

# FINAL PROGRAM



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## MOVING TOWARD EXPERT SYSTEMS GLOBALLY IN THE 21ST CENTURY



*Estoril Sol Hotel*  
*Lisbon/Estoril*  
*January 10-14, 1994*

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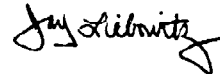
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On behalf of the International Technical Committee and the 22 cooperating organizations, I would like to welcome you to the Second World Congress on Expert Systems, January 10-14, 1994 in Estoril/Lisbon, Portugal. The focus of the Congress is to provide a forum with widespread international participation in bridging the gap between the academician and the expert systems practitioner. We feel that we have achieved this goal as this Congress has 95 technical sessions on expert systems technology, applications, and management with 47 countries represented. The reviewers, speakers, regional chairs, tutorial instructors, panel and paper chairs, technical liaison and advisory committee, and selected others are commended for their help in molding the technical program. A special note of appreciation goes to Professor Ed Feigenbaum (the Honorary Chairman) and his "Knowledge Future" plenary panelists, Phil Klahr, Robert Miranda at Cognizant Communications Corporation, Sheila Bergman and Justine Palazzo at Horizons Unlimited, Helena Weinstein at Certame, and Dorothy Bomberger, Chuck Thies, Jason Espie, and Lisa Hadeed at Congrex (USA). Also the support from such organizations as ESPRIT, ALGIS, the Lisbon and Estoril Tourist Boards, and others is gratefully acknowledged. A congratulatory note also goes to the Feigenbaum Medal recipient Dr. Peter Friedland, Chief of the AI Research Branch at NASA Ames.

We hope you enjoy this Congress, and we look forward to seeing you at the 3rd World Congress on Expert Systems in 1996 in Seoul, Korea under the co-chairmanship of Professor Jae Kyu Lee of KAIST in Korea.



Professor Jay Liebowitz  
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for the following  
World Congresses:*

**The Third World  
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Seoul, Korea • January 1996



*Request for Proposals  
by July 1994*

**The Fourth World  
Congress on  
Expert Systems**

1998

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**GENERAL INFORMATION**

- Meeting Rooms** Meeting room locations for Tutorials and Technical Sessions appear after the title of each session. The two hotel sites are listed in parentheses. SOL is the Hotel Estoril Sol, and EDEN is the Hotel Estoril Eden.
- Information Desk** WCES Information Desks can be found in the lobbies of the Estoril Sol and Estoril Eden hotels. The desks will be open during registration hours.
- Transportation** WCES Social functions and the Opening Ceremony will have Motor Coach transportation provided from the Estoril Sol Hotel. Departure times will be posted at the Information Desk.
- Message Center** A Message Center will be available at the Congress registration area in the lobby of the Estoril Sol Hotel. All incoming messages and messages from Congress participants will be posted.
- Telephone & Fax** The Congress Secretariat can be reached at (Tel: 351-1-483-2595 Fax: 351-1-484-4904). Congress participants can use these numbers for incoming messages. Messages received by the Secretariat will be held for pick-up in the Office of the Congress Secretariat. Notices of such messages will be posted at the Message Center.
- Lunch & Banquet** Extra Lunch and Banquet tickets can be purchased at the Registration Desks Ticket throughout the Congress. Lunch tickets are \$35.00 and Banquet tickets are \$60.00.
- Gala Farewell Evening** 14 January - Estoril Casino nightclub - Includes round-trip transfers - Dinner, two drinks & fabulous Continental floorshow - \$85.00. Detail at information desk. Reservation must be made by Friday 10am.
- Exhibition** The WCES Exhibition is coordinated by CERTAME Lda., Rua Rodrigo da Fonseca, 74 R/C, Dte. 1200 Lisboa, Portugal. Tel: 351-1-386-1041 Fax: 351-1-386-4245.

# Second World Congress on Expert Systems®

## Schedule

### January 9-15, 1994



#### January 9 Sunday

15:00-18:00 REGISTRATION OPENS

#### January 10 Monday

07:30 REGISTRATION OPENS  
 08:30-10:00 Morning and full-day **tutorials**  
 10:00-10:30 Coffee Break  
 10:30-12:00 Morning and full-day **tutorials**  
 12:00-13:30 Mid-day break  
 13:30-15:00 Afternoon and full-day **tutorials**  
 15:00-15:30 Coffee Break  
 15:30-17:00 Afternoon and full-day **tutorials**

#### January 11 Tuesday

07:30 REGISTRATION OPENS  
 08:45-12:30 Opening Ceremony, **Feigenbaum Medal Address & Plenary Session** at the **Estoril Casino**  
 Feigenbaum Medal Recipient:  
**Dr. Peter Friedland**, Chief of AI Research, NASA Ames, USA  
 12:30-14:00 Welcome luncheon at Estoril Sol Hotel  
 14:00-18:00 **Exhibition Open**  
 14:00-15:30 Concurrent Technical Sessions  
 15:45-17:15 Concurrent Technical Sessions  
 17:30-19:30 Welcome Reception

#### January 12 Wednesday

08:00 REGISTRATION OPENS  
 08:30-10:00 Concurrent Technical Sessions  
 10:00-17:30 **Exhibition Open**  
 10:00-10:30 Coffee Break  
 10:30-12:00 Concurrent Technical Sessions  
 12:00-13:30 Luncheon at Estoril Sol Hotel  
*Speaker: Dr. Philip Klahr*, Inference Corp., USA "1993 *Innovative AI Applications Case Studies*"  
 13:30-15:00 Concurrent Technical Sessions  
 15:00-15:30 Coffee Break  
 15:30-17:00 Concurrent Technical Sessions  
 Evening Open- **Optional Lisbon by night with dinner**

#### January 13 Thursday

08:00 REGISTRATION OPENS  
 08:30-10:00 Concurrent Technical Sessions  
 10:00-17:30 **Exhibition Open**  
 10:00-10:30 Coffee Break  
 10:30-12:00 Concurrent Technical Sessions  
 12:00-13:30 Mid-day Break  
 13:30-15:00 Concurrent Technical Sessions  
 15:00-15:30 Coffee Break  
 15:30-17:00 Concurrent Technical Sessions  
 20:00-22:30 Congress Banquet at Estoril Sol Hotel

#### January 14 Friday

08:00 REGISTRATION OPENS  
 08:00-13:00 **Exhibition Open**  
 08:30-10:00 Concurrent Technical Sessions  
 10:00-10:30 Coffee Break  
 10:30-12:00 Concurrent Technical Sessions  
 12:00 REGISTRATION CLOSED  
 Afternoon open for Optional tours and golf tournament  
 20:30 **(Optional) Gala Farewell Evening at Casino Estoril**

#### January 15 Saturday

**Optional Tour - Fatima & Nazare**

- **Pre- and Post Congress Tours also Available - See Social Program**
- **Accompanying Persons Program Daily**
- **7:00-8:30 Buffet Breakfast Daily - at each hotel**

# An Expert System for Reproducing Human Cognitive Processes in Automatic Software Design

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The prime goals of this project are (1) developing an automatic software design system that aims at reproducing human cognitive processes; (2) automating software design by shifting the prototyping and modifications to higher design levels rather than source code. Particularly, this paper introduces an experimental expert system CREATOR2 for automatic design of switching software. Basic features of this system are: object-oriented (OO) representation of the design process knowledge, composed of *design rules* for detailing, and *tacit knowledge*; using multiple strategies in applying this knowledge; and integrating it with a SDL CASE tool. This leads to having a uniform modeling and advanced reasoning environment for software design. Experiments on designing switching software are reported. Presently, the CREATOR2 system together with an SDL CASE tool offers 60-100 times the code expansion rate.

## 1. Introduction

(1) Conventional CASE tools generally facilitate requirement analysis, detailed design and code generation. Such CASE tools cannot support the higher level *knowledge-intensive* activities of design unless incorporated with the knowledge representation and sophisticated reasoning methods [11]. Presently, higher level design activities, such as those related to selecting proper pieces of knowledge, decision making and evaluation, are to be handled by human designers. The software design knowledge can be captured and implemented in the CASE tools using Artificial Intelligence (AI) techniques. This paper introduces an approach towards developing a Knowledge Based Software Engineering (KBSE) tool using SDL-based CASE tool and object-oriented (OO) techniques.

(2) The main stream of software development involves implementation of the design using top-down hierarchical decomposition and refinement [8, 3]. In some empirical studies of software design it is observed that both expert and novice designers decompose their initial design goal in a top-down manner until reaching a point that a portion of the decomposed structure or subgoals can be converted to the code using an elementary program unit that has the same 'function', and is represented by a collection of simple 'graphic symbols' used in the CASE tools.

Opposite to novice designers, experts can manage to develop many subgoals at the same level of abstraction before further proceeding to the next level [3]. However, in designing complex systems, as the number of subgoals increases, it becomes increasingly difficult to keep track of all of the active and pending subgoals. A main problem is that even expert designers show rather poor performance in considering all intermediate pieces of information and subgoals simultaneously. This is called *tunneling* effect of the *cognitive overload* [5].

The experimental expert system CREATOR2 aims at reproducing human cognitive processes considering minimization of the cognitive overload. This is achieved by efficient encoding the design knowledge. The limited capacity of the short term memory of human designer is replaced by stack, queue and array that have a larger capacity, in principle. In representing the domain concepts and organization of design input/output OO techniques are found useful. Each graphic symbol of the CASE tool is represented by an object and design refinement is nothing but a proper selection of such objects or their child instances and inserting message paths among them. Yet other objects are used to control data access and selection, and the whole structure can cope with the event-driven nature of design process, ensuring high flexibility of the design and maintaining its rationale.

(3) In *Software Creation* project [9, 10] automatic software design by simulating human designers is studied. The main idea is to follow design steps of human designers. Human designers' knowledge is extracted from an actual design and is reused by an expert system. The design rules are extracted by comparing the design documents in successive design phases. The research starts from the lowest and the most detailed design and goes upward hierarchically to more knowledge intensive areas.

The CREATOR2 is built to demonstrate some of the results of this project [6]. Figure 1 depicts the basic idea and corresponding design phases in this system. These design phases are introduced in detail in the following sections.

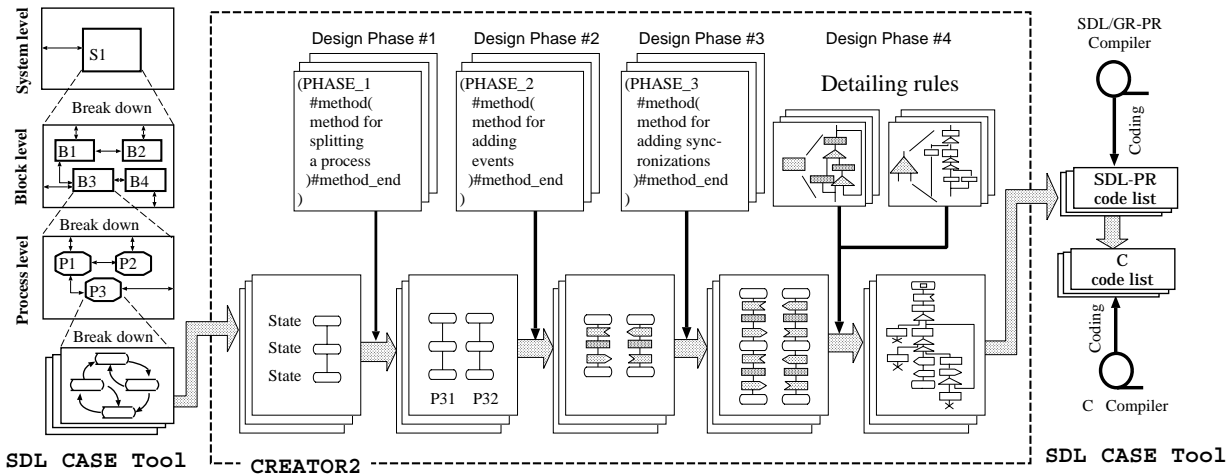


Figure 1. Successive design phases in CREATOR2.

(4) This paper is structured as follows: Section 2 presents the design knowledge representation in the CREATOR2 system. Section 3 describes the CREATOR2 system in detail and Section 4 gives some experimental results. Finally, Section 5 concludes with a summary of achievements and suggests some future research directions.

## 2. Software design knowledge

In CREATOR2 we intend to capture and reason with the sort of knowledge that software design experts use in design. Software design knowledge includes *design product knowledge* and *design process knowledge*. Here we concentrate on representation and support of software knowledge in reusable form, by introducing an structure for integrating these two.

## 2.1. Design product knowledge

The *design product knowledge* relies on the perspective that the design system is viewed. It includes domain-specific concepts, constraints and qualitative or quantitative models of the system. We have used the Specification and Description Language (CCITT-SDL) [2] for representing the design product knowledge. In CCITT-SDL a system is viewed as a collection of ‘blocks’ embodying concurrent ‘processes’. Processes are represented by an *Extended Finite State Machines (EFSM)* that communicate with discrete signals. An advantage of using CCITT-SDL is its ability to concentrate on the process as the basic module of design and exchange messages between processes that corresponds with our OO view of the system. SDL has both graphic (SDL/GR) and text-based (SDL/PR) versions. Figure 2 shows an example of SDL/GR and SDL/PR.

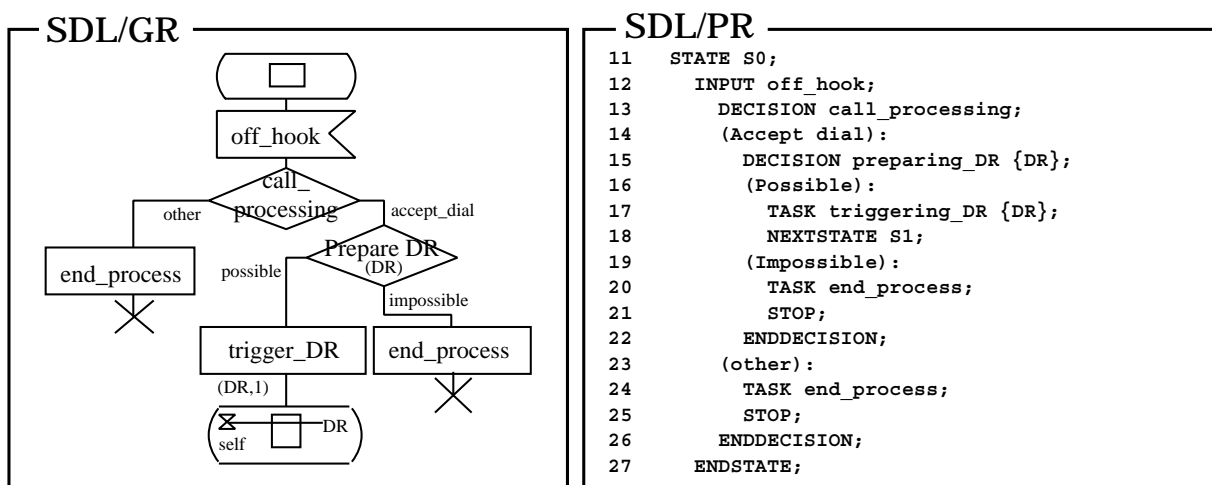


Figure 2. Example of SDL-GR and SDL-PR.

In CREATOR2, the design product knowledge is represented by a structure of *class* and *instance* objects (frames). Each SDL/GR symbol is associated with a frame that embodies all the information related to that symbol, such as its class, function, name, connections, etc. Figure 3 shows frame representation for the DECISION symbol. As shown in the same figure, in CREATOR2, a design input file in SDL, is represented by a structure of such frames.

## 2.2. Design process knowledge

Design process is viewed as a progression towards a goal by applying detailing patterns. The design process knowledge involves ‘design rules’ (detailing patterns) acquired from human design, and ‘tacit knowledge’ to make such patterns operational.

### 2.2.1. Design rules

Design rules are used for replacing a given symbol with a number of other symbols in detailing the function, generating a task from successive states, etc. A method for deriving design rules has already been introduced [1, 9].

In CREATOR2, the detailing design rules are classified in 4 groups defined by TASK- RULE, DECISION-RULE, OUTPUT-RULE and INPUT-RULE. Each design rule is composed of a parent frame for pre-transformation symbol and a number of child frames for post-transformation ones.

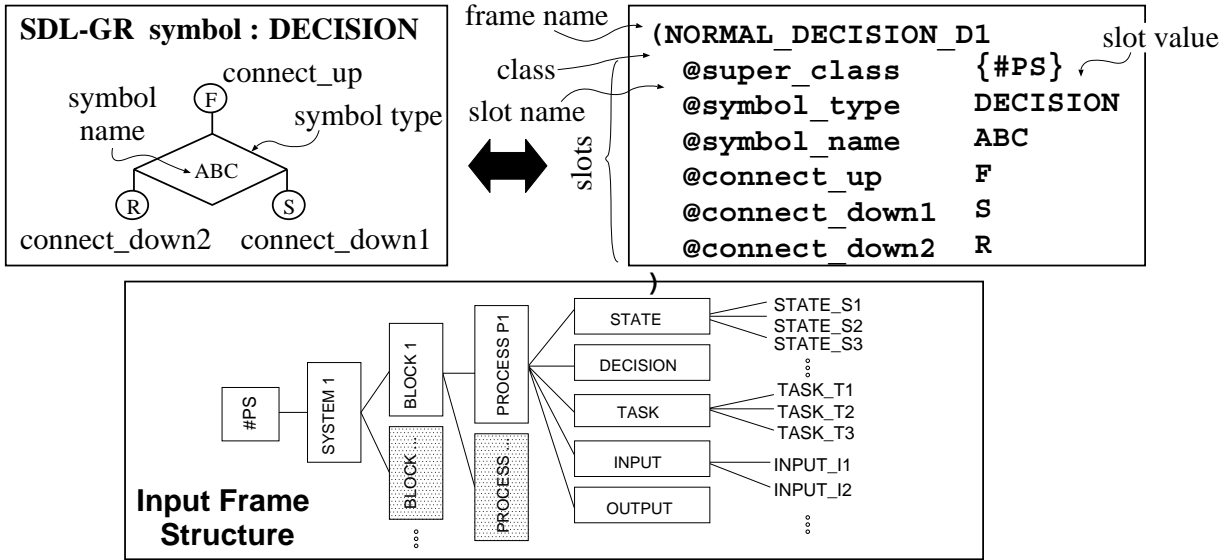


Figure 3. Frame representation of a typical SDL/GR symbol and a design input file.

### 2.2.2. Tacit knowledge

A main activity in human design involves selection and application of design rules using the tacit knowledge. It is believed that tacit knowledge is neither declarative as in the design rules, nor sequential as in the design product knowledge. Here each step may be triggered based on a certain symptom. The need for a scheme that can integrate the pure top-down approach with the data driven strategy has already been mentioned [3].

Opposite to the design rules, tacit knowledge does not depend on a particular design and can be implemented independently. In the CREATOR2, we have developed a collection of ‘design schemas’ in the CREATION expert unit that embody the tacit knowledge. Each design schema is a coded form of a human design activity. Those schemas are collected and applied in three successive phases (see Figure 1). This is explained in more detail in Section 3.3.

## 3. Experimental Expert System

### 3.1. Overview

The CREATOR2 system is composed of 6 expert units. The system is shown in Figure 4. The human designer prepares an initial design sketch using graphic symbols by an SDL CASE tool. This is converted to SDL/PR and is fed to the CREATOR2 system. The SDL/PR is converted to frame structure, suitable for processing by the expert system. The CREATOR2 checks if this frame structure can be detailed by either a design scheme or an already recorded design rules that can be customized to exhibit the required function. The results detailing and customization are recorded in the created frame structure which is finally converted to SDL/PR. The designer can check and modify the results, if it is necessary.

The CREATOR2 is implemented on Hitachi 3050 Workstation using ES/KERNEL/2 expert system shell [4] that works together with the SDT CASE Tool [15]. SDT is used for graphical input/output and editing, translation between SDL/PR and SDL/GR, and converting the results to the C code. The other design tasks, such as creation, conversion, knowledge based reasoning and detailing are performed by CREATOR2.

The expert units in CREATOR2 fall within three groups: *conversion*, *reasoning and detailing*, and *customization and learning* experts. Their function is explained in the following paragraphs.

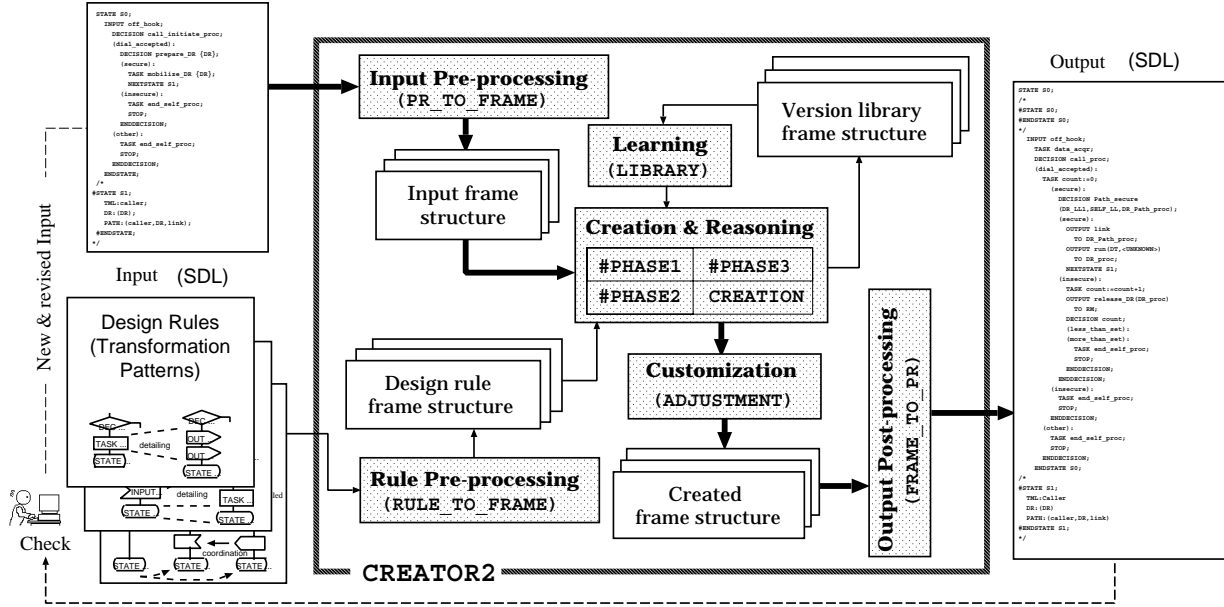


Figure 4. Experimental expert system CREATOR2.

### 3.2. Conversion expert units

(1) The PR\_TO\_FRAME expert is used for parsing and converting the SDL/PR to the frame structure suitable for processing by the CREATOR2. Presently, a set of frequently used SDL symbols and pictorial elements are accounted for [6]. This is sufficient for most of the design cases and can be extended if required.

(2) Design rules are converted to the frame structure using the RULE\_TO\_FRAME expert in the same manner. Each design rule is composed of a parent frame representing the pre-transformation symbol and a number of child frames for post-transformation ones. The RULE\_TO\_FRAME expert receives as its input a design rule in the SDL/PR format and converts it to the frame structure.

(3) After detailing is finished, the FRAME\_TO\_PR expert converts the final frame structure to SDL/PR that can be used by the SDT CASE tool.

### 3.3. Reasoning and detailing expert unit

The CREATION expert stays as the core of the CREATOR2. There are already two set of frames for the input file and design rules. The CREATION expert is responsible for checking the input frame structure, expanding it using design schemas, fetching design rules and inserting child frames of the matched rules in the input frame structure.

In implementing tacit knowledge in the CREATOR2, we have distinguished between two strategies for applying tacit knowledge, i.e. *inter-process detailing* and *intra-process detailing*. In inter-process detailing, an instance of a new process is created and the detailing is performed based on the information obtained from the original process. In intra-process detailing, the design rules are applied to a given process. For instance, a graphical SDL/GR symbol is replaced by a collection of other symbols that exhibit the same function in more detail within the process with some elaboration or

fine tuning to fit it into the specific case.

In inter-process strategy a look-ahead (e.g., finding the succeeding state and finding match for the events) or look-back (e.g., finding the preceding state, matching the events, add to the block, system, etc.) search strategies are applied. However, in intra-process strategy, a local and limited search is sufficient to find the proper design rule.

Inter-process detailing is realized by a collection of design schemas in three phases. The procedure for these three phases is shown in Figure 5.

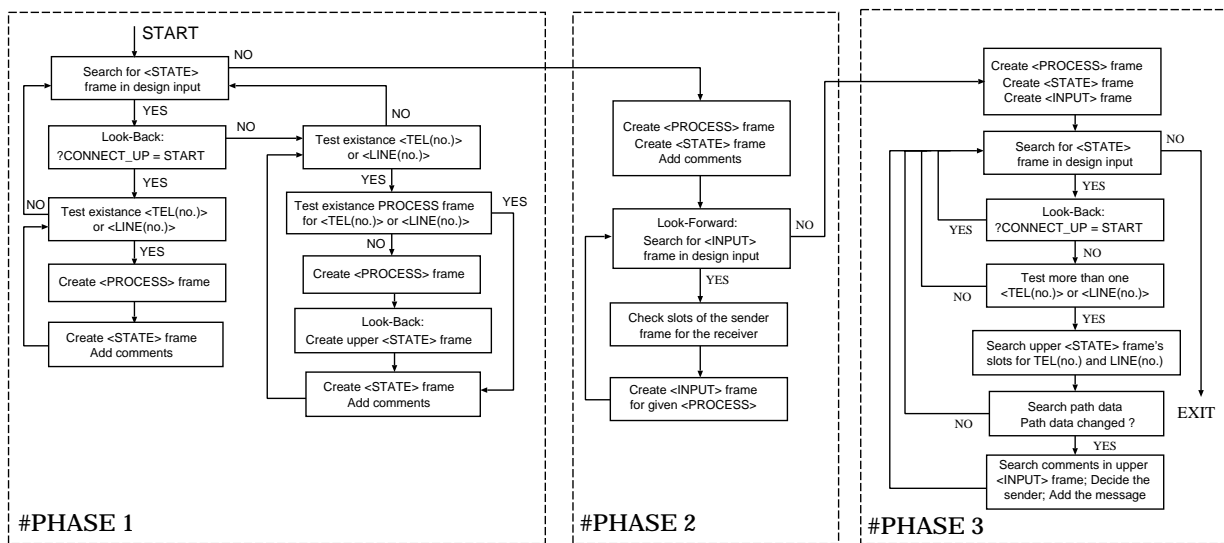


Figure 5. Inter-process detailing procedure.

Various steps of intra-process detailing is coded by the *methods* of the **CREATION** expert. Figure 6 shows an example of a method for intra-process detailing by the **CREATION** expert. Here the **CREATION** expert fetches a frame of the input frame structure, matches its name and other attributes with a design rule, and replaces the input frame with those child frames of the matched rules. All design steps are recorded according to their order of appearance and the system can explain each step if asked to.

### 3.4. Customization and learning expert units

(1) The results of creation are delivered to the **ADJUSTMENT** expert which is responsible for customizing the candidate frames and adjusting the links. This is the most time consuming task of automatic design because every single slot of a candidate frame must be checked and all the newly created frames should be accounted for.

(2) The **LIBRARY** expert keeps record of the design rules that are already used and customized. This is necessary for saving time in similar design cases and when a design rule is applied repetitively. The **ADJUSTMENT** and **LIBRARY** experts together realize the learning function of **CREATOR2**.

## 4. Experimental Results

Switching software is considered as the problem domain. The central part of switching control program is chosen as a typical example. In an experiment for designing the Plain Ordinary Telephone Service (POTS), we start with a single SDL process, describing ‘call’ (caller and called) behavior.

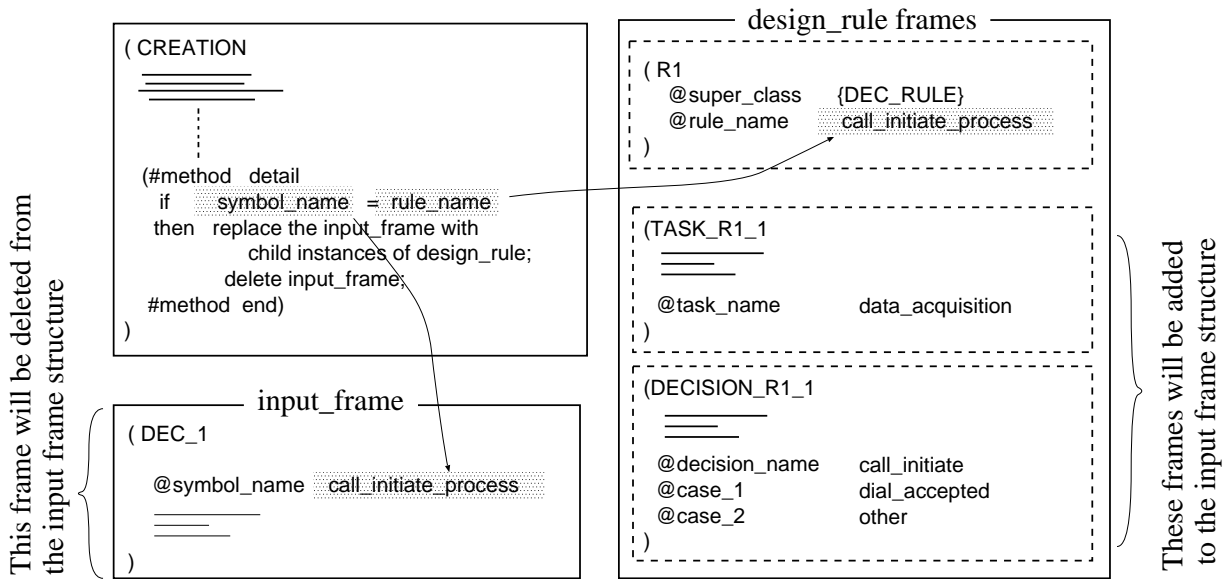


Figure 6. Intra-process detailing procedure by CREATION expert.

The system then splits it to two ‘caller’ and ‘called’ processes and inserts the design rules. It takes about 12 minutes to design simplified POTS composed of about 50 SDL/GR symbols.

Similar experiments are performed for other switching services such as Full-Call-Back-Transfer (FCBT) [13]. Figure 7 shows the overall progress of detailing for POTS and FCBT. During the design by the CREATOR2 system, the input file is detailed around 6-10 times. Then the SDT converts it to C codes of 10 times number of lines, resulting in 60-100 times the code expansion.

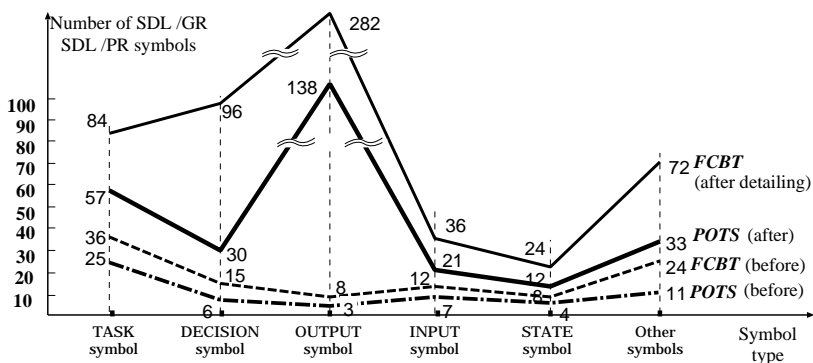


Figure 7. Detailing results for POTS and FCBT.

## 5. Related Works and Conclusion

This paper presents an implementation of an automated software design tool in the experimental expert system, CREATOR2 that follows the design steps of human designers by extracting and reusing the design process knowledge. Experiments on developing switching software is reported. In this project we have applied Schema based design refinement and graphical symbol based detailing rather than text-based one, which is more common in the other works, such as [12, 14, 7]. This allows integration of the presently available CASE tools with the knowledge based reasoning techniques.

In some works the need for distinguishing between the design product knowledge and design process knowledge is mentioned [16]. We have proposed a unified framework for representing both the design process and the design product knowledge using OO techniques. We have distinguished between the design rules and the tacit knowledge of the design process. The former is domain oriented and derived from actual design. The latter is general and can be used in design of software other than switching software.

The CREATOR2 system is currently a domain-specific program synthesis system. It serves as an experimental platform for the study of human design and lessons learned from its implementation contributes to building a more sophisticated Knowledge Based Software Engineering (KBSE) system.

### Acknowledgements

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