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Abstract

This paper explores the issues involved in the development of a knowledge based system targeted for use across Europe. It draws on the experiences of the multi-national team involved in the MODEMA project, addressing issues such as project management, knowledge elicitation and modelling, interface design and evaluation. The solutions found by the team are discussed and some recommendations made for use in further projects.

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Abstract
This paper explores the issues involved in the development of a knowledge based system targetted for use across Europe. It draws on the experiences of the multi-national team involved in the MODEMA project, addressing issues such as project management, knowledge elicitation and modelling, interface design and evaluation. The solutions found by the team are discussed and some recommendations made for use in further projects.

1.0   Introduction

MODEMA is a knowledge-based browsing system that is used to assist with the integration of disabled people into a working environment. The system was developed during an 18 month project, ending in June 1993, funded under the EC pilot TIDE initiative (Technology for the Integration of the Disabled and Elderly). At the heart of the system are databases with information relating to employment legislation, advice and compensatory equipment for the disabled. Access to this information is guided through a job/task/disability profile which enables the users to gain pertinent advice relating to their particular queries.

The project team was composed of six partners from five countries (UK, Belgium, Norway, Spain and Portugal) with varying expertise domains, making a multi-disciplinary team. The nature of the project team (i.e. dispersed in different countries and multi-disciplinary), of the particular problem domain , and of the development time scale (18 months) meant that particular innovative solutions had to be sought in the design and building of the system in order to ensure that the final demonstrator met the usability requirements of a diverse set of users in different countries.

Various important decisions were made early in the project which guided the subsequent development strategies. The comparative lack of use of any existing 'disability databases' led us to believe that an innovative approach to the provision of information was needed. The use of a user-centred prototyping development approach enabled us to test early and subsequent prototypes on potential users in all participating countries, thus supporting the development of a system which fitted user requirements. The short time scale meant that knowledge extraction and validation had to take place in parallel with prototype development, thus necessitating a closely monitored evaluation programme which combined validation of the knowledge models with evaluation of the user interface.

In designing the system it became apparent that diverse types of knowledge were required if it was to function efficiently. On the one hand, it would be necessary to model the knowledge held by advisers to the disabled relating to the classifications of disability, relevant legislation, the suitability of a person for a particular employment task and the specialist equipment they might use in the task. On the other hand, the knowledge held by employers and by disabled employees about task requirements for a particular job would be necessary to build up a general model of employment environments. It is apparent that no one expert has knowledge about all these areas; in our experience we found that advisers were not always fully aware of the functionality of specialist equipment nor of the task requirements of a particular job. A two-part knowledge extraction methodology was designed which was suitable for use in different countries and which would capture the depth of an expert's knowledge as well as a broader view of work environments.

The validation and evaluation programme was designed to be used in the five participating countries and to be carried out by non-expert practitioners. A scenario based approach was used, with test scenarios being collected independently of the main knowledge extraction process. The use of audit trails was introduced to deal effectively with conflict resolution. A final evaluation by expert panels in each country provided a broad spectrum of opinions on the final system as well as important pointers to further areas for development.

2.0   Management Issues

The consortium comprised six partners in five countries, with each partner having several personnel working on the project. One partner was designated 'co-ordinating partner', but although this gave them the responsibility for filling in reports and dealing with the finance, it did not give them overall control of the project. At the beginning of the project a collaboration agreement was signed stating the terms for agreement between the partners. This ensured that all significant decisions had to be made by consensus, or, where this was not possible, by majority vote of the designated team leader from each participating group. This 'management by consensus', whilst proving fair and equitable, was not without its problems, particularly when team personnel changed and new members did not share the same vision of the original cohesive team.

All communications were carried out in English, and inevitably some problems of communication occurred, particularly in meetings when there was a tendency to forget that some members might have trouble in following a rapid conversation. One solution adopted for a particularly important meeting was to provide simultaneous translation. This was not entirely successful due to the lack of expertise of the participants in using the headsets and microphones. A more pragmatic solution was to ensure that copies of all notes were distributed well in advance to give participants a chance to read and understand them.

In the initial stages of the project, there were several misunderstandings between partners, due in part to their different expertise domains, but also exacerbated by language problems. It is fairly common for people from different disciplines to use different terms to describe a problem or to use the same terms to mean different things, and, in a situation where everyone is trying to reach agreement, it is easy to overlook the fact that different meanings may have been attached to a statement. In this context, the importance of a social programme in conjunction with the official meetings schedule cannot be over-estimated. It is essential that team members have a chance to meet and talk socially if they are to work effectively together, and to gain the confidence to disagree with their partners and to ask for clarification if they do not understand a point.

A further cause for misunderstanding is the different expectations of the partners regarding the amount of work they should put in to the project and the projected outcome of the project. It is apparent from observation of several European projects that some partners take part for purely financial reasons and have no great interest in the final outcome of a project other than to fulfil the minimum requirements to get paid. Others, often the ones who wrote the proposal, see the project as a mission and will put in extra work, even to the extent of doing other partners' work for them. They may sound like ideal partners, but can seem overbearing and inflexible to other team members. A third type of partner is the one with a particular expertise who has a vested interest in doing a particular piece of research and will pursue their own goal even if it does not fit entirely into the project plan.
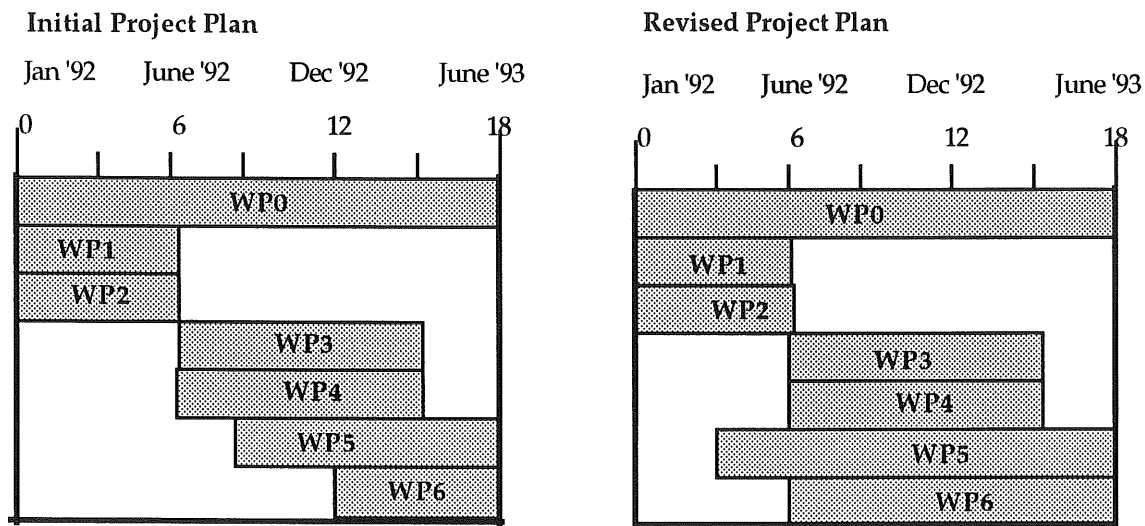
The expectations partners have of each other can also be a cause for concern. It is fairly natural to assume that all participants will be capable of turning in work to an acceptable standard, but each partner may have a different view of what is acceptable. It is a good idea to ensure that all partners produce some work early in the project and before a critical deadline is looming. In this way, differences can be ironed out, and, if necessary, responsibilities re-distributed. It is recommended that all reports are finally proof-read by a native-speaking partner, although this imposes further organisational constraints with respect to deadlines.

All the above points highlight the need for strong project management and emphasise the fact that a large amount of time must be allocated to communications and management, particularly in the early stages of the project.

2.1   Project Planning
Certain constraints were imposed on the project planning, in addition to the 18-month time scale. The dates of six-monthly reviews by the European Commission were fixed in advance and each partner was expected to take responsibility for at least one work package in the program. The project plan and proposed deliverables were presented in the Technical Annex at the start of the project, thus providing a framework for development; however, by the first six-monthly review it had become necessary to adjust the plan to account for an iterative prototyping approach to the development. Figure 1 shows the initial and altered project plans. In the revised plan, it can be seen that work packages 3 to 6 were carried out

largely in parallel, thus providing maximum flexibility in the development programme, but causing more organisational problems.

Initial Project Plan

Jan '92   June '92   Dec '92   June '93

Revised Project Plan

Jan '92   June '92   Dec '92   June '93

Legend: WP0: Project Management   WP4: Representation and Modelling
         WP1: User Requirements   WP5: Implementation
         WP2: Methodology and Setup WP6: Evaluation
         WP3: Knowledge Extraction

Figure 1: Initial and Revised Project Plans for MODEMA

In the following sections we review particular aspects of the project where multicultural issues had to be considered and problems taken into account.

3.0 Knowledge Elicitation and Modelling

The requirements of the MODEMA project differ markedly form those prevailing in most knowledge based system developments. In the development of Traditional knowledge based systems there are relatively few experts within which the knowledge to be modelled is concentrated. Knowledge is usually extracted from these experts in an intense knowledge extraction process [1] that may go on for a very long time indeed, involving lengthy focusing on a highly restricted group of experts.

The MODEMA project faced a challenging scenario. The expertise is highly distributed and there is no truly integrated compilation of information on the employment of the disabled. This is one of the reasons that the project was initiated, there are no experts on employment of the disabled, rather a large number of people with narrow bands of expertise. These narrow bands can be grouped into three main types: the disabled themselves, potential employers and those who advise the disabled in employment. Each of these narrow band expert types is also a potential main user type of the finished knowledge based system. As a user they would be primarily concerned in gaining access to the knowledge that the other narrow band expert types might have.

The requirements identified for the knowledge extraction process were [2]:
* it must be portable across international boundaries
* it must allow knowledge extraction by practitioners with varying degrees of expertise
* it must be possible to use it in a wide variety of settings
* it must be capable of testing existing hypotheses about the knowledge base
* it must capture knowledge in a form that is readily convertible into the form necessary for the computerised system.

After some experimentation with interview and questionnaire formats, two different approaches were designed - a fairly traditional questionnaire and interview format to elicit expert knowledge

regarding legislation and advice and a task-based method to enable the development of models of the working environment for disabled people. This is described in the next section.

3.1   Task Oriented Cross-Referencing

This method utilises an iterative approach to building a generic model of a working environment. It builds on previous research into the building a model of the office environment [3], but concentrates on the identification of tasks related to particular job functions and on the use of compensatory equipment and services by disabled people carrying out those tasks. It was the aim of the project team to build models of two types of working environment - the office and the shop floor, and to identify differences, if any, between these working environments in different countries. In fact no significant differences were identified, and it is felt that more work is needed before any conclusions can be drawn.

The method is designed to be operated over several iterations, using a checklist that is refined after each iteration to better reflect the generic model. In addition to the checklist a short questionnaire is provided to elicit such details as job title, disability, length of employment, type of organisation etc..

A preliminary task analysis is carried out for a specified environment to develop a set of hypothesised generic objects and actions. These are represented on a "cross referenced checklist" (see figure 2) which is used in subsequent knowledge capture interviews. The left-hand side of the checklist contains lists of typical actions, grouped according to the 'role' to which they belong, so for example 'supervise staff' comes under the managerial role., 'use programming environment' under the Programmer Role. The Priority Column allows some indication of the importance of the task to the job, from 1, marginal to 5, essential.

TASK	Priority	Compensatory Equipment/Services
SOFTWARE ENGINEER		
Programmer:		
use program'g env.	5	using audiodata - speech
read manuals	3	via personal reader
create documentation	5	braille printer
create diagrams	3	via thrid party
read diagrams/graphics	2	via personal reader
deal with clients	3	

Figure 2: An extract from a Task Check List

Although the checklist forms the basis of a structured interview, it was not deemed to be a good idea to simply work through them with the interviewees; experience has shown that this does not give a true picture of the tasks carried out. It was envisaged that the interviewer could fill them in as s/he conducted the interview, but this proved impractical in the early stages as the interviewers were not familiar with the forms and found it too disruptive to stop the interview whilst they tried to find the right place to make an entry. An added problem is one of language - if the form is left in English then the interviewer may have trouble interpreting it, but if it is translated there is more scope for error when the results are compiled back into English (although the fixed format helped to alleviate this problem).

The method preferred by most interviewers was for the interview to be carried out (in the native language) without the use of the form and for the interviewer to fill in the (English) form afterwards from notes or tape recordings taken at the time of the interview. Where possible, the form was checked back with the employee to ensure that all data was correct.

Two iterations of this procedure were carried out involving about 100 interviews in five countries, with the model being refined after each iteration in accordance with the findings. The extracted knowledge was fed into the prototype computer system which was used to validate the model.

3.2   Scenario Generation

The model created from the task checklists was used to provide users with guidance in relating compensatory equipment to tasks and in identifying ways to overcome any problems which might arise when considering a person's ability to do a job.   It allowed the generation of profiles for particular roles or jobs showing typical core tasks, these could be used to test scenarios of employment of people with disabilities, so that compensatory equipment requirements might be considered and tasks which need further thought could be identified.

4.0   Interface Design Issues

The interface design for MODEMA was particularly problematic in that it had to meet the needs of three user types as well as being suitable for use in all member countries.
Without specific tools to aid the simultaneous development of prototype systems in different languages, it was not practicable to develop in more than one language. This caused some problems when evaluating the system , particularly with the extensive user trials, since the trials were biased by including only users with some knowledge of English. A partial solution was found by providing the system controls (buttons and menu bars) in the native language, although the main text was not translated.

The developers put a lot of effort into providing an interface that assisted users in making structured queries based on job, task and disability profiling whilst still providing more fundamental database access for the more informed user who knew what to look for. Although the system was in English, care was taken to include data from all countries in the form of case studies, legislation and equipment details. An aspect of the system that was not fully addressed was the development of an update and maintenance interface. In retrospect, it would have been a good idea to provide an update facility early in the project so that all partners could have input their own data to the system, thus sparing the developers from the task of data input.

The use of video clips and photographs to illustrate the use of equipment is particularly beneficial in the presentation of information rich scenarios, such as the use of rehabilitation technology in a working environment. Their added benefit in an international system is that, so long as the videos do not use sound, they do not present a language problem.

A further problem was that the state-of-the-art machines in some countries did not match those of the system implementor. This meant that routines which were slow but acceptable on the development machine were much slower and intolerable on slower machines, thus adversely affecting user performance with the system.

More fundamental differences were identified in the content and style of information presenting advice on disability and employment. One partner group did not think it was suitable for disabled people to see advice aimed at employers on subjects such as 'how to interview a blind person', preferring this to be hidden if the system user was disabled. This view seemed to stem from the culture prevalent in that country which was to shield disabled people by providing them with sheltered work environments, rather than enabling them to compete in an open market by providing them with appropriate support services and equipment. It is possible that such a fundamental difference in perspective could have rendered the project unworkable, and although it was not so extreme in this case, it does identify a need to investigate such matters early in the project.

4.1   Recommendations for Internationalising an interface
In order to fully exploit the internationalisation of a system interface, several requirements should be met:
a)   The interface management system should allow the separation of captions from controls so that new language sets can be easily added.
b)   A restricted natural language should be used for text, thus facilitating the application of automatic translation. This approach has been followed successfully by Perkins [4] in the production of technical manuals where authors are restricted to PACE (Perkins Approved Clear English), and given a set of ten simple rules for producing text.
c)   Support for fine-tuning the translations should be given in the form of on-line dictionaries, spelling and grammar checkers.
d)   The interface for translators should be designed so that the translator need not be a system expert, but can see the context in which the text is to be used in the system.

e)   Designers should be wary of ordering controls such as menu items and lists alphabetically, since they will appear in a different order in a different language and could cause confusion to anyone who has to use the system in two languages.

5.0   The Evaluation Programme

The evaluation programme for MODEMA needed to accomplish the validation of the knowledge models at the same time as evaluating the user interface.   Three evaluation sessions were planned, with all partners taking part. In addition the developers held several more informal sessions both within their own establishment and at conferences and exhibitions.

The approach used for the first two major evaluation sessions was scenario driven prototype validation. As has already been discussed this caused some problems in the form of internationalisation of the prototype software, but it did allow simultaneous validation of the knowledge model with evaluation of the system.

The evaluation took place in each of the five participating countries. It was essential therefore that the validation procedure would be applied uniformly. Accordingly organisers for each country attended an evaluation workshop at which the method of evaluation was explained and the organisers participated in an example evaluation session.

Within each evaluation session, three short scenarios were used to train the subjects to use the prototype. They were then asked to carry out three specified test scenarios and comment on the usefulness and accuracy of the information provided. The validation session finished with the completion of a structured interview designed to ensure the subject's views were captured as accurately as possible. Transcripts of the subject's responses were collated along with their name, experience, area of expertise, any useful background information, country and locale of testing, name of the evaluator, date and version of the prototype.

The integration of this mass of data from five countries presented something of a challenge. Conflict resolution can be a serious problem when extracting knowledge from multiple experts, on the whole however, this was not a major problem in MODEMA. The key to effective conflict resolution was the maintenance of audit trails to enable the developers to trace knowledge representation decisions back to the knowledge extraction or validation processes that gave rise to those decisions and the main factors that influenced those processes. To maintain and use these audit trails the following were important:

* recording the characteristics of the subject: name, experience, area of expertise, nationality and locale on which that expertise is based
* recording the characteristics of the evaluation session: name of the evaluation organiser, date of the session and version of the prototype
* documenting all conclusions drawn from validation reports and referencing them to the reports on which they were based
* documenting all decisions about changes to the knowledge structure and cross referencing them to the conclusions above
* all documents were annotated with counter indications from validation and knowledge extraction sources

In the event of discovering conflicting knowledge, the audit trail enabled the backtracking to the source documents and correlation factors such as: a particular subject, session, organiser, location, country or a version of the prototype. Thus it was possible to detect and rectify any problems with the evaluation process.

In the early evaluation a surprising range of errors were reported. Many of these apparent errors were found to be caused by variations in local practice: either in the way that local organisations and facilities catered for the disabled or in the way the validation was carried out. Where there was a conflict that was hard to resolve, the subject of the conflict was made an explicit goal of the next phases of knowledge extraction.

The final (summative) evaluation was carried out through expert panels in each participating country. A number of domain experts were invited to take part in the panel. They were given time to familiarise themselves with the system if needed, although in practice many had already seen it. They were presented with scenarios as an aid to using the system. Following this familiarisation, the panel were encouraged to discuss the system under such headings as: 'actual and future needs in the field',

'advanatages and disadvantages of the final product', 'final product characteristics', 'Potential recipients of the final product in the market'.

The results of the expert panels are currently helping to formulate the strategic development plan for the product.

6.0 Conclusions

This paper has highlighted the particular aspects of MODEMA where multicultural issues had to be taken into account. Many of the problems stem from language difficulties, but differences in expectations and understanding of the problem domain can also contribute to problems.

The early prototyping approach was particularly beneficial in designing this application where there was no previous system and no consensus on user requirements, although tools to facilitate the building of prototypes in different languages would have been beneficial.

We have identified new approaches to deal with the particular problems of this project, namely:
- the distribution of the development team across several countries
- the necessity of carrying out task analysis, knowledge extraction and usability evaluation in different countries by non-expert practitioners
- the need to carry out knowledge extraction, evaluation and development in parallel.

In addition we have identified a required set of recommendations for internationalising an interface, and have discussed some of the problems inherent in managing this type of project.

The problems identified are not unique and are likely to be experienced to a greater or lesser extent in any collaborative project, particularly where partners are from different countries and different disciplines and have not worked together before.

7.0 References

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