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Abstract. This paper discusses the need for a systematic framework which can be used to analyse software processes and derive process models. We propose the idea of process viewpoints which have associated process models and which incorporate questions about process and potential process improvement. The questions associated with each process viewpoint are derived from organisational concerns which must be explicitly identified. This work has been carried out in the context of a project which is investigating approaches to requirements engineering process improvement.

1   Introduction

Over the last ten years, the software process community has focused its attention on the development of process models, process modelling formalisms and methods of enacting these process models to support the development process. Less attention has been paid to the problem of discovering the actual process models which are used. It has been generally assumed that it is relatively straightforward to understand existing processes (although it is recognised that these processes may be complex) and that the principal problems lie in producing realistic models of these processes.

We note a parallel here with the requirements engineering community who based their work for many years on the idea that system requirements were simply floating around to be 'captured' and used as the basis of a system model. We now realise that understanding and discovering system requirements is a very difficult process which is far removed from the idea of fishing in a sea of readily available requirements. We suggest that if informal and unstructured approaches are used to analyse software processes and derive process models, these are unlikely to be successful. Rather, we need to derive systematic approaches to discovering the actual processes used in an organisation and their relationships. The Elicit approach [1] is an example of one of the few systematic approaches which have been developed for process understanding.

The need for a systematic approach to process understanding was confirmed by a number of empirical studies of software processes which we carried out in a number of organisations [2](Rodden, King et al., 1994 [3]). We discovered that different participants in the process were working to different process models. We believe that this finding goes some way towards explaining the 'non-conformance' to process models which is very obvious in many organisations. It is not that a published or standardised process model is necessarily incorrect. It is simply that the process model represents only one particular model (usually that of management). Non-conformance to this model reflects the fact that other process participants are working to some different (but not necessarily less 'correct') model.

We do not believe that this problem of non-conformance can be solved by finding a single, all-encompassing model which is acceptable to all who have a

direct or indirect interest in the process. Rather, we should accept that multiple process models exist and we should focus on discovering these models and, where appropriate, reconciling them. This is particularly important if a process is to be supported by some process technology or if process improvements are proposed. If improvement proposals do not apply across the different models held by process stakeholders, they are unlikely to be successful.

Ethnographic studies can provided useful insights into software processes but we discovered that they were not the best approach to deriving models of parts of the process. The duration of software processes is too long for ethnographic analysis to cost-effective. We concluded that ethnographic studies had a role to play in process understanding but only if they were used in conjunction with some more systematic framework. This framework should capture the diverse process models held by different process stakeholders and act as a starting point for reconciling these models and improving software processes.

We propose that we should explicitly identify process viewpoints and associate one or more process models with each of these viewpoints. The notion of process viewpoints which we are developing has been influenced by Basili and Rombach's GQM (Goals-Questions-Metrics) approach to process improvement [4] and by work on viewpoints for software requirements elicitation and analysis [5-7].

A process viewpoint is an encapsulated process description which incldues a process model, the sources of model information, and the questions which were posed to derive that process model. These questions may be derived from organisational considerations which are common to all viewpoints. These organisational considerations may be specific process activities such as 'the design activity' or may be related to process attributes such as cost or product quality. We call these organisational considerations 'concerns'. The notion of a concern is a critical one and we discuss it in more detail later in the paper.

Concerns are used to stimulate the generation of process questions which may be specific to a particular process viewpoint or which may be posed to all viewpoints. Process questions fall into two principal classes, with some overlap between them:

1. *Exploratory questions* These are intended to discover information about the process which is being studied. The answers to these questions influence the process models associated with a viewpoint. An example of an exploratory question associated with a cost concern (say) would be 'what mechanisms are incorporated in the process to monitor the costs of project activities'.

2. *Improvement questions* These are intended to discover what is required to effect improvement in the process. The answers to these questions should help identify process revisions. An example of an improvement question might be 'how can we reduce the time required to review documents'. Answering improvement questions may result in the creation of new process models.

Process questions are used to drive the process analysis. Answers to these questions may be discovered either by explicitly asking process stakeholders or by observation, studies of process documentation and other material. The process models or associated information (such as process rationale) which are derived should reflect the answers to the questions associated with the process viewpoint.

We are currently applying this approach to studies of the requirements engineering process in two different organisations in a European project called REAIMS. The overall objective of REAIMS is to provide a framework for

requirements engineering process improvement. We are therefore concerned with deriving both exploratory and improvement questions about these processes.

2 A definition of process viewpoints

It has been recognised since the mid-1970s that top-down system analysis is simplistic and that the requirements for a system derive from many different sources. Each of these sources considers the system in different ways (e.g. the driver of a train looks at a signalling system in a different way from the train operating company). It is often the case that the system requirements derived from different sources are inconsistent and conflict in some way.

We argue that a comparable approach should be taken to understanding processes and that such a multi-perspective approach is likely to lead to a deeper understanding of the real process and the needs of the participants in that process. We believe that there is no such thing as a single software process model which will be accepted by all of the stakeholders in the process. Rather, we argue that there are different ways of looking at the process (viewpoints) with different associated process models.

We do not think it useful to consider these different process models to be views of some all-encompassing process model. While it may be possible to integrate all the separate models, the resulting overall model is likely to be so complex that it will be completely incomprehensible. It may never, therefore, be produce a 'complete' model of the process. We do not see this as a problem so long as we can define and manage interfaces between the different models held by different viewpoints.

We consider a process viewpoint to be an encapsulation of process information. It may be modelled as a septuple as follows:

Viewpoint = { Name, Scope, Models, Concerns, Organisational questions, Local questions, Sources }

Name

The name of a viewpoint is a meaningful term used to refer to the viewpoint.

Scope

The scope of a viewpoint is a specification of the limits of that viewpoint i.e. it defines the focus of a viewpoint on a particular process. For example, the scope of a viewpoint may be the accounting function. It would therefore be expected that associated models would focus on resource utilisation. An explicit identification of scope helps us to understand why models have been formulated in a particular way.

Models

A viewpoint may have one or more associated process models. These can be in any appropriate notation from natural language descriptions to formal mathematical text. This flexibility is essential as there is no single formal notation which could be understood by all viewpoints.

Concerns

Each viewpoint has an associated set of concerns which are used to drive the process of process understanding, modelling and improvement. Typical concerns might be cost reduction, improved time to delivery, increased process visibility, etc. Concerns must be addressed by all viewpoints.

Organisational questions

Each viewpoint has an associated set of organisational questions which must be addressed as part of the process modelling and improvement process. Organisational questions are those questions which constrain or influence local questions derived in a viewpoint. For example, an organisational question might be 'what is the relationship between all of the product development processes in the organisation'. Each viewpoint should then address this question and refine it to more specific local questions. Organisational questions are usually derived from local questions generated in other viewpoints.

Local questions

Each viewpoint has an associated set of local questions which may be refinements of the organisational questions or which may be separate questions in their own right. Local questions, therefore, may develop or reword organisational questions so that they are appropriately formulated for that viewpoint.

Sources

Each viewpoint has an associated set of sources (people or documents) which provide the information associated with the viewpoint. The explicit maintenance of sources allows us to trace information and to know who to negotiate with when conflicts and disagreements arise.

We classify viewpoints into two groups namely:

1. *Direct viewpoints* These are associated with participants in the process such as designers, programmers, test engineers, etc. Viewpoints, however, are not normally mapped on a 1-1 basis to roles. Rather, they would normally be associated with teams (e.g. a testing team) which may encompass a number of different roles.

2. *Indirect viewpoints* These are associated with organisations and customers who may influence the process used but who do not actively participate in it.

It is important to emphasise that viewpoints are ways of looking at a process and that the same person can look at a process in quite different ways. For example, project managers can consider a process from a technical (direct) viewpoint if they are interested in the activities undertaken by the project development team. They can also take an organisational (indirect) viewpoint when considering issues of process management.

The classification into direct and indirect viewpoints is useful because it recognises the inherent tension between user-centred models and organisational models. We know that published organisational process models often do not reflect reality. The actual process followed by software engineers is quite different from these published models. The question we seek to answer is why the organisational models are so different. By collecting both organisational and participant models, we hope to discover conflicts and discrepancies and hence understand the relationships between these different models.

3   Concerns

The notion of a concern is an important one and it is worth explaining it in a bit more detail here. Basically, a concern is an organisational issue which must be considered by all viewpoints irrespective of whether they are direct or indirect viewpoints. The term 'concern' is used intuitively in that an organisation may be *concerned* with issues such as the cost of a process, the design methods which are used or the interaction between different teams involved in the process. Of course, a viewpoint may decide that a particular concern is irrelevant but it should make and document this choice explicitly rather than simply ignore that concern.

Figure 1 shows the orthogonality of viewpoints and concerns. The actual enacted process is at the apex of the triangle so that as the viewpoint moves from the apex to the base, it becomes more and more remote from the process itself. However, remoteness is not the same as irrelevance. Indirect viewpoints often have much more political power than direct viewpoints or organisational viewpoints which are close to the process. Therefore, a large customer may mandate a process model which must be used (or which, at least, the organisation must appear to use) irrespective of the organisational models which are already in place.
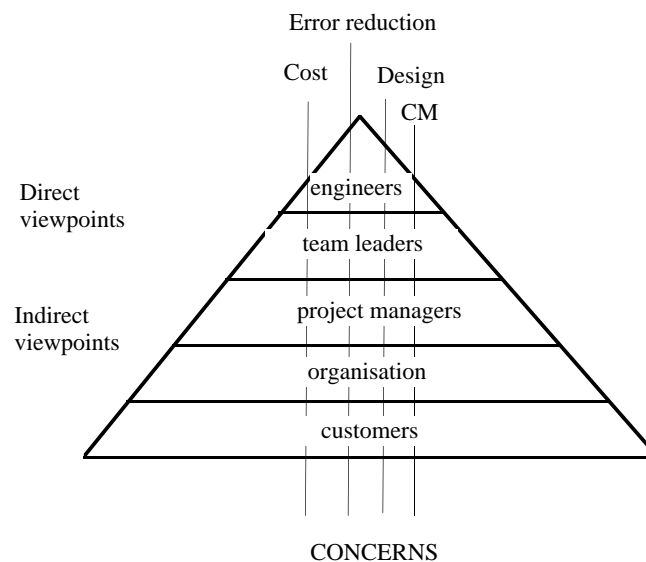

Figure 1 Viewpoints and concerns

There are two principal types of concern:

1. *Sub-processes* A concern is a particular sub-process. Examples of these concerns would be 'testing', 'design', 'configuration management', etc.

2. *'Non-functional' concerns* These are concerns such as cost, quality, time to delivery etc. They are not generally considered in isolation but in conjunction with other concerns.

For each-sub-process concern, each viewpoint may have an associated process model (Figure 2). Part of the analysis process considers each concern for all viewpoints and compares the process models. Discrepancies in these models

suggest potential process problems and misunderstandings between participants and process stakeholders.

Concerns are used to generate questions which may be either local questions or which may be broader questions concerning organisation issues. These broader organisational questions are exported from a viewpoint to all other viewpoints. Therefore, all viewpoints share a common set of organisational questions which are developed during an initial analysis. Because organisational questions do not all emerge at once, this means that the analysis process is necessarily iterative; as new organisational questions emerge, each viewpoint has to re-enter the analysis activity. Clearly, some tool support will be needed for this but we have not yet looked at what level of support can be economically provided.
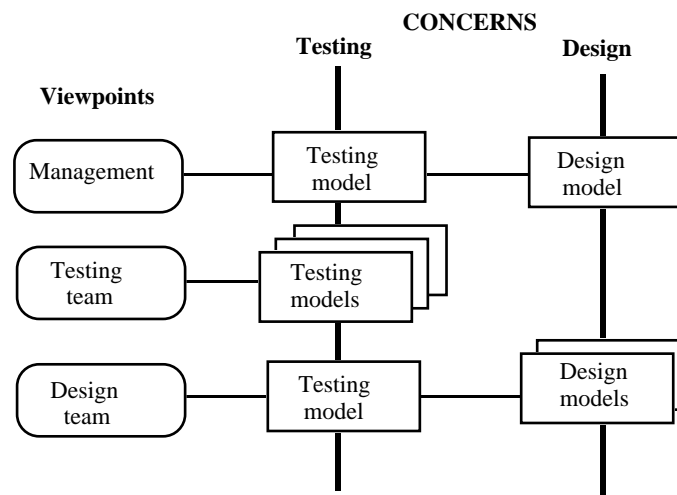

Figure 2 Concerns and models

As a general rule, all concerns should either be explicitly rejected by a viewpoint or should have at least one question associated with them. We have not yet developed a process for using the viewpoints approach but we anticipate that question generation from concerns will be a key part of this process.

4 Conclusions

The proposed approach to process analysis has been prompted by our previous empirical process studies which revealed considerable process complexity and diversity. They also revealed the high costs of these empirical studies and the difficulties of applying the output from these studies in an effective way. We have therefore developed this more structured approach which we hope will reduce the costs of analysis and provide us with more rapidly useable information.

The work described here is still at an early stage of development and we have not yet attempted to apply it to real process analysis. We are still developing the ideas of process viewpoints and plan to carry out the first experimental trials of these ideas in mid-1995. Our intention is firstly to carry out paper studies using process data derived from ethnographic analyses then to apply them in an industrial context in studies of the requirements engineering process.

5 Acknowledgements

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