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The DIADEM Software Development Methodology extended to Multimedia Interfaces

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Abstract

DIADEM, created by THOMSON-CSF, is a methodology for specifying and developing user interfaces. It improves productivity of the interface development process as well as quality of the interface. The method provides support to user interface development in three aspects. (1) **DIADEM** defines roles of people involved and their tasks and organises the sequence of activities. (2) It provides graphical formalisms supporting information exchange between people. (3) It offers a basic set of rules for optimum human-machine interfaces. The use of **DIADEM** in three areas (process control, sales support, and multimedia presentation) was observed and evaluated by our laboratory in the European project DIAMANTA (ESPRIT P20507). The method provides an open procedure that leaves room for adaptation to a specific application and environment. This paper gives an overview of **DIADEM** and shows how to extend formalisms for developing multimedia interfaces.

Introduction

From November 1995 to December 1996, the *Systems Engineering and Human-Machine Systems Laboratory* at the University of Kassel participated in the project DIAMANTA, supported by the European Union as project 20507 in the ESPRIT programme. Goal of this project was to confirm the suitability of the software development methodology **DIADEM** (Dialogue Architecture and Design Method) as a means of developing graphical user interfaces that inherently satisfy user needs. Our group had a two-fold role. First, we provided one of the three teams that experimentally applied **DIADEM** to a software development problem. Second and independently from the first, we designed and applied a formal method to observe the three teams, to determine their progress and experiences and, thus, to assess the benefits of using **DIADEM** itself. We write this paper from the views of the *manager* (a **DIADEM** *role* described later) of the development team as well as from the view of the main responsible person for the evaluation.

The other partners in DIAMANTA were *THOMSON-CSF* (France), *Sistemas y Tratamiento de Informacion S. A.* (STI, Spain), and *Informationssysteme für computerintegrierte Automatisierung GmbH* (ISA, Germany). THOMSON-CSF provided knowledge about **DIADEM** and supervised its application.

We will briefly outline the methodology itself and report our experiences gained during application of the methodology to the development of a process control interface. We will show

how to extend DIADEM to different and new applications and figure out how these adaptations may look like for multimedia applications in process control.

The DIADEM Methodology

The process of user interface development becomes more and more an important economic factor for software development companies. Experience shows that the user interface software requires about 20% to 50% of the total software development costs. On the other hand, a well-designed user interface improves the usability of the product and, by this, the efficiency of its use and its acceptance by the users.

Against this background, the DIADEM methodology aims at giving software developers support for their development activities. Based on a dialogue model and an ergonomic approach to user interface design, THOMSON-CSF COMMUNICATIONS created DIADEM in 1992 in conformation to the THOMSON-CSF software reference system. From the beginning, the method featured an adaptable multi-modal dialogue based on ergonomic principles. Use in over 30 projects in the THOMSON group provided feedback for a new version, until from the end of 1995 the project DIAMANTA evaluated DIADEM.

The objectives of DIADEM are to enhance the efficiency in developing human-machine interfaces and to ensure the quality of the user interfaces to be developed. These objectives shall be achieved by providing a guide to structure, organise, and supervise all activities of the software development team. For the activities, DIADEM defines *development phases*, for the team members, DIADEM defines *roles*. We will describe both in the following sections along with our experience made during the DIAMANTA project.

DIADEM Roles

DIADEM suggests distinguishing the role of a *manager*, a *specifier*, a *human factors specialist*, a *programmer*, and a *user*. It was a large industrial company that developed DIADEM, and, therefore, the original users of the method were large teams. All teams in our project were smaller. The practical evaluation of DIADEM in our group as well as in the other development teams showed that it is difficult to have exactly these persons or group of persons covering these professions constantly available in a development team. Thus, it is better to speak of *roles covered* by different people in the development team while one person may cover different roles as well as one role may keep several persons busy.

By giving roles, DIADEM describes the responsibilities and activities of the people involved in the software development. The manager is responsible for the overall organisation and supervision of the development process. The specifier interacts closely with the end user during task analyses and develops comprehensive specifications for the user interfaces. These specifications formally describe the interaction of the user with the interface and build the basis for the software coding activities of the programmer. It appeared, that the original role of the human factors specialist should better be distributed to two roles: The *cognitive ergonomist* and the *practical ergonomist*. The cognitive ergonomist supports the specifier during the tasks analyses and ensures an appropriate breakdown of the user activities. The practical ergonomist generates the Man-Machine Interface (MMI) Handbook. This is an application-specific set of rules ensuring consistency and usability of the interface, based on a general set of ergonomic rules and guidelines. In addition to the task analyses at the beginning of the development, the ergonomists involve end users throughout the whole development process in usability tests.

The development team at the University of Kassel involved five persons on the development side and two end users. One student acted as specifier while writing his diploma thesis on task breakdown and operation strategies in the application. Two students worked as practical ergonomists, writing homework (Studienarbeit) on human factors guidelines in the application-specific MMI Handbook. The programmer was a mechanical engineer who just finished his degree. An engineer and a senior operator from a chemical plant supported the development team as end users of the system to be developed. Finally, one of the authors covered the roles of manager, human factors specialist, and partly of the programmer, and he also assisted the specifier. This last combination of roles in one person contradicts some of the basic ideas of **DIADEM**, in which the human factors specialist should defend the user's needs against the manager. However, the two practical ergonomists counterbalanced this inadequacy during enthusiastic debates.

DIADEM Formalisms

In the whole, **DIADEM** focuses on having a common basis for communication within the development team, and on being able to supervise and trace the development process. More than that, the comprehensive formal descriptions of the user interface make maintenance and further development of the software product easier. To co-ordinate the work within the development team, **DIADEM** provides several formal specifications. A *task graph* represents a first formal description of the users' task derived from a task analysis.

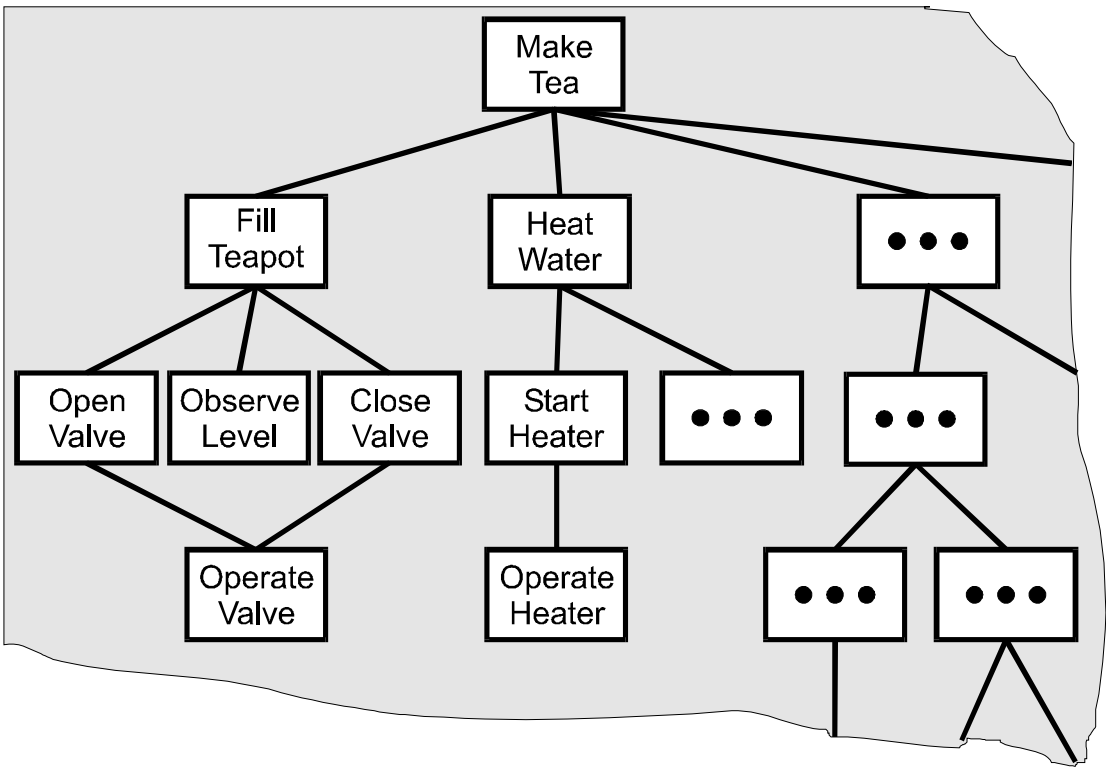

Figure 1 Sample Task Graph

The task graph shows a breakdown of the user's goals in a hierarchical structure. So-called *use relations* connect the levels of the hierarchy. To achieve the specific goal, the user *uses* the tasks on the lower level. The task graph in our application showed the overall goal "produce product" and lower-level goals like "start the system" and "correct error". Figure 1 shows a more everyday example.

The task graph enforces re-use of software components: On the lower levels, a small number of generic tasks were used to reach several goals on a higher level. In the process control application, the two tasks "change a pump status" and "set a valve position" alone could form the lowest level. For the implementation, this means only two software modules, one to control a pump and another for operating a valve.

Further formalisms provided by **DIADEM** are *technical sheets*, one for each task in the task graph. The technical sheet comprises a *strategy graph*, giving an abstract description of the interaction between user and dialogue system. The strategy graphs formed the main source of information for the programmer. Using a window-based system, the programmer created one dialogue window for each task. The strategy defined the logic of interactions in this window. It is important to note that the strategies only define the logic of interactions. They do not define the mechanism and media to be used. To keep use of mechanism and media consistent throughout the development, they are defined in the application's *MMI Handbook*.

This MMI Handbook is another formalism provided by **DIADEM**. With the specifications recorded here the programmer can turn the strategies into algorithms driving the interface in a correct, economical sound and consistent way. Rules defining how to implement an interaction in a specific application enforce consistency. This starts with common presentation choices like colours of window border, window background, character fonts used, and it continues with window organisation and failure handling. The MMI Handbook must cover the whole range of decisions to take when implementing the strategies. If not – it needs to be extended with the necessary additional decisions. Figure 2 shows rules from the handbook written for our application.

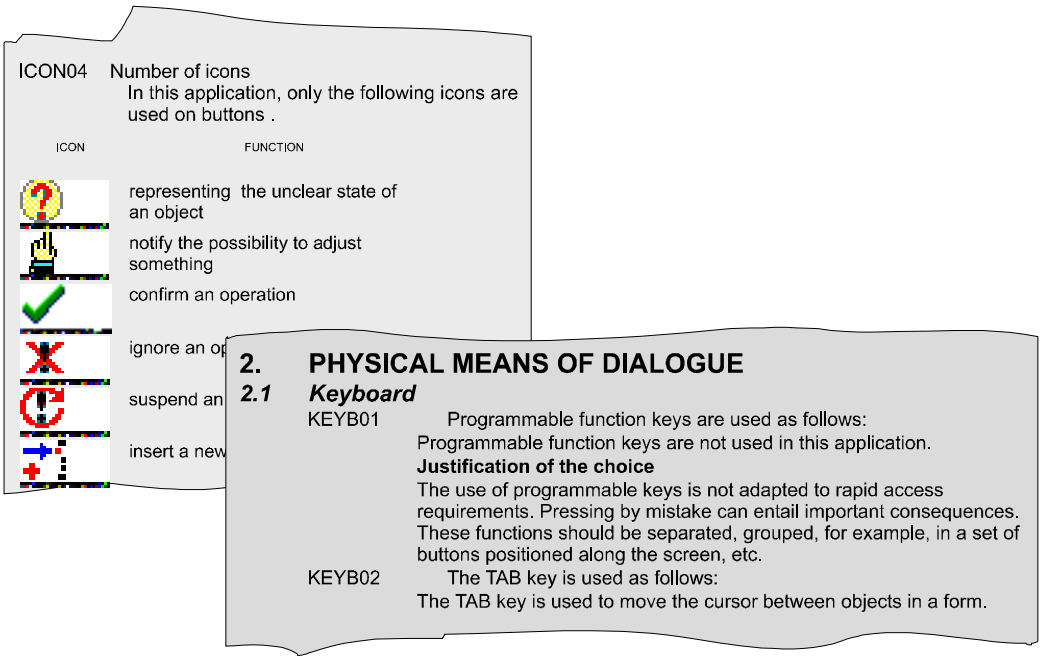

Figure 2 Definitions in the MMI Handbook (from Engel and, Quittkat, 1996)

The **DIADEM** handbook "Guidelines for Authors" (THOMSON 1995, 4) provides a table of topics to be treated in the MMI Handbook. A set of general rules is contained in a generic MMI Handbook (THOMSON, 1995, 5) that can be extended and adapted to any kind of ap-

plication to ensure the consistency of the user interface and the adherence to ergonomics rules.

DIADEM Activities

Besides proposing a certain staff composition for the development team and providing formalisms to specify the user interface, **DIADEM** also suggests how to organise the development process. In the ideal case, this process should follow the downward part of the V-model, covering system specification, software specification, preliminary design, detailed design, iterative modification, and finishing phase. Nevertheless, even if the development process will not follow the V-model, this will not affect the possibility to make use of the concepts and formalisms provided by the method. **DIADEM** defines activities grouped in four development phases, called *System Requirements*, *Software Requirements*, *Preliminary Design*, and *Detailed Design*.

The System Requirements phase starts with a task analysis and defines requirements and capabilities of the user interface based on user goals and means necessary to achieve these goals. The Software Requirements phase defines descriptions of the user's tasks and user objects. The MMI Handbook is written during this phase, defining the future appearance of the interface or, at least, of the first prototype. **DIADEM** enforces the early generation and evaluation of prototypes involving end users, leading to modifications of the definitions in several cycles. The graphical formalisms described above ease user comments to software designers. The software architecture is designed during the Preliminary Design phase while in the Detailed Design phase presentation and dialogue descriptions are completed.

Our project covered a development process up to the preliminary design phase involving four prototypes of growing complexity and functionality. As with the roles, here again the problem of a small group compared to a large software development company shows up. It was not possible to follow strictly the sequence of development phases, as all the people in the development team must be kept continuously busy in the assigned roles throughout the project. Thus, phases were overlapping and not consecutive and activities were scheduled more regarding the availability of people than depending on the completeness of required inputs. For example, MMI prototyping started when the programmer was available and the first user task descriptions existed; it did not wait for a complete task analysis and a satisfactory MMI requirements definition. However, going through four prototyping cycles in four months stepwise compensated the early deficiencies.

Evaluation of DIADEM

The **DIADEM** methodology for user interface development has been designed to be applicable to any kind of software application. The Trial Application Project DIAMANTA was initiated to show that this goal could be achieved. Therefore, **DIADEM** was used to develop three very different kinds of software applications. These three applications were a tourism information system, developed by STI; a sales support system for used cars, developed by ISA; and an interface to chemical process control, developed by our group.

By applying **DIADEM** to develop the applications, its overall suitability was evaluated and the specific costs and benefits of using **DIADEM** were pointed out. This was done by means of an evaluation procedure especially designed for the DIAMANTA project.

The primary focus of the DIAMANTA evaluation activities was on the efficiency of the software development processes. However, the quality and usability of the user interfaces to be

developed were a second important aspect. Therefore, we designed an evaluation and measurement procedure to cover these two criteria. This procedure, as shown in Figure 3, is based on three parts: *Continual Evaluations*, *Periodical Evaluations*, and *Final Evaluations*.

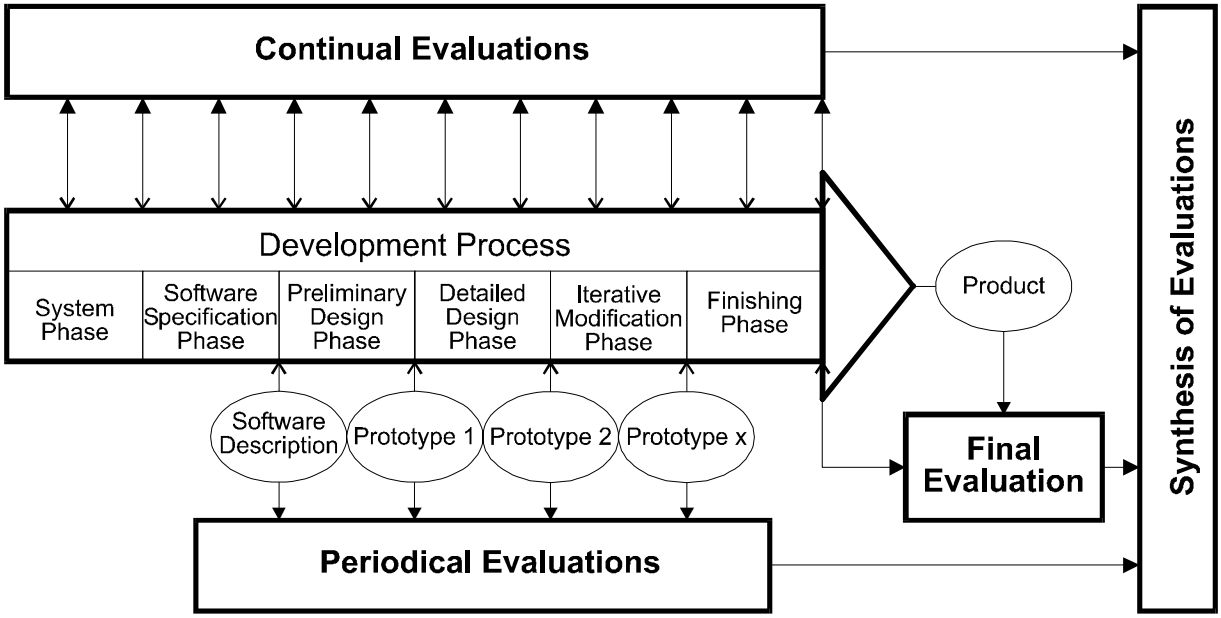

Figure 3: The DIAMANTA evaluation procedure

Weekly Continual Evaluations accompanied the development processes. They recorded the effort for development activities and subjective assessments by the developers in regular intervals. Periodical Evaluations followed each development phase completed. These aimed at recording the current state of the development process as well as the assessments by the developers referring to the respective development phase. Furthermore, we demanded to perform evaluations of the specifications and the interface prototypes in co-operation with real end users after finishing a development phase. The evaluation process ended with a Final Evaluation. It consisted of two parts: concluding assessments of the developers referring to the whole development process and a usability test of the developed interface by the end user.

All data recorded along the DIAMANTA trial application developments were processed, analysed and interpreted. Finally, the following conclusions were drawn:

- **DIADEM** is sufficiently generic and flexible to use it in a large range of applications and organisations.
- The adaptation of **DIADEM** to the specific projects would have been much easier with the *Customisation Guide* now available.
- The generic MMI Handbook provided by **DIADEM** is a valuable basis to develop a consistent interface.
- The formalisms provided by **DIADEM** turned out to be a good basis for communication within the development team. They represent unambiguous specifications for the user interface, improve the efficiency of the development process, and make later modifications or extensions easier.
- The dialogue specifications are to a high degree independent from the kind of interface, thus, it will be possible to re-use existing specifications as the basis for development of future interfaces, including interfaces which use emerging interaction technologies.

As pointed out above, the evaluation of the **DIADEM** methodology within the DIAMANTA project led to very satisfactory results. **DIADEM** increased the efficiency of all three application developments, and the user interfaces developed were of a good quality and usability by the end users of the respective systems.

The good overall result is based on a comprehensive definition of user requirements at the very beginning of the development activities and on a constant involvement of end users in the development process. This leads to a reduced effort for expensive changes at a later stage.

Furthermore, all requirements identified and all specifications become described in a formal way. This improves tracing the development process and communication between the people involved. Even validating the software developed is simplified by the formal descriptions. Finally, these specifications are invaluable means for developing future versions of the software.

One significant result of the evaluations performed in the framework of the DIAMANTA project is that the evaluations of the three very different applications led to the same conclusions. Additionally, evaluation results of the development processes correspond with the results of a heuristic evaluation of **DIADEM** from a theoretical point of view. This suggests that the conclusions drawn are valid even for a broad field of applications.

Customising DIADEM to Multimedia Interfaces

The common benefits of using **DIADEM**, as pointed out in the DIAMANTA project, are a result of the generic concept of the **DIADEM** methodology. However, this generality also induces the need to customise the method to a specific application.

Multimedia applications are a new field, providing features that are quite different from those of conventional software. Therefore, developing multimedia interfaces puts new requirements on the specification work. To meet these new requirements, the formalisms provided by **DIADEM** must be extended in an appropriate way. The significance of multimedia extensions to process control interfaces is already stressed in another contribution from our group in this conference (Borys and Johannsen, 1997). Backed by our good experience during the trial application of **DIADEM,** we now consider continuing the use of the skill gained in future software development projects.

The main anchor point we see for extending **DIADEM** to multimedia applications is the MMI Handbook. Task analyses deliver task graphs and strategy drawings describing dynamics of interactions necessary to operate an application. They leave completely open by what means or media this interaction would take place. The MMI Handbook is based on the "General Rules and Guidelines" (THOMSON 1995, 5). First, this handbook needs extensions to cover the decision "what medium to use for what type of interaction". A beginning is already made in Chapter 5 *Dialogue: Common Choices* with rule DIAM01:

> "*The dialogue modes must be chosen taking into account the characteristics of the users and the task requirements: For example ... use frequency, ... time constraints...*"
> (THOMSON 1995, 5, pg. 59).

Some new basic rules should cover ergonomics of additional media: Size of video presentation, level of acoustical output, speed of synthesised speech. An interesting research topic would relate to spatial sound sources, corresponding to **DIADEM** rules in Section 4.6 of the handbook covering arrangement of elements on the screen. Rule SPGR03 defines the greatest distance for grouped objects, SPGR04 the minimum distance for separated objects, both in

visual angel. Besides the angle, a rule for sound presentation must take care of differences in frequency, perceived distance, and loudness.

Some amount of new rules will certainly extend Chapter 4 ("Presentation: Common Choices") and Chapter 9 ("Interaction Tools"). Especially the latter, which currently only mentions cursor and mouse, will undergo some extensions. It must cover additional input media like voice or the famous (but expensive) cyber glove, but it also must regard additional more-dimensional mouse operations like pointing in space and rotations. Rules could be

> "when dialogue mode is question/answer and presentation mode is speech and answer is short, input medium should be voice"

or

> "when object moves, video bandwidth must permit a frame rate of…".

Finally, our aim is always to involve the user in the development. Thus, a basic guideline would be

> "when the user wants to hear it, provide sound, when the operator is used to feel it, provide vibrations".

This will bring back the operator from the distant control room to the plant again, as it is also required in our other contribution to this conference.

Conclusions

DIADEM, a methodology for development of user interfaces, leads developers through the developing process. One of the last steps is turning strategies, derived from task analyses, into program code. When extending **DIADEM** to multimedia interfaces, this last step needs to take into account the capabilities of new media available. Additional research, extending the rule set provided by **DIADEM**, will provide a useful basis to develop multimedia interfaces.

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