INTERNATIONAL DESIGN CONFERENCE - DESIGN 2002
Dubrovnik, May 14 - 17, 2002.

DAMOCIA-DESIGN. AN EXPERIENCE OF DESIGN OF GREENHOUSES STRUCTURES MODELING THE PROFESSIONAL KNOWLEDGE WITH CommonKADS

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Keywords: Knowledge Intensive Design, Greenhouse Design, CommonKADS

1. Introduction

The Almería province, located in southeast Spain, holds the largest concentration of greenhouses of the world (> 40000 H), representing its main income source (0.5 - 1.0 billion euros/year). Actual and future opening of global markets represents a crucial challenge, it is necessary to improve the production in quality, opportunity and quantity. One work line is to develop new and more efficient structures in order to increase the control over the production reducing cost. In this line we have worked from 1990, participating in the development of diverse structures, practical experiences and support tools.

In this papAer, we presents a knowledge intensive design tool, DAMOCIA-Design, which supports the design of greenhouse structures. After stating the initial necessity of a specialized tool that helps the agronomic and industrial engineers developing more competitive greenhouse structures for our area, we presents the evolution of the design tool through three successive versions, analyzing and justifying their technical characteristics and capabilities. One key point in this evolution was managing specialist knowledge, which required using a knowledge modeling methodology as CommonKADS.

Cofinanced by the EU (ESPRIT Special Action P7510) and the Spanish Ministry of Industry (PATI PC191), the DAMOCIA project supposed the integration of diverse companies and research groups in order to develop more advanced tools for the design, simulation and field evaluation of new structures. The design edge of the project supposed developing DAMOCIA-Design, which using a smart interface generates plans, budgets and structural analysis of real greenhouse structures.

2. Evolution of the design tool

When we started developing new and improved greenhouse structures, ten years ago, the first design challenge was the no existence of specialized design tools for greenhouses. Designing greenhouses is an extremely specialized task, where there are a great quantity of repetitive elements, a special vocabulary and an extended and diverse set of heuristics (even covers orientation is considered differently by alternative specialists).

Along this time, we have developed three versions of the design tool, as described in table 1. We started with a compact tool, where the user manages directly the design elements over a single tool. From this we changed to a more complex one, with a distributed architecture using alternative commercial software packages, that users command through a simple interface [García 1997], with a great diversity of automatic processes that can be activated by the user. Main reason of this evolution was the increasing requirement of flexibility of the design system, in order to take account of the technical evolution (with new external products) and extension of the design knowledge added by more field specialists (with different backgrounds, terminology and methodologies).

Table 1. Evolution of the design tool

1. GreenhouseDTool-1	A classic design tool. It specialized in designing greenhouse structures of the main typologies used in our work area, integrating drawing, structure analysis and budget evaluation of customized projects.
2. GreenhouseDTool-2	A distributed tool, which integrated multiple external tools. It managed external products using a distributed software architecture (DACAS) [Bienvenido1998]. Evolution of new structures requires new modules [García-Lázaro 1999].
3. DAMOCIA-Design	A knowledge based tool. It includes multiple alternatives from different specialists. It is extremely flexible in order to include new design schemes. New structures are included reusing previous knowledge [Das 1996] and adding specific methods.

Our first objective was to develop a simple design tool, assembling a library of elements and macros, in order to simplify obtaining new alternatives. This way we developed GreenhouseDTool-1, using AutoCAD tools as a base. We built a set of elemental blocks, which let us to insert complex design parts usually included into the structures, and work macros to execute repetitive tasks (as distributing the pillars over the work area or assigning space to the lateral bands). All the processing elements were developed using AutoLisp. Once the structure was designed, we extracted using internal data a relation of elements, which was treated with a simple C program to obtain budgets. Simple structural analysis was added using complex AutoLisp macros. Users were required to manage AutoCAD.
GreenhouseDTool-1 presented three main problems when the agronomists and greenhouse builders used it:

- The designing sequence, set of steps to develop a new structure for a given place, was not clearly defined. The user had to activate in a correct order the different macros.
- All the users were asked to manage a specific tool when sometimes he used to subcontract final drawings and budget after simple sketches.
- There were diverse alternative and expensive tools installed. Users demanded to make use of them, taking advantage of their previous handling knowledge.

This led us to a second version of the tool. This was distributed over diverse modules, using a distributed architecture specially developed, DACAS, which is shown in figure 1. It was redefined a simple windows user interface which commanded all the specific processes. This launched (and launch), as required, different tasks:

- Configuration modules specifically developed to propose solutions to specific conditions.
- Drawing modules implemented as managers of external tools as the different versions of AutoCAD and MicroStation.
- Budget modules that generate full reports in Word, WordPerfect, Lotus or Excel formats.
- Structural analysis modules, which extracted basic elements data generating the specification of diverse structural analysis packages. We added a single module, written specifically, for most simple structures.

Using this second version of the tool, there were developed new structured exploited experimentally and professionally. Main problem of this version was developing the configuration modules. Different specialist proposed alternative approaches to the same problems, it was required to order all this heuristics, alternatives and methodologies. This took us to develop a third version of the tool, DAMOCIA-Design, using knowledge acquisition and modelling techniques as described next.

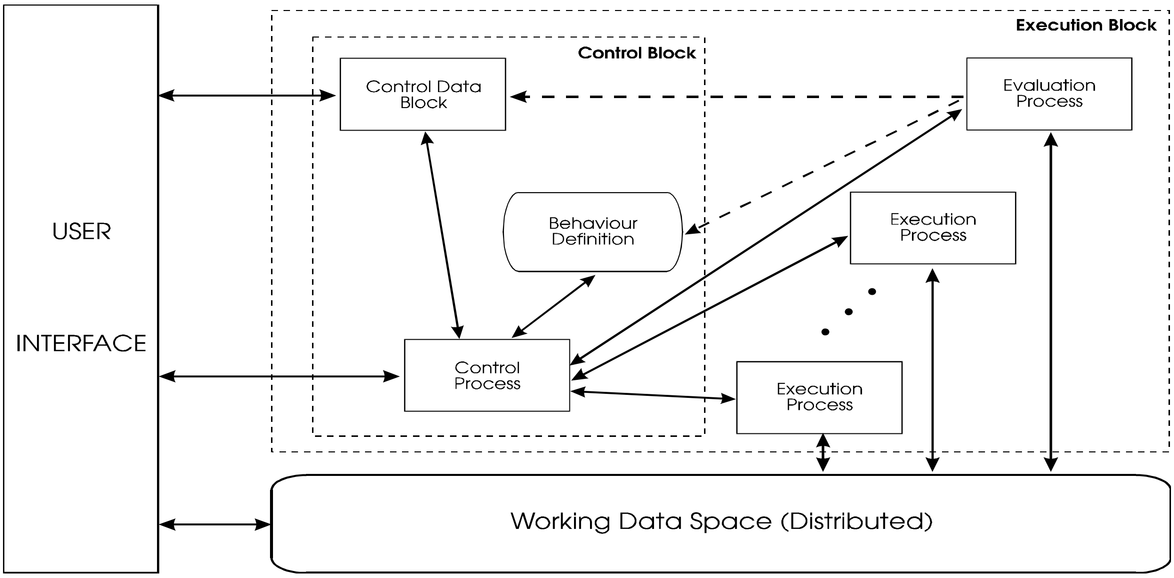


Figure 1. DACAS distributed architecture

3. Knowledge modeling

Ordering the diverse knowledge contributed by the field specialist, reusing as much as possible work methods and software elements [Das 1996], was the main objective of the third version of the design tool. This was primarily a problem of knowledge management and acquisition. We decided to use the CommonKADS methodology [Schreiber 2000], used, actually, as standard framework for knowledge systems development in Europe. We use, mainly, the task-method diagrams and CML description of the knowledge model. Previous notation have been extended in order to included the dynamic selection of methods (translating the decision of using alternative design methods to the execution time), figure 2 presents the extended notation of the TMDs.

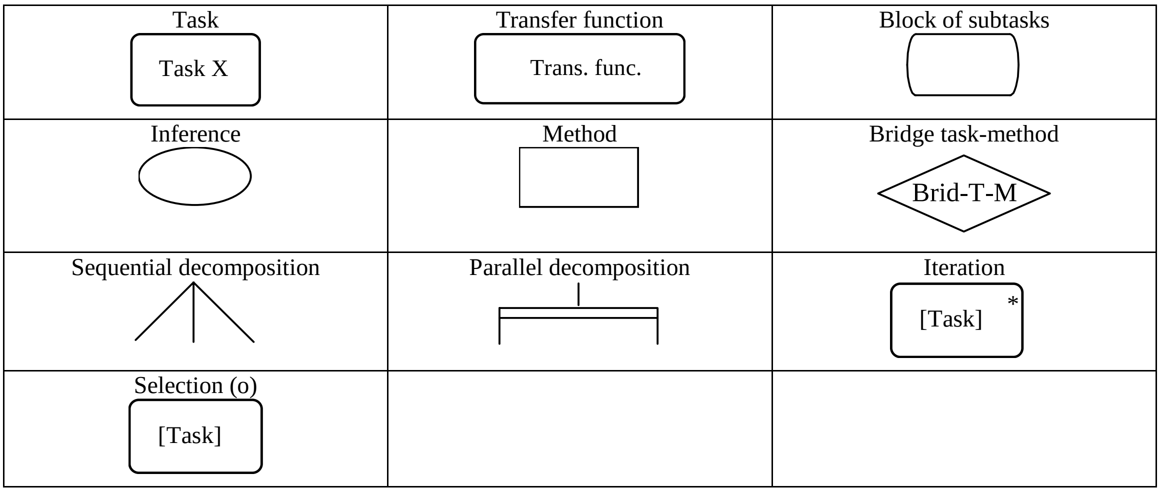


Figure 2. Extended notation of the TMD diagrams

As general work framework, we assembled a general model of design by steps with local evaluation, STE (from specification, translation and evaluation), which TMD for three steps is shown in figure 3. This general design model was instantiated to design greenhouses, as it is shown in figure 4. This presents the different modules for specification, translation and evaluation and their interrelation.

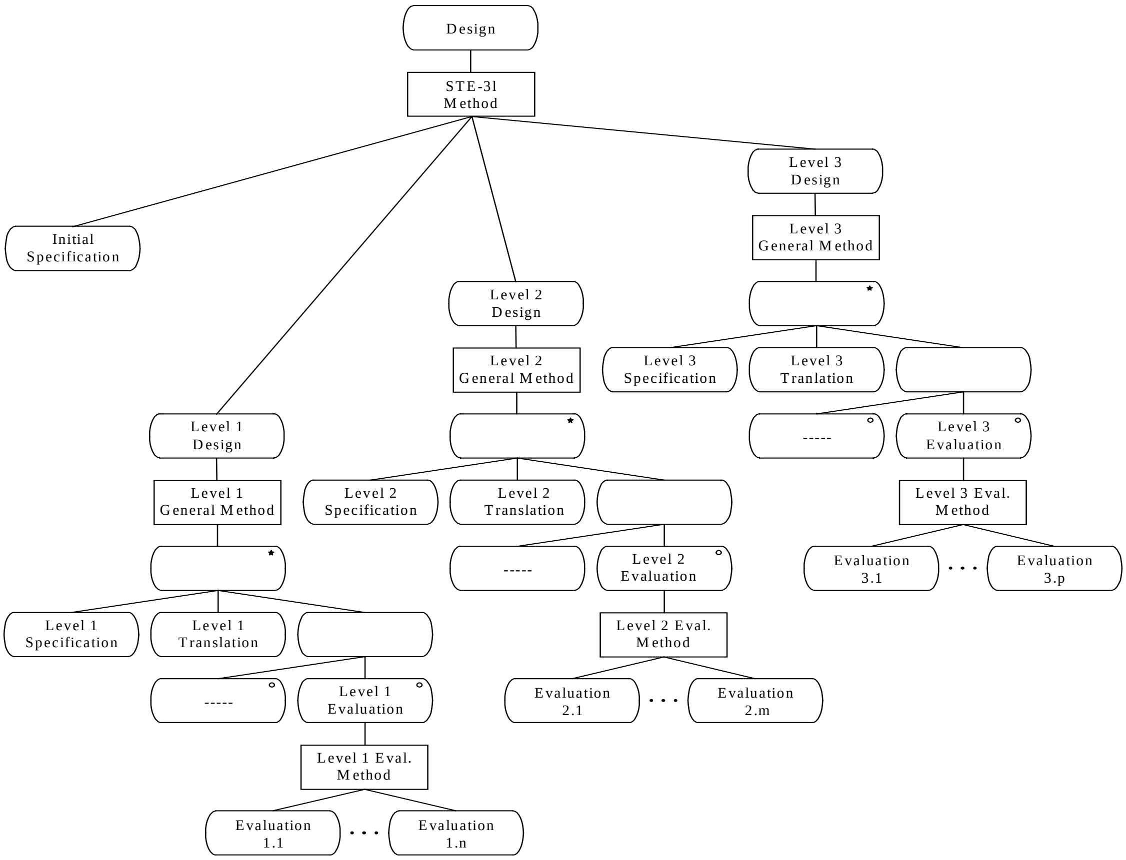


Figure 3. TMD of a design by three steps model

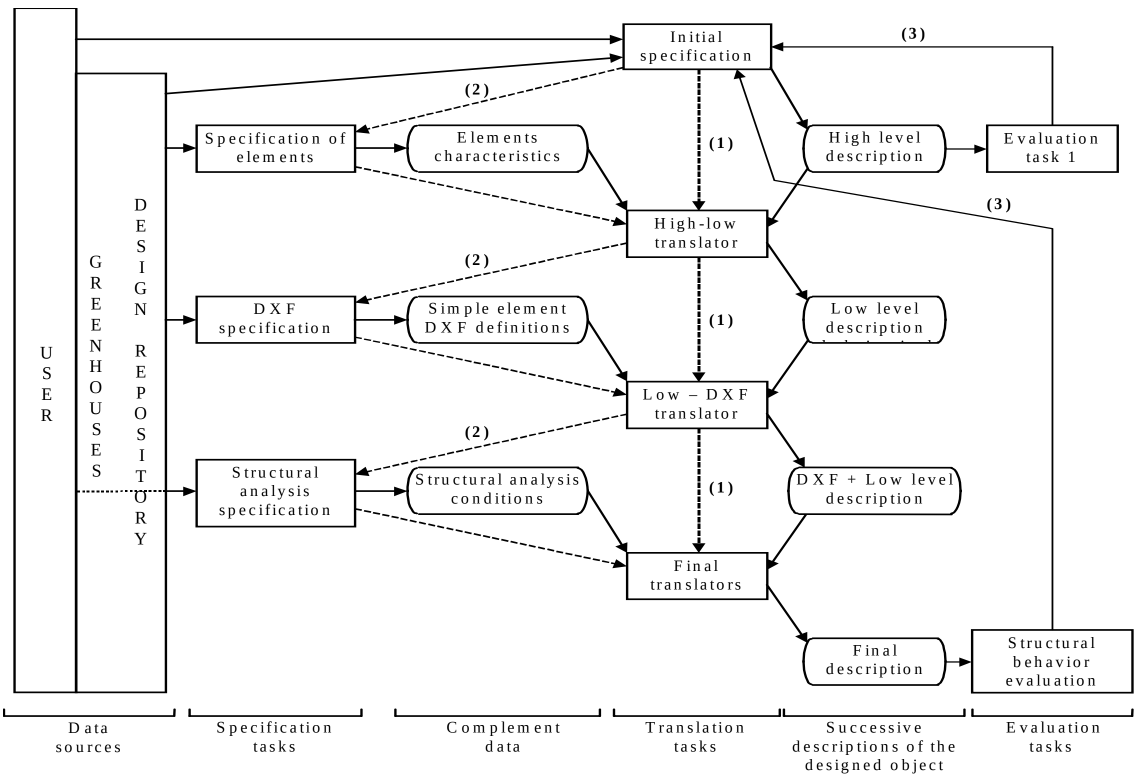


Figure 4. Greenhouse specific modules interrelation

Specification modules presents multiples alternatives stored into the greenhouse design repository, which are activated using user given data, previous suppositions and the behavior knowledge stored also into the knowledge repository.
Figure 3 presents a general design framework (STE model) which it is instantiated in figure 4 for designing greenhouse structures. The STE model is applicable to other design fields where the designed elements can be described formally and the designing process can be broken into clearly defined phases (including tasks of specification, translation (transformation of the formal description) and evaluation).

4. Results

The general design framework, which includes alternative methods to specify the greenhouse at different levels of description as the selection of the type of structure, distribution, materials, or providers. There are, too, alternative methods of similar behaviour associated to different work conditions, as the CAD software licenses activated. The user can specify the greenhouse structure giving a minimum of data (he uses a maximum of automatic rules) or a maximum of data (he gives directly near all the configuration data). Proposed structures are analysed by the evaluation modules (activated by the tool manager and users). Figure 5 shows part of the interface of the actual DAMOCIA-Design tool and figure 6 presents some example results. These later can be obtained giving exclusively the working area when the maximum of specification heuristics is activated.

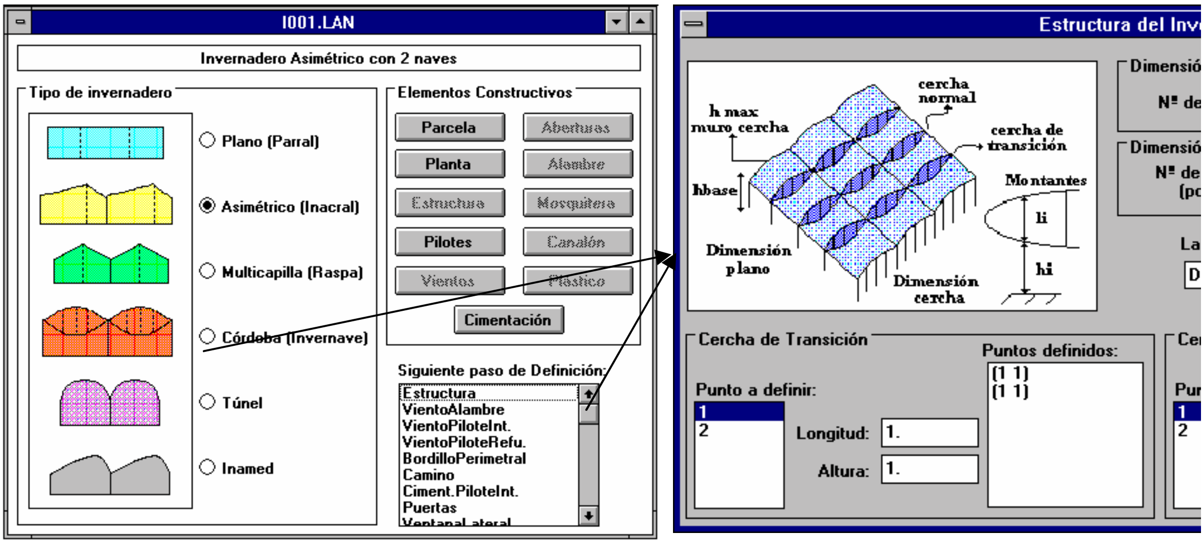


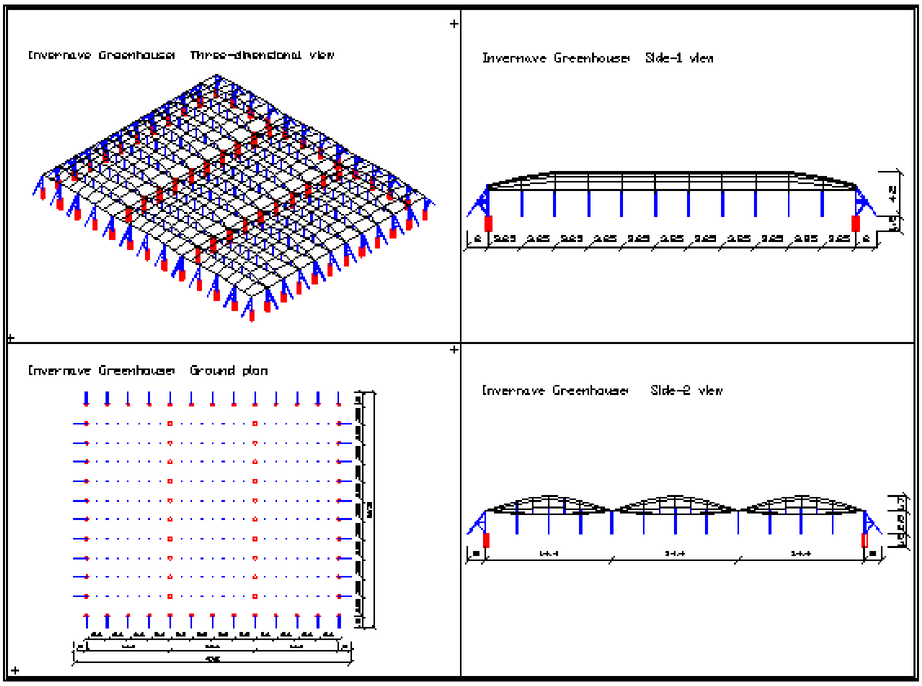
Figure 5. Design interface

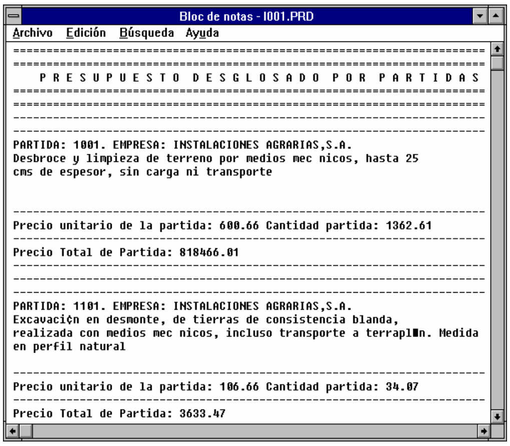
5. Conclusions and further works

Main conclusions are:

- It is possible and valuable to improve classic design tools adding design heuristics, transforming representation and computing tool into real design tools.
- Design knowledge can be modeled efficiently using CommonKADS.
- Dynamic selection of methods offers the possibility of include multiple alternatives, which are evaluated in execution time.
- It has been modeled a general design framework based on specification, translation and evaluation task.

Actual works include developing formally an ontology of design methods, and extending the design experience to other fields as the development of shape-tools for the aeronautical industry.





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Desbroce y limpieza de terreno por medios mec nicos, hasta 25 cms de espesor, sin carga ni transporte

Precio unitario de la partida: 600.66 Cantidad partida: 1362.61

Precio Total de Partida: 818466.01

PARTIDA: 1101. EMPRESA: INSTALACIONES AGRARIAS,S.A.
Excavaci¢n en desmonte, de tierras de consistencia blanda, realizada con medios mec nicos, incluso transporte a terrapl■n. Medida en perfil natural

Precio unitario de la partida: 106.66 Cantidad partida: 34.07

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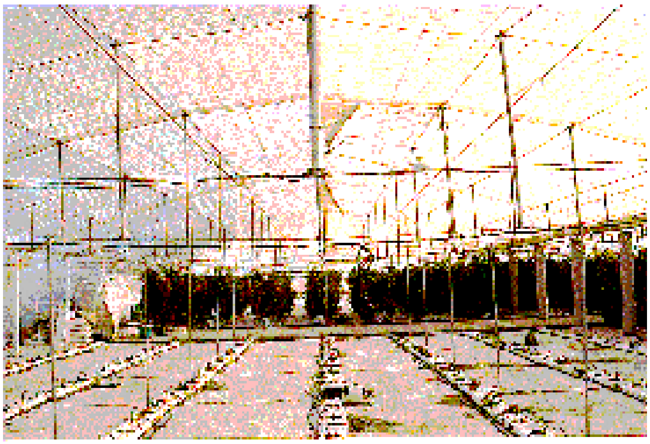

Figure 6. Examples of practical results

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