-drop operations on icons.
This paper describes various aspects of ISMuS: the circumstances that led to its development, the current status of ISMuS, and future developments.

2. CACE at NLR

Computer-Aided Control Engineering is applied at NLR in a variety of applications, such as:

- robotics: NLR contributes for instance to the development of the European Robotic Arm ERA [1].
- fluid-structure interaction, especially "wet" satellites such as the Sloshsat FLEVO spacecraft, see [2] and [3].
- windtunnel design: development of the model support system (see [4]) and Mach number controller (see [5]) of NLR's High Speed wind Tunnel.
- aircraft flight control systems.
- satellite attitude control and thermal control systems.

For such applications the CACE working environment has to support the CACE activities at various levels, ranging from fast prototyping to system engineering support and extensive simulation studies. The main categories of activities are:

i. Modelling of dynamical systems.
In order to gain insight in the characteristics of a controlled dynamical system, a mathematical model

of the dynamical system is required. The model is used for mathematical analysis and/or numerical experiments.

ii. Design of controllers for dynamical systems.
In order to optimise, with respect to certain objectives, the behaviour of a dynamical system, control will have to be applied.

iii. System studies.
In order to assess the performance of a controller or to evaluate the behaviour of a controlled dynamical system, a system study is performed. A system study usually comprises a number of simulation runs with varying parameter settings and subsequent analysis of the simulation results.

iv. Information management.
Activities in each of the preceding categories generate information to be managed. Information such as data and source code, must be stored in a structured way and made easily accessible for subsequent browsing and retrieval.

The ultimate goal of ISMuS, and a CACE working environment in general, is to supply an integrated computer-based environment for control engineering. Important aspects of an integrated CACE environment are:

- a rich set of state-of-the-art CACE tools;
- uniform user environment;
- uniform environment for CACE data;
- functional integration of the different CACE tools;
- accessible from one workplace, although tools may reside on various hosts in the computer network;
- extendibility and openness, to allow for the integration of future tools;
- usage of public domain tools and standards.

These aspects are covered by the Framework Reference Model (FRM) for an open architecture for CACE as described in [6]. For the development of ISMuS this Framework Reference Model has been adopted.

3. ISMuS Architecture

In the initial situation at NLR the various CACE tools were distributed over hosts in the NLR computer network or were sometimes only available on a stand-alone computer system. To perform a sequence of CACE activities, several tools had to be used from different systems using *telnet*, *rlogin*, and *ftp*, or, if necessary, by physically moving to another computer system and transferring data via diskettes.

The first step towards an integrated CACE has been the creation of a working environment from which all CACE users can access all resources for their activities. These resources include tools and information in various formats (e.g., software, input/output data, and documents), located on various computer systems and file servers throughout the NLR computer network. ISMuS v1.0 is the version of ISMuS in which this first step has been realised.

The working environment ISMuS has been created as a so-called instantiation of SPINE (see paragraph 3.1 and [7]), which is a generic package that provides the basic facilities for the installation, operation, and maintenance of a working environment. CACE-specific components (see paragraph 3.2) have been integrated into the working environment.

3.1 SPINE

In order to facilitate transparent use of the network and to organise available application-specific tools into working environments for specific application areas, such as CACE, NLR uses the SPINE package. A SPINE-based working environment provides access to the network as if it were a single virtual computer. Networking details, such as logins to remote systems, file transfer between computers, starting and operating programs or tools on various computers, and data conversions, are transparent for the user.
The user interacts with, and operates, the virtual computer using a graphical user interface. The user interface provides file manipulation and program activation through point-and-click and drag-and-drop operations on icons.
In addition to network transparency, SPINE provides facilities for management of, and access to software, data, and documents available from the network.

In general SPINE comprises the following subsystems, which together support the realisation and use of working environments:

- User Shell, which is the graphical user interface that allows the user to access and operate resources

available from a working environment.
- Environment Management System, which comprises a set of tools and facilities that support the process of creating, modifying, and installing working environments, and that support the operational use of working environments in a network.
- Information Management System, which comprises a set of tools and facilities that support management of source code, data files, electronically available documents, and electronic forms.

Presently, these SPINE subsystems are constituted by the following software:
- User Shell:
  SUS/UI (SPINE User Shell/User Interface).
- Environment Management System:
  SUS/System (SPINE User Shell/System).
- Information Management System:
  - SR for source-code version control.
  - DFMS (Data-File Management System) for management of, and access to, data files.
  - PIMS for management of, and access to, electronically available documents, bibliographies, and electronic forms.

SPINE has not only been successfully used for the realisation of ISMuS, but also for the following NLR working environments:
- ISNaS, for Computational Fluid Dynamics (CFD);
- ISRaP, for radar-data processing;
- ISEnS, for Computer-Aided Software Engineering (CASE).

3.2 CACE-specific components

The following CACE-specific tools to provide CACE functionality are available within ISMuS v1.0.

For modelling of dynamical systems:
- the formula manipulation package MAPLE V
- MATLAB/SIMULINK

For controller design:
- MATLAB toolboxes (e.g., Control System, μ-Analysis, Robust Control, Nonlinear Control)
- the formula manipulation package MAPLE V

For system study and analysis:
- MATLAB/SIMULINK
- MIMOSE (an NLR simulation tool, see [8])
- PROSIM (an NLR real-time simulation tool, see [9])
- EuroSim (a commercial general purpose simulation tool, see [10])
- PV-WAVE (a commercial data analysis package)

In ISMuS v1.0 a basic set of CACE tools is available. Functional integration between these CACE tools is not yet explicitly supported.

4. ISMuS now and in the future

ISMuS v1.0 has been operational at NLR since June 1995. After starting an ISMuS session, the end user is presented with the top-level browser of the working environment and a uniform mechanism for accessing tools and data (either shared data or data owned by the user himself). All of the tools listed in paragraph 3.2 have been made available transparently from the working environment (see Figs. 1-5). Knowledge of the location of tools and information is not necessary, allowing the end user to concentrate on the job to be done.

An additional advantage is the availability of a central place for user activities, combined with the high adaptability of ISMuS. Changes to the working environment, such as the extension with additional tools or information, will be effective for all end users immediately and can be communicated to all end users more effectively. Other events, such as moving a tool from one machine to another, are not visible to the end user. All changes to the working environment are implemented using configuration control procedures and can be tested before becoming operational. The end user of ISMuS is furthermore supported by a context-sensitive help system, based on HTML.

Presently ISMuS v1.0 is used for a number of CACE projects at NLR. Further development of ISMuS will be an ongoing effort, depending on user feedback and advances in CACE in general. At this moment, for instance, ISMuS is being extended with a CACE engineering database and a workflow management system.

Another important factor is the continued extension of SPINE's functionality, from which ISMuS will benefit.

5. Conclusion

With the implementation of ISMuS, a platform for CACE activities has been realised. The initial purpose of ISMuS, which was to centralise the availability and accessibility of useful tools and information related to CACE, has been realised.

ISMuS provides a stable working environment which is easily adaptable, because its maintenance facilities allow controlled extensions or changes to the working environment.

An additional benefit, resulting from the use of SPINE at NLR, is the reduction of the required familiarisation time for using other working environments for applications such as CFD and software engineering. Because these working environments are all instantiations of SPINE and hence have the same look and feel, experience with the use of one of them can be reused for the others.

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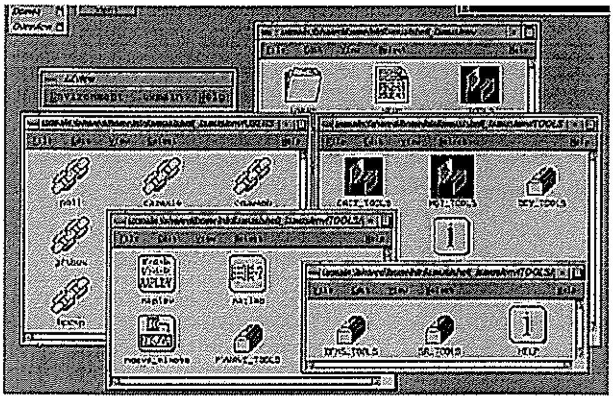

Fig. 1 The graphical user interface of ISMuS provides transparent access to CACE applications on networks

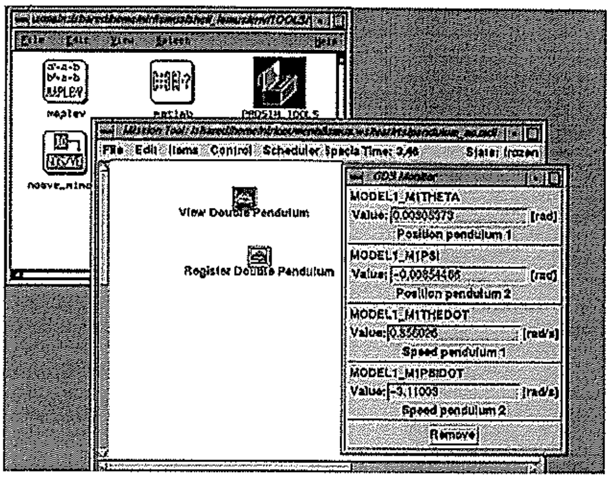

Fig. 4 Simulation

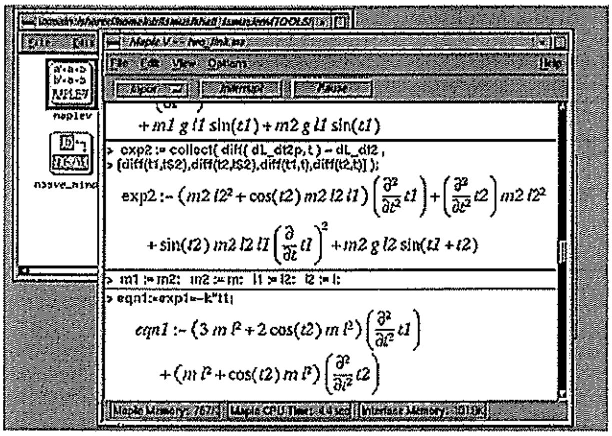

Fig. 2 Modelling a dynamical system

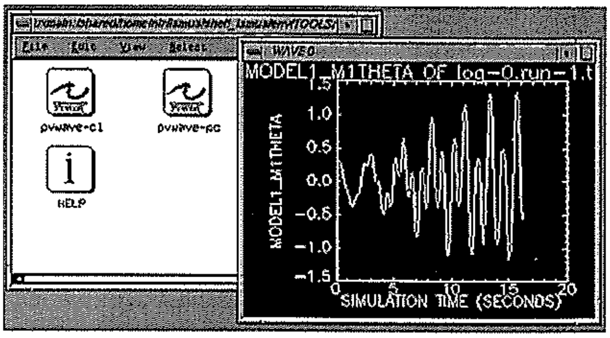

Fig. 5 Evaluation

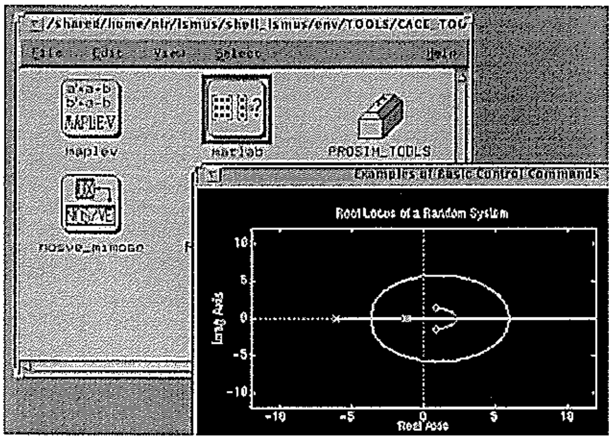

Fig. 3 Controller design

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