Feasibility Analysis for Web Project Engineering Encoded as Rule-Based Expert System

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Abstract

The initial steps in carrying out a feasibility analysis for a web project, based on information obtained interactively from a prospective client, are modelled as a rule-based expert system that draws on empirical formulas to provide a quantitative valuation of the clients replies. The model is centred in the pre-design phase, concerned in particular with ascertaining whether coherent aims, message, audience and services have been identified for the web project. The model is constructed empirically by means of a knowledge acquisitions process. The various data collected from the user are described, as well as the way in which these data are translated into quantitative values that subsequently play a role in the final diagnose for the web project. The system has been evaluated in two ways: system users were asked to provide feedback, and the experts who took part in the knowledge acquisition phase were asked to review system performance.

1. Introduction

In the last few years there has been a great boom in the construction of web pages for a very wide spectrum of clients: newspapers, museums, airlines, train services, local authorities, travel agents, car dealers, real estate agencies, bookshops, artists, associations... The urgency of the demand and the innovative nature of most of the work have resulted in development processes that diverge from accepted practice in general software development. An important part of the work carried out so far did not take into account any specific aims - beyond having a presence on the web - and did not consider whether a service of some sort was to be provided. Projects undertaken under these circumstances generally fulfil no aim and provide no service, and users stay away from them. Companies perceive no significant improvement in their results and soon come to disregard the innovation.

Web developers and their clients must carry out initial feasibility studies in order to decide whether a project is worth attempting or not. A crucial ingredient is to identify the aims that the project sets out to achieve and the services it intends to provide. Current practice among commercial web developers shows an important concern in this direction.

The present paper refines an attempt to build an expert system for the feasibility analysis of web site projects. Of all the stages of a feasibility study, it targets the critical first step of evaluating whether the project will meet the client's objectives. Section 2 sketches the issues involved in web feasibility analysis, and presents previous attempts at modelling the complete process. Section 3 presents an expert system for the evaluation of satisfaction of objectives. This expert system relies on quantitative modelling of relevant parameters to support its rule-based decisions. Section 4 discusses the evaluation of the prototype and section 5 presents some general conclusions and further work.

2. Feasibility analysis for web site projects

The general concept of feasibility is associated with projects of al kinds (housing, marketing, ecological, scientific, industrial...), and specifically bound to an engineering approach to project development. Whenever a project of any kind is to be carried out systematically, through careful consideration and - wherever possible - measurement of the parameters involved, a feasibility study becomes an integral part of the project work. In the field of software development, due mainly to conceptual difficulties in identifying the right parameters to measure, this engineering approach has been slow to take hold [22]. Web development, as a related sub-field, has suffered from the same problem.

An important question to be taken into account is that a feasibility study should be relatively cheap and quick, and it should inform the decision of whether to go ahead with a more detailed analysis. The input to a feasibility study is an outline description of the system and how it will be used within an organisation, and the result should be a report that recommends whether or not it is worth carrying on with the development of the project.

A more general description of the aims of a feasibility study is found in Putnam and Myers [23], where it is defined as a having to cover four different dimensions:

- technology (whether the project is technically feasible given the prevailing state of the art)
- finance (whether it is financially feasible within cost and budget envisaged by the client)
- time (whether it will beat the competition to the market)
- resources (whether the organisation has the required resources to attempt the project)

An important aspect is to consider the risks that would make the project infeasible. According to Sommerville [24], a feasibility study aims to answer certain questions:

1. Does the system contribute to the overall objectives of the organisation?
2. Can it be implemented within current technology and within given cost and schedule constraints?
3. Can it be integrated with other systems that are already in place?

Of these, the first question is considered critical. The most common cause for organisations developing systems that do not contribute to their objectives is not having a clear statement of these objectives to start with.

A feasibility study involves information assessment (identify information required to answer the three questions), information collection (question information sources to discover the answers), and report writing (make a recommendation about whether or not the system development should continue; propose changes to the scope, budget and schedule; suggest further high-level requirements for the system).

The relevant information sources for acquiring the necessary information may include managers of departments where the system will be used, software engineers who are familiar with the type of system that is proposed, technology experts, end-users of the system.

2.1. Software engineering issues in web development

The current boom in web development took place at a time when there was already an important body of work on software engineering, and when generally accepted best practices in software development had already been adopted in many industrial and commercial contexts. However, existing software engineering techniques and best practices for software development have had little impact on web development so far. Researchers agree that the development of hypermedia and web applications is usually *ad hoc* [12], web site development is usually carried out without following a well-defined process [11, 20], and most current WWW site development and management practices rely only on the developer's knowledge and expertise [11]. Although there has been an increasing interest in design methods, models, and techniques for hypermedia applications, the process by which hypermedia applications can or should be developed has been at least partially overlooked. At best, existing predefined processes have been adapted to fit the new problems, or individual stages of development have been studied in the absence of a generic process specifically tailored to the general problem [20].

This lack of uptake in the context of web development, happening at a time when software engineering is universally accepted in the development of other kinds of software, can be explained by the existence of important differences in the nature of the development of hypermedia and the development of software. Due to these differences, simply transposing processes from more traditional software engineering may not be adequate, since each type of development will require substantially different processes.

The following fundamental differences between are considered relevant to the need for specific software engineering processes for web development:

1. In hypermedia systems the designer has much less initial information about the user, and less control over user actions [19]

2. Traditional software methodologies turn out to be inadequate for the development of hypermedia applications, because they do not address aesthetic and cognitive aspects that are especially relevant for an effective hypermedia design [21]

3. People with very different skills (content experts, user-interface designers, programmers, graphic designers, etc.) are involved in hypermedia development [19, 20]

4. Hypermedia development is more communication intensive than software development [20]

5. Due to fierce competition on the WWW, web site development under continuous pressure to take up the latest technological options, and to continuously update content [16]

6. Traditional software systems have relatively well defined development and release cycles, and they are maintained in well-structured increments, whereas Web sites have an initial development up to the point where they are first released, and then further development is carried out in a complex combination of fine-grained and almost constant modifications, more substantial structural changes, and possibly even occasional complete overhauls and re-releasing. [20, 11]

7. the non-linearity of the hyperdocuments and the ease of connection to other web applications makes it easy for the user to get lost [19]

All of these issues must be taken into account when trying to apply existing software engineering techniques to web site development. The corresponding techniques must be carefully revised and adapted to suit the different conditions. For our present purposes, differences 1 and 2 make it necessary to develop particular techniques for carrying out feasibility studies for web projects.

The last few years have seen an important advance in the number of methodologies for hypermedia development put forward to address some of these issues. However, most of these methodologies do not address early and late lifecycle activities, such as project management, feasibility studies, requirement analyses, planning, evaluation and maintenance [12].

A number of methodologies for hypermedia and Web development published in the last few years are reviewed in [19]. Of the 10 methodologies reviewed, only two cover the whole development process, all the others focusing mostly on the design workflow. Nonetheless, some of the issues addressed are relevant to the current endeavour.

In particular, WSDM (Web Site Design Method) [13] devotes a special phase to modelling the potential users/visitors of the Web site, identifying them according to their interests and navigational preferences.

Another methodology, RNA (Relationship-Navigational Analysis) [10] includes a stage of *stakeholder analysis*, where the application's audience is identified.

Finally, the MacWeb approach [21] concerns itself with the creative aspects involved in the hypermedia development processes, adding to the traditional stages dealt with in other methodologies and orthogonal *mental process*, dedicated to the complex task of generating the right contents with the required structure.

The importance attached in these methodology to providing the designer with adequate information about the intended users, and modelling the process of designing the content of the web site, suggests that work upon these two ingredients should be reinforced during the initial stages of the development lifecycle. The technique employed for feasibility studies in the system presented in this paper addresses these two issues and some other aspects considered important by the interviewed experts.

2.2. A brief survey of current practice

In order to obtain a picture of how often feasibility studies are considered an integral part of the process in professional web development an informal survey was carried out. An additional aim was to register whether any specific company offered the possibility of carrying out an initial feasibility analysis for web projects over the web, and, if so, to study the parameters it considered and the formulation it chose for its results.

The initial sample was obtained by querying a search engine [1] with various combinations of words related to web project development (web, page, site, development, consulting). Of the results obtained - restricted to the first 50 pages of results -, those identified as web developers were manually checked for mentions of feasibility studies in the generic description of their business. Of all these, nine mentioned feasibility studies in some way (Houck & Associates [4], NET ability, Inc. [7], Acme Internet [1], Fowler Software Design LLC [3], Meridian Systems Management Co., Inc. [6], AlterCom [2], Mark Services [5], Tech Direct [8], Teleteria [9])[2].

The breakdown of the specific approaches taken in each of these cases is as follows:

1. one (Acme Internet) only mentions feasibility studies as a task to be carried out, without providing any description of it.

2. two (Fowler Software Design LLC; AlterCom) describe briefly the types of discussion involved in a feasibility study

[1] http://www.google.com

[2] For readability, the corresponding URLs are listed as references under the company name.

3. four (NETability; Houck & Associates; Meridian Systems Management Co., Inc; Mark Services) devote a special section to describing in detail the issues involved in web feasibility

4. two (Teleteria; Tech Direct) actually provide forms to be filled in by the client, collecting relevant information for an initial assessment of feasibility.

In all reviewed cases but one, the process of obtaining a judgement on the feasibility of the proposed project is left to human experts. These experts either actually interview the client (cases in groups 1, 2 and 3), or ponder the information provided before arriving at a decision (those in group 4 except for Teleteria). Only in one case did the web page in question automatically provide an answer (Teleteria, in reply to a test presented as a web form).

In general terms, according to Sommerville's description of feasibility studies as taking place in three phases we can say that:

- phase one (information assessment) has been partially formalised - as a set of relevant issues to be considered - in six out of nine of the reviewed cases
- phase two (information collection) has been formalised - as forms to be filled in by the client - only in two out of the nine cases
- phase three (report writing) has been formalised only in one out of the nine cases

In the only case where the complete process has been formalised in some way (Teleteria) results are presented as a score for the proposed project. This score is compared with a range from 0 to 40 that indicates the appropriateness of the project in terms of the question "Is the web for you?": 0-10 (may be not), 10-20 (not essential), 20-30 (good complement), 30-40 (significant opportunity).

In some cases, the process of evaluating feasibility at the preliminary stage can be automated in terms of simple parameters. However, the sketchiness of the results provided in such cases suggests that a lot of the expertise that operates behind the judgement of a human expert has not been brought to bear on the issue. If the feasibility question were to be addressed automatically in greater detail, more powerful technologies for knowledge representation would have to be engaged.

2.3. An expert system for determining web project feasibility

Knowledge-based systems technology [18] is a well tested approach to capturing expertise in terms of declarative rules that has proved it is worth through many years of success stories. The applicability of this technology to the issue of web project feasibility analysis has been shown in the past [17, 14]. The expert systems designed in these cases were based on JESS, the Java Expert System Shell [15]. This technology adapts the traditional rule-based paradigm for development in client/server web environments. The information assessment phase of these systems, carried out by means of knowledge acquisition interviews with professional web consultants, had isolated a set of parameters as relevant to the issue: message intended, aims, intended audience, services to be provided, planning aspects already considered by the client.

The information collection phase was carried out by means of a question answer dialogue through a graphical web interface. As a result of this phase, ordered lists of the following relevant parameters were made available to the system: messages, aims, audiences, services, considered planning aspects.

The report writing phase resulted in the generation of a printed report containing the intermediate data collected together with a final judgement out of the following list of possibilities: not feasible, needs refining, inconsistent specifications, mismatch between demands and resources, design specifications missing, and feasible.

An important conclusion of this work concerned the complexity of reasoning involved in this type of analysis: a large number of parameters were involved, with several possible interactions between them. Additionally, the number of intermediate conclusions that experts drew from these original data was almost as large as the original data set. This suggested that the process might be more fruitfully dealt with in smaller steps. As a result, the present paper focuses on modelling only the task of deciding whether the intended web project will fulfil the company's objectives. This task is considered critical and it should be addressed before other tasks are attempted.

3. Feasibility at the pre-design stage

The general process of analysing the feasibility of a web project is divided into two different sub-tasks: a pre-design stage, and a subsequent design stage. The pre-design phase deals with issues related with the general aims to be served by the web project. The design phase is concerned with particular details about how the aims will be achieved.

The pre-design stage is intended to provide a specific declaration of purpose for the project. This is later used as guideline for the rest of the analysis. It is centred on discovering the user's intentions regarding the specific aims that the web project will address, the type of audience that it will try to reach, and the general services that it will provide.

More specific issues like choice of content, content format, content structure, and constraints on the server are postponed to the design stage. This way of dividing the process arises from a conviction that the issues assigned to the design stage ought not to be considered at all until the user has a very clear idea of what this replies to the issues at the pre-design stage are.

3.1. Expert Judgement on the Pre-Design Phase

The knowledge acquisition effort carried out for the complete process of feasibility analysis had shown a number of possible answers:

1. Not feasible, fundamental aspect missing
2. Needs refining. Specific aspects are unclear
3. Inconsistent specifications
4. Mismatch between demands and resources
5. Design specifications missing, or
6. Feasible.

Of these, only 1, 2 and 6 affect the issue of prospective satisfaction of client's objectives. With respect to the required data to reach a decision, the experts isolated the following parameters as relevant:

- any message that the web site should communicate
- any objectives that should be met by the web site
- any intended audience at which the web site is addressed
- any services that the web site should provide

These data are collected through an interactive process of question and answer with the client. This process is controlled by the expert system to ensure that questions are only asked if their possible answers may have a discriminating effect on the outcome.

The experts also identified a number of trivial cases where the answer was straightforward. If the client is unaware of any message, objective or intended audience for his web site, the project is discarded. If the client has positive answers for all the required data, the project may be feasible, as long as it is not too ambitious. The main challenge for the system lay in determining the borderline between cases where the project definition needs refining and cases where it could be taken into the design phase.

In order to provide insights on this issue, the experts tried to identify whether any of the following were true of the envisaged project:

1	Advertising the firm
2	Providing information about products/services
3	Attracting clients
4	Help Desk
5	Transmitting a technological image
6	E-commerce
7	Order collection
8	Reducing costs of internal communication
9	Decision support
10	Others

Table 1. Basic aims for a web project

- it involves a web site carrying too many messages
- it pursues contradictory or unrelated objectives
- it tries to address either too many audiences or audiences that are not related
- it considers services unrelated to the objectives it should meet

These four issues are quantitatively modelled in the system to provide support for the decision rules.

3.2. Quantitative Modelling of Message Weight

The information collected about intended messages takes the form of a main message and an ordered list of additional messages. A complexity weight CW for the number of messages proposed by the user is calculated by means of a weighted formula 1. This complexity weight considers a weight W_m for the main message of the web site, and a smaller weight W_{si} for secondary messages [14].

$$CW = W_m + \sum_{i=1} nW_{si} \qquad (1)$$

An additional parameter to be determined is the threshold for message complexity over which the project becomes questionable. The actual weights are determined empirically by the experts.

3.3. Quantitative Modelling of Objective Consistency

A simplified approach has been chosen, whereby the user is asked to select possible aims for his project from the list given in table 1.

Two measures are defined to evaluate whether objects chosen by the client are contradictory or unrelated.

Prospective cost of objective fulfilment is calculated in terms of whether the chosen objectives are related. The proposed objectives are grouped into five families. For a given client choice there will be m families involved and n_m objectives from each family. The prospective cost PC is calculated using formula 2, where K_j is a constant assigned to family j.

$$PC = \sum_{j=1}^{m} \sum_{i=1}^{n_j} \frac{K_j}{i} \quad (2)$$

This corresponds to considering a logarithmic relation in the sense that the relative cost of adding objectives belonging to a family that is already represented in the client's choice decreases exponentially with the number of objectives of the same family already chosen.

Confidence in client's assessment of the objectives is defined in terms of whether known interrelations between the proposed objectives are taken into account in the client's choice. The interrelations between the objectives give rise to a directed graph where nodes represent objectives and edges represent a prerequisite relation between them. As a first approximation, the confidence value is calculated by adding the number of instances of edges of the graph for which the target node is present in the client's choice when the source node is not. This value is inversely proportional to the confidence in the client's assessment.

3.4. Quantitative Modelling of Audiences

The system gathers information about the main audience, and an ordered list of secondary audiences. Each audience is characterised roughly in terms of a set of seven sociological factors considered significant by the experts.

If the user provides more than one intended audience, the system requires him to establish priorities between them. Quantitative values are calculated for the relative similarity of the profiles.

The *degree of dispersion* of the intended audiences is not calculated numerically, but rather by using rules provided by the experts: under two types of audiences is considered good, three is acceptable, four is bad, and more than five is as bad as not having an intended audience.

A high degree of dispersion - too many target audiences - may be offset by having audiences that are very similar to one another.

The *similarity between two audience characterisations* is calculated by counting the number of sociological factors shared between them. The *average similarity between audience pairs* is used by the system to balance the degree of audience dispersion. This allows for cases where the client is being over zealous in his description of his audiences, describing as several groups what might have been described as a single group with common characteristics.

1	Product information
2	Chat
3	Mailing list subscription
4	Personalisation
5	Transactions
6	Site search
7	Related links
8	Information Harvesting on Possible Clients
9	Others

Table 2. Services provided by a web project

3.5. Quantitative Modelling of Services

The user is asked to select possible services to be provided by the project from the list given in table 2. If the user has selected several services, priorities are requested from him in the same way as was done for audiences. The system calculates additional confidence values based on a comparison between the aims selected at the earlier stage and the services chosen here. These confidence values are based on a graph similar to the one described for relations amongst objectives. This graph captures known dependencies between objectives and services, i.e. requiring the web site to provide transactions if the main objective is e-commerce.

The *confidence in the client's assessment of required services* is calculated by the same procedure described for objectives.

3.6. Arriving at a Final Decision

Based on the additional quantitative information described, the system discriminates between cases where the rules cannot provide a clear cut decision. This is done by taking the values obtained for the parameters described on the basis of the client's input. The rules that operate directly on the client's input are extended with additional rules which take into account the quantitative information. The quantitative values are used in conjunction with the rules to chose the correct diagnose for the web project.

4. Knowledge Acquisition and Evaluation

The current version of the system is intended as an initial prototype of the type of information that needs to be collected and the knowledge that bears upon it when deciding on the feasibility of a web project. To obtain the necessary initial knowledge, a knowledge acquisition process was carried out involving the web development experts of Rampholeon, a small software development company based in Madrid. This company has explicitly attempted to apply software engineering techniques to its commercial operations from its inception. As a result, company experts have

Result of feasibility study	% projects
Project not feasible	5.9
Part of the project to be subcontracted	35.3
Project split into smaller subprojects	58.8

Table 3. Results of feasibility studies at Rampholeon

Effort of feasibility study (in % of total)	Estimated effort of total project
9.5	100

Table 4. Ratio of effort saved for non-feasible projects

been involved in providing web development services for a few years and over these years had developed a set of techniques to address feasibility studies.

Company records at Rampholeon show that the feasibility studies they have carried out associated to their development projects over the last two years have had a significant impact on the subsequent development of projects. Table 3 shows the recorded results of feasibility studies in relation to the total number of projects.

For the cases where projects were considered to be not feasible and were abandoned, table 4 shows the ratio between the effort actually spent by developers and clients and the estimated development effort had the project been attempted. Since the result of the feasibility diagnosed the project as not feasible, all the effort saved would have been wasted had the feasibility study not been carried out in advance.

The effort invested in terms of knowledge acquisition for the present has been directed towards obtaining a general picture of the parameters involved in web site feasibility analysis. A set of systematic techniques for the quantitative analysis of these parameters is introduced, aimed at producing a useful judgement regarding the likelihood of a project being achievable. Various experts have been interviewed and their approach to web feasibility has been collected. The various sets of parameters deemed relevant have been collected, and the different quantitative techniques have been applied and combined over the whole set. In some cases, techniques initially suggested for one parameter have been applied to neighbouring parameters with similar behaviour or problems. Web development experts, who took part in the design process of the system, have also closely supervised this task of combination and cross-fertilisation between the expertise of different experts. The resulting process of feasibility analysis covers a wide range of types of projects, as described by different sets of objectives and services to be provided. It also takes into account a broad spectrum of client attitudes towards the project. One extreme is the complete outsider who has to conceive from scratch during his interaction with the system what he actually wants from his projects. The other extreme is the well-informed returning client who arrives with all the relevant information at his fingertips and has simply to type it in at the request of the system.

Although these considerations imply that the designed system is robust and has originated from reliable sources, it makes direct evaluation difficult.

The system has been evaluated in two ways. On one hand, users applying the system to their particular projects have been asked to provide feedback on the experience. On the other hand, the experts who took part in the knowledge acquisition phase were asked to review system performance and validate system judgements for a set of examples.

Users confronted with the system came up with comments along two different lines. The two main different reactions can be traced to different attitudes of the client to a project at its inception.

Users who did not have a fair idea of what they wanted their project to be were surprised at the amount of information that the system attempted to collect. Initial responses varied from “I don’ know - surely that information should be provided by the developer” to “I hadn’t thought of that but it’s a good point”. In general, most agreed that the system considers too much information at an early stage of the interaction with the client.

Users who were pretty clear about what they wanted found that the system was on the lookout for a lot of information that they had taken great pains to gather or identify as relevant, and were consequently impressed. However, because they already had the information arranged in their own minds, they tended to find the question-answer interface a bit cumbersome.

Validation of system judgements by the experts who partook in its design was generally positive. There were however two general observations in which there was overall agreement.

Experts found the system slightly lacking in initiative whenever a particular user reply clearly indicated - to their educated opinion - that no further dialogue would be useful unless the client devoted more time off-line to pondering what his aims really were. The system tended to carry on with its questioning regardless of the fact that the client was obviously unprepared for that degree of interaction.

Experts who had defended a particular technique in favour of others were initially dismissive of the dialogue fragments in which the system attempted to collect the information required for applying rival techniques. However, all were able to reach an agreement as soon as they had been allowed some time to discuss the issues at stake.

In general, evaluation indicates that the following observations should be considered when further developing the system:

- the system's information assessment phase should be narrowed down so that, having identified a particular type of problem, it concentrates on the collection of information specifically relevant to that problem during the next phase
- the system's information collection phase should refined in order to provide more agile means for users with a clear idea of what they want
- in view of expert disagreement, relevant judgements on the efficiency of the system have to be postponed until comparable data are available concerning final development or operation results for projects judged by both experts and the designed system

One possible refinement for the collection phase would be to provide an 'advanced user' alternative in terms of forms to fill. The system would switch to this mode of operation when enough positive feedback is received from the user. It would return from this mode when the user is unable to fill in too many of the requested fields.

5. Conclusions

Validating appropriate objectives for a web site project is a crucial stage in determining its feasibility. Encoding the decision mechanisms involved in this process is a useful first approximation to modelling feasibility analysis in general. The system presented here addresses this in terms of refining a rule-based decision process by defining quantitative parameters to provide additional information. These quantitative parameters capture expert intuitions and model complex interrelations between the input data. They are subsequently considered as input for further expert-designed rules that provide a diagnose. In general, the two evaluation procedures followed (user satisfaction and expert validation) yielded reasonable results, taking into account the corresponding noise factors. Some users disliked being brought down from their dream of Internet magic for their enterprise. Experts who saw their own method downplayed by the final system tended to be dismissive of the application.

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