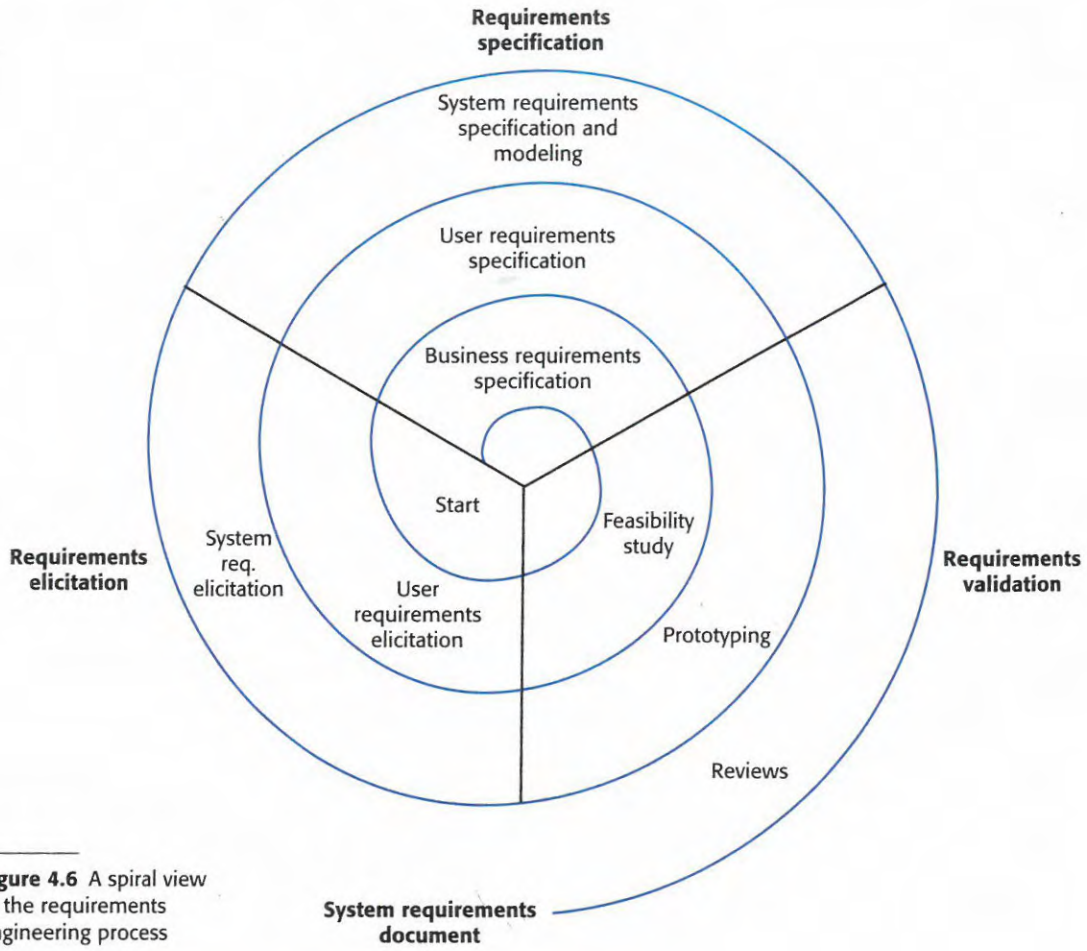

Figure 4.6 A spiral view of the requirements engineering process

4.3 Requirements elicitation

The aims of the requirements elicitation process are to understand the work that stakeholders do and how they might use a new system to help support that work. During requirements elicitation, software engineers work with stakeholders to find out about the application domain, work activities, the services and system features that stakeholders want, the required performance of the system, hardware constraints, and so on.

Eliciting and understanding requirements from system stakeholders is a difficult process for several reasons:

1. Stakeholders often don't know what they want from a computer system except in the most general terms; they may find it difficult to articulate what they want the system to do; they may make unrealistic demands because they don't know what is and isn't feasible.

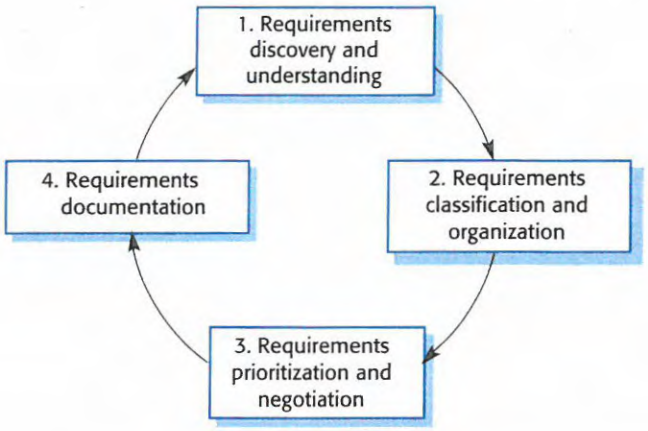

Figure 4.7 The requirements elicitation and analysis process

2. Stakeholders in a system naturally express requirements in their own terms and with implicit knowledge of their own work. Requirements engineers, without experience in the customer's domain, may not understand these requirements.
3. Different stakeholders, with diverse requirements, may express their requirements in different ways. Requirements engineers have to discover all potential sources of requirements and discover commonalities and conflict.
4. Political factors may influence the requirements of a system. Managers may demand specific system requirements because these will allow them to increase their influence in the organization.
5. The economic and business environment in which the analysis takes place is dynamic. It inevitably changes during the analysis process. The importance of particular requirements may change. New requirements may emerge from new stakeholders who were not originally consulted.

A process model of the elicitation and analysis process is shown in Figure 4.7. Each organization will have its own version or instantiation of this general model, depending on local factors such as the expertise of the staff, the type of system being developed, and the standards used.

The process activities are:

1. *Requirements discovery and understanding* This is the process of interacting with stakeholders of the system to discover their requirements. Domain requirements from stakeholders and documentation are also discovered during this activity.
2. *Requirements classification and organization* This activity takes the unstructured collection of requirements, groups related requirements and organizes them into coherent clusters.
3. *Requirements prioritization and negotiation* Inevitably, when multiple stakeholders are involved, requirements will conflict. This activity is concerned with prioritizing requirements and finding and resolving requirements conflicts

Viewpoints

A viewpoint is a way of collecting and organizing a set of requirements from a group of stakeholders who have something in common. Each viewpoint therefore includes a set of system requirements. Viewpoints might come from end-users, managers, or others. They help identify the people who can provide information about their requirements and structure the requirements for analysis.

http://www.software-engineering-book.com/web/viewpoints/

through negotiation. Usually, stakeholders have to meet to resolve differences and agree on compromise requirements.

4. *Requirements documentation* The requirements are documented and input into the next round of the spiral. An early draft of the software requirements documents may be produced at this stage, or the requirements may simply be maintained informally on whiteboards, wikis, or other shared spaces.

Figure 4.7 shows that requirements elicitation and analysis is an iterative process with continual feedback from each activity to other activities. The process cycle starts with requirements discovery and ends with the requirements documentation. The analyst's understanding of the requirements improves with each round of the cycle. The cycle ends when the requirements document has been produced.

To simplify the analysis of requirements, it is helpful to organize and group the stakeholder information. One way of doing so is to consider each stakeholder group to be a viewpoint and to collect all requirements from that group into the viewpoint. You may also include viewpoints to represent domain requirements and constraints from other systems. Alternatively, you can use a model of the system architecture to identify subsystems and to associate requirements with each subsystem.

Inevitably, different stakeholders have different views on the importance and priority of requirements, and sometimes these views are conflicting. If some stakeholders feel that their views have not been properly considered, then they may deliberately attempt to undermine the RE process. Therefore, it is important that you organize regular stakeholder meetings. Stakeholders should have the opportunity to express their concerns and agree on requirements compromises.

At the requirements documentation stage, it is important that you use simple language and diagrams to describe the requirements. This makes it possible for stakeholders to understand and comment on these requirements. To make information sharing easier, it is best to use a shared document (e.g., on Google Docs or Office 365) or a wiki that is accessible to all interested stakeholders.

4.3.1 Requirements elicitation techniques

Requirements elicitation involves meeting with stakeholders of different kinds to discover information about the proposed system. You may supplement this information

with knowledge of existing systems and their usage and information from documents of various kinds. You need to spend time understanding how people work, what they produce, how they use other systems, and how they may need to change to accommodate a new system.

There are two fundamental approaches to requirements elicitation:

1. Interviewing, where you talk to people about what they do.
2. Observation or ethnography, where you watch people doing their job to see what artifacts they use, how they use them, and so on.

You should use a mix of interviewing and observation to collect information and, from that, you derive the requirements, which are then the basis for further discussions.

4.3.1.1 Interviewing

Formal or informal interviews with system stakeholders are part of most requirements engineering processes. In these interviews, the requirements engineering team puts questions to stakeholders about the system that they currently use and the system to be developed. Requirements are derived from the answers to these questions. Interviews may be of two types:

1. Closed interviews, where the stakeholder answers a predefined set of questions.
2. Open interviews, in which there is no predefined agenda. The requirements engineering team explores a range of issues with system stakeholders and hence develops a better understanding of their needs.

In practice, interviews with stakeholders are normally a mixture of both of these. You may have to obtain the answer to certain questions, but these usually lead to other issues that are discussed in a less structured way. Completely open-ended discussions rarely work well. You usually have to ask some questions to get started and to keep the interview focused on the system to be developed.

Interviews are good for getting an overall understanding of what stakeholders do, how they might interact with the new system, and the difficulties that they face with current systems. People like talking about their work, and so they are usually happy to get involved in interviews. However, unless you have a system prototype to demonstrate, you should not expect stakeholders to suggest specific and detailed requirements. Everyone finds it difficult to visualize what a system might be like. You need to analyze the information collected and to generate the requirements from this.

Eliciting domain knowledge through interviews can be difficult, for two reasons:

1. All application specialists use jargon specific to their area of work. It is impossible for them to discuss domain requirements without using this terminology. They normally use words in a precise and subtle way that requirements engineers may misunderstand.

2. Some domain knowledge is so familiar to stakeholders that they either find it difficult to explain or they think it is so fundamental that it isn't worth mentioning. For example, for a librarian, it goes without saying that all acquisitions are catalogued before they are added to the library. However, this may not be obvious to the interviewer, and so it isn't taken into account in the requirements.

Interviews are not an effective technique for eliciting knowledge about organizational requirements and constraints because there are subtle power relationships between the different people in the organization. Published organizational structures rarely match the reality of decision making in an organization, but interviewees may not wish to reveal the actual rather than the theoretical structure to a stranger. In general, most people are generally reluctant to discuss political and organizational issues that may affect the requirements.

To be an effective interviewer, you should bear two things in mind:

1. You should be open-minded, avoid preconceived ideas about the requirements, and willing to listen to stakeholders. If the stakeholder comes up with surprising requirements, then you should be willing to change your mind about the system.
2. You should prompt the interviewee to get discussions going by using a springboard question or a requirements proposal, or by working together on a prototype system. Saying to people "tell me what you want" is unlikely to result in useful information. They find it much easier to talk in a defined context rather than in general terms.

Information from interviews is used along with other information about the system from documentation describing business processes or existing systems, user observations, and developer experience. Sometimes, apart from the information in the system documents, the interview information may be the only source of information about the system requirements. However, interviewing on its own is liable to miss essential information, and so it should be used in conjunction with other requirements elicitation techniques.

4.3.1.2 Ethnography

Software systems do not exist in isolation. They are used in a social and organizational environment, and software system requirements may be generated or constrained by that environment. One reason why many software systems are delivered but never used is that their requirements do not take proper account of how social and organizational factors affect the practical operation of the system. It is therefore very important that, during the requirements engineering process, you try to understand the social and organizational issues that affect the use of the system.

Ethnography is an observational technique that can be used to understand operational processes and help derive requirements for software to support these processes. An analyst immerses himself or herself in the working environment where

the system will be used. The day-to-day work is observed, and notes are made of the actual tasks in which participants are involved. The value of ethnography is that it helps discover implicit system requirements that reflect the actual ways that people work, rather than the formal processes defined by the organization.

People often find it very difficult to articulate details of their work because it is second nature to them. They understand their own work but may not understand its relationship to other work in the organization. Social and organizational factors that affect the work, but that are not obvious to individuals, may only become clear when noticed by an unbiased observer. For example, a workgroup may self-organize so that members know of each other's work and can cover for each other if someone is absent. This may not be mentioned during an interview as the group might not see it as an integral part of their work.

Suchman (Suchman 1983) pioneered the use of ethnography to study office work. She found that actual work practices were far richer, more complex, and more dynamic than the simple models assumed by office automation systems. The difference between the assumed and the actual work was the most important reason why these office systems had no significant effect on productivity. Crabtree (Crabtree 2003) discusses a wide range of studies since then and describes, in general, the use of ethnography in systems design. In my own research, I have investigated methods of integrating ethnography into the software engineering process by linking it with requirements engineering methods (Viller and Sommerville 2000) and documenting patterns of interaction in cooperative systems (Martin and Sommerville 2004).

Ethnography is particularly effective for discovering two types of requirements:

1. Requirements derived from the way in which people actually work, rather than the way in which business process definitions say they ought to work. In practice, people never follow formal processes. For example, air traffic controllers may switch off a conflict alert system that detects aircraft with intersecting flight paths, even though normal control procedures specify that it should be used. The conflict alert system is sensitive and issues audible warnings even when planes are far apart. Controllers may find these distracting and prefer to use other strategies to ensure that planes are not on conflicting flight paths.
2. Requirements derived from cooperation and awareness of other people's activities. For example, air traffic controllers (ATCs) may use an awareness of other controlles' work to predict the number of aircraft that will be entering their control sector. They then modify their control strategies depending on that predicted workload. Therefore, an automated ATC system should allow controllers in a sector to have some visibility of the work in adjacent sectors.

Ethnography can be combined with the development of a system prototype (Figure 4.8). The ethnography informs the development of the prototype so that fewer prototype refinement cycles are required. Furthermore, the prototyping focuses the ethnography by identifying problems and questions that can then be discussed with the ethnographer. He or she should then look for the answers to these questions during the next phase of the system study (Sommerville et al. 1993).

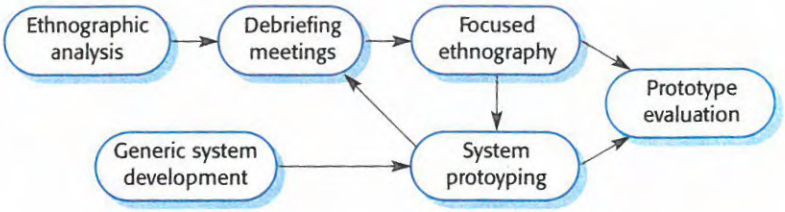

Figure 4.8 Ethnography and prototyping for requirements analysis

Ethnography is helpful to understand existing systems, but this understanding does not always help with innovation. Innovation is particularly relevant for new product development. Commentators have suggested that Nokia used ethnography to discover how people used their phones and developed new phone models on that basis; Apple, on the other hand, ignored current use and revolutionized the mobile phone industry with the introduction of the iPhone.

Ethnographic studies can reveal critical process details that are often missed by other requirements elicitation techniques. However, because of its focus on the end-user, this approach is not effective for discovering broader organizational or domain requirements or for suggestion innovations. You therefore have to use ethnography as one of a number of techniques for requirements elicitation.

4.3.2 Stories and scenarios

People find it easier to relate to real-life examples than abstract descriptions. They are not good at telling you the system requirements. However, they may be able to describe how they handle particular situations or imagine things that they might do in a new way of working. Stories and scenarios are ways of capturing this kind of information. You can then use these when interviewing groups of stakeholders to discuss the system with other stakeholders and to develop more specific system requirements.

Stories and scenarios are essentially the same thing. They are a description of how the system can be used for some particular task. They describe what people do, what information they use and produce, and what systems they may use in this process. The difference is in the ways that descriptions are structured and in the level of detail presented. Stories are written as narrative text and present a high-level description of system use; scenarios are usually structured with specific information collected such as inputs and outputs. I find stories to be effective in setting out the "big picture." Parts of stories can then be developed in more detail and represented as scenarios.

Figure 4.9 is an example of a story that I developed to understand the requirements for the iLearn digital learning environment that I introduced in Chapter 1. This story describes a situation in a primary (elementary) school where the teacher is using the environment to support student projects on the fishing industry. You can see this is a very high-level description. Its purpose is to facilitate discussion of how the iLearn system might be used and to act as a starting point for eliciting the requirements for that system.

Photo sharing in the classroom

Jack is a primary school teacher in Ullapool (a village in northern Scotland). He has decided that a class project should be focused on the fishing industry in the area, looking at the history, development, and economic impact of fishing. As part of this project, pupils are asked to gather and share reminiscences from relatives, use newspaper archives, and collect old photographs related to fishing and fishing communities in the area. Pupils use an iLearn wiki to gather together fishing stories and SCRAN (a history resources site) to access newspaper archives and photographs. However, Jack also needs a photo-sharing site because he wants pupils to take and comment on each other's photos and to upload scans of old photographs that they may have in their families.

Jack sends an email to a primary school teachers' group, which he is a member of, to see if anyone can recommend an appropriate system. Two teachers reply, and both suggest that he use KidsTakePics, a photo-sharing site that allows teachers to check and moderate content. As KidsTakePics is not integrated with the iLearn authentication service, he sets up a teacher and a class account. He uses the iLearn setup service to add KidsTakePics to the services seen by the pupils in his class so that when they log in, they can immediately use the system to upload photos from their mobile devices and class computers.

Figure 4.9 A user story for the iLearn system

The advantage of stories is that everyone can easily relate to them. We found this approach to be particularly useful to get information from a wider community than we could realistically interview. We made the stories available on a wiki and invited teachers and students from across the country to comment on them.

These high-level stories do not go into detail about a system, but they can be developed into more specific scenarios. Scenarios are descriptions of example user interaction sessions. I think that it is best to present scenarios in a structured way rather than as narrative text. User stories used in agile methods such as Extreme Programming, are actually narrative scenarios rather than general stories to help elicit requirements.

A scenario starts with an outline of the interaction. During the elicitation process, details are added to create a complete description of that interaction. At its most general, a scenario may include:

1. A description of what the system and users expect when the scenario starts.
2. A description of the normal flow of events in the scenario.
3. A description of what can go wrong and how resulting problems can be handled.
4. Information about other activities that might be going on at the same time.
5. A description of the system state when the scenario ends.

As an example of a scenario, Figure 4.10 describes what happens when a student uploads photos to the KidsTakePics system, as explained in Figure 4.9. The key difference between this system and other systems is that a teacher moderates the uploaded photos to check that they are suitable for sharing.

You can see this is a much more detailed description than the story in Figure 4.9, and so it can be used to propose requirements for the iLearn system. Like stories, scenarios can be used to facilitate discussions with stakeholders who sometimes may have different ways of achieving the same result.

Uploading photos to KidsTakePics

Initial assumption: A user or a group of users have one or more digital photographs to be uploaded to the picture-sharing site. These photos are saved on either a tablet or a laptop computer. They have successfully logged on to KidsTakePics.

Normal: The user chooses to upload photos and is prompted to select the photos to be uploaded on the computer and to select the project name under which the photos will be stored. Users should also be given the option of inputting keywords that should be associated with each uploaded photo. Uploaded photos are named by creating a conjunction of the user name with the filename of the photo on the local computer.

On completion of the upload, the system automatically sends an email to the project moderator, asking them to check new content, and generates an on-screen message to the user that this checking has been done.

What can go wrong: No moderator is associated with the selected project. An email is automatically generated to the school administrator asking them to nominate a project moderator. Users should be informed of a possible delay in making their photos visible.

Photos with the same name have already been uploaded by the same user. The user should be asked if he or she wishes to re-upload the photos with the same name, rename the photos, or cancel the upload. If users choose to re-upload the photos, the originals are overwritten. If they choose to rename the photos, a new name is automatically generated by adding a number to the existing filename.

Other activities: The moderator may be logged on to the system and may approve photos as they are uploaded.

System state on completion: User is logged on. The selected photos have been uploaded and assigned a status "awaiting moderation." Photos are visible to the moderator and to the user who uploaded them.

Figure 4.10 Scenario for uploading photos in KidsTakePics

4.4 Requirements specification

Requirements specification is the process of writing down the user and system requirements in a requirements document. Ideally, the user and system requirements should be clear, unambiguous, easy to understand, complete, and consistent. In practice, this is almost impossible to achieve. Stakeholders interpret the requirements in different ways, and there are often inherent conflicts and inconsistencies in the requirements.

User requirements are almost always written in natural language supplemented by appropriate diagrams and tables in the requirements document. System requirements may also be written in natural language, but other notations based on forms, graphical, or mathematical system models can also be used. Figure 4.11 summarizes possible notations for writing system requirements.

The user requirements for a system should describe the functional and nonfunctional requirements so that they are understandable by system users who don't have detailed technical knowledge. Ideally, they should specify only the external behavior of the system. The requirements document should not include details of the system architecture or design. Consequently, if you are writing user requirements, you should not use software jargon, structured notations, or formal notations. You should write user requirements in natural language, with simple tables, forms, and intuitive diagrams.