Chapter 4 – Requirements Engineering

Topics covered

- ✧ Functional and non-functional requirements
- ✧ Requirements engineering processes
- ✧ Requirements elicitation
- ✧ Requirements specification
- ✧ Requirements validation
- ✧ Requirements change

Requirements engineering

- ✧ The process of establishing the services that a customer requires from a system and the constraints under which it operates and is developed.
- ✧ The system requirements are the descriptions of the system services and constraints that are generated during the requirements engineering process.

What is a requirement?

- ✧ It may range from a high-level abstract statement of a service or of a system constraint to a detailed mathematical functional specification.
- ✧ This is inevitable as requirements may serve a dual function
  - May be the basis for a bid for a contract - therefore must be open to interpretation;
  - May be the basis for the contract itself - therefore must be defined in detail;
  - Both these statements may be called requirements.

Requirements abstraction (Davis)

The term requirement is not used consistently in the software industry

"If a company wishes to let a contract for a large software development project, it must define its needs in a sufficiently abstract way that a solution is not pre-defined. The requirements must be written so that several contractors can bid for the contract, offering, perhaps, different ways of meeting the client organization's needs. Once a contract has been awarded, the contractor must write a system definition for the client in more detail so that the client understands and can validate what the software will do. Both of these documents may be called the requirements document for the system."

Types of requirement

- ✧ User requirements
  - Statements in natural language plus diagrams of the services the system provides and its operational constraints. Written for customers.
- ✧ System requirements
  - A structured document setting out detailed descriptions of the system's functions, services and operational constraints. Defines what should be implemented so may be part of a contract between client and contractor.

User and system requirements

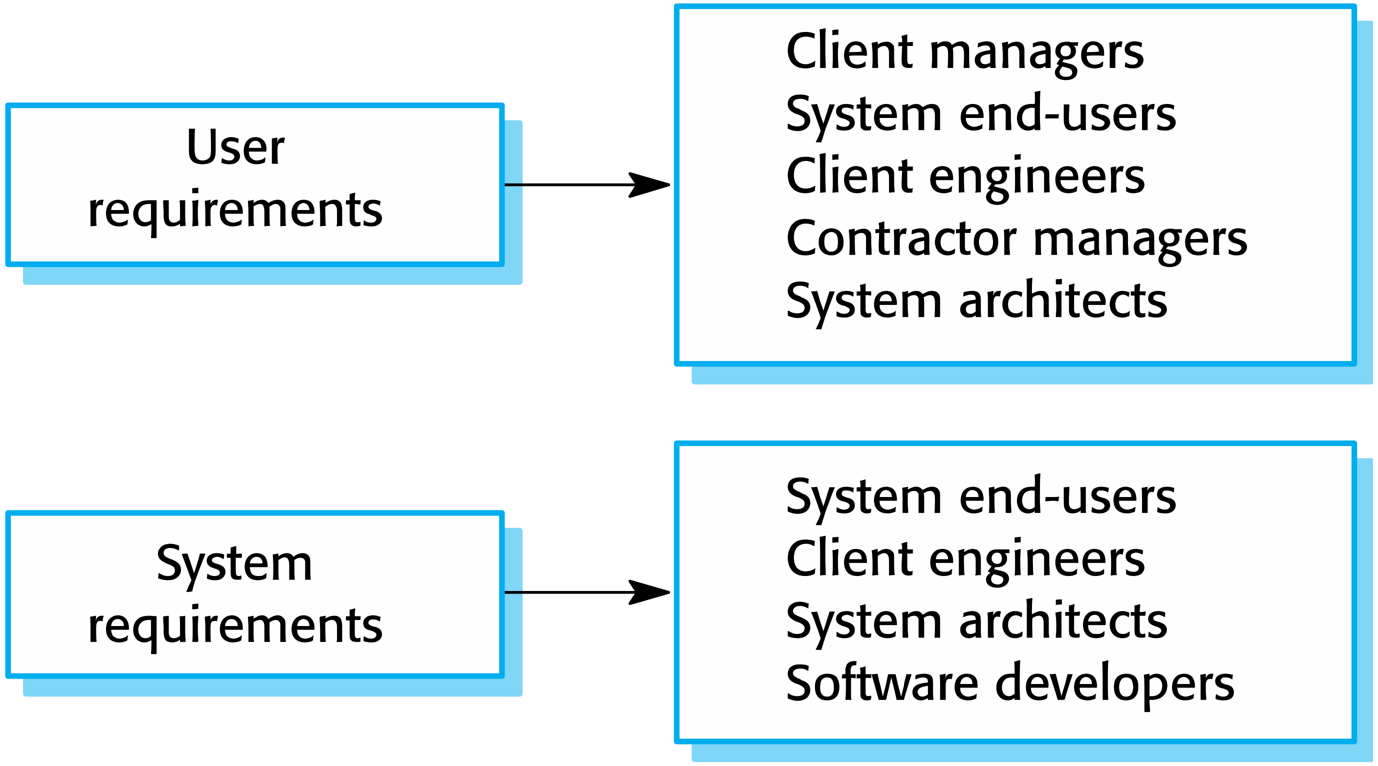
User requirements definition

1. The Mentcare system shall generate monthly management reports showing the cost of drugs prescribed by each clinic during that month.

System requirements specification

1.1 On the last working day of each month, a summary of the drugs prescribed, their cost and the prescribing clinics shall be generated.
1.2 The system shall generate the report for printing after 17.30 on the last working day of the month.
1.3 A report shall be created for each clinic and shall list the individual drug names, the total number of prescriptions, the number of doses prescribed and the total cost of the prescribed drugs.
1.4 If drugs are available in different dose units (e.g. 10mg, 20mg, etc) separate reports shall be created for each dose unit.
1.5 Access to drug cost reports shall be restricted to authorized users as listed on a management access control list.

Readers of different types of requirements specification



System stakeholders

- ✧ Any person or organization who is affected by the system in some way and so who has a legitimate interest
- ✧ Stakeholder types
  - End users
  - System managers
  - System owners
  - External stakeholders

Stakeholders in the Mentcare system

- ✧ Patients whose information is recorded in the system.
- ✧ Doctors who are responsible for assessing and treating patients.
- ✧ Nurses who coordinate the consultations with doctors and administer some treatments.
- ✧ Medical receptionists who manage patients' appointments.
- ✧ IT staff who are responsible for installing and maintaining the system.

Stakeholders in the Mentcare system

- ✧ A medical ethics manager who must ensure that the system meets current ethical guidelines for patient care.
- ✧ Health care managers who obtain management information from the system.
- ✧ Medical records staff who are responsible for ensuring that system information can be maintained and preserved, and that record keeping procedures have been properly implemented.

Agile methods and requirements

- ✧ Many agile methods argue that producing detailed system requirements is a waste of time as requirements change so quickly.
- ✧ The requirements document is therefore always out of date.
- ✧ Agile methods usually use incremental requirements engineering and may express requirements as 'user stories' (discussed in Chapter 3).
- ✧ This is practical for business systems but problematic for systems that require pre-delivery analysis (e.g. critical systems) or systems developed by several teams.

Functional and non-functional requirements

Functional and non-functional requirements

- ✧ Functional requirements
  - Statements of services the system should provide, how the system should react to particular inputs and how the system should behave in particular situations.
  - May state what the system should not do.
- ✧ Non-functional requirements
  - Constraints on the services or functions offered by the system such as timing constraints, constraints on the development process, standards, etc.
  - Often apply to the system as a whole rather than individual features or services.
- ✧ Domain requirements
  - Constraints on the system from the domain of operation

Functional requirements

- ✧ Describe functionality or system services.
- ✧ Depend on the type of software, expected users and the type of system where the software is used.
- ✧ Functional user requirements may be high-level statements of what the system should do.
- ✧ Functional system requirements should describe the system services in detail.

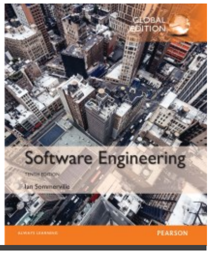
Mentcare system: functional requirements

- A user shall be able to search the appointments lists for all clinics.
- The system shall generate each day, for each clinic, a list of patients who are expected to attend appointments that day.
- Each staff member using the system shall be uniquely identified by his or her 8-digit employee number.

Requirements imprecision

- Problems arise when functional requirements are not precisely stated.
- Ambiguous requirements may be interpreted in different ways by developers and users.
- Consider the term ‘search’ in requirement 1
  - User intention – search for a patient name across all appointments in all clinics;
  - Developer interpretation – search for a patient name in an individual clinic. User chooses clinic then search.

Requirements completeness and consistency



✧ In principle, requirements should be both complete and consistent.

✧ Complete

- They should include descriptions of all facilities required.

✧ Consistent

- There should be no conflicts or contradictions in the descriptions of the system facilities.

✧ In practice, because of system and environmental complexity, it is impossible to produce a complete and consistent requirements document.

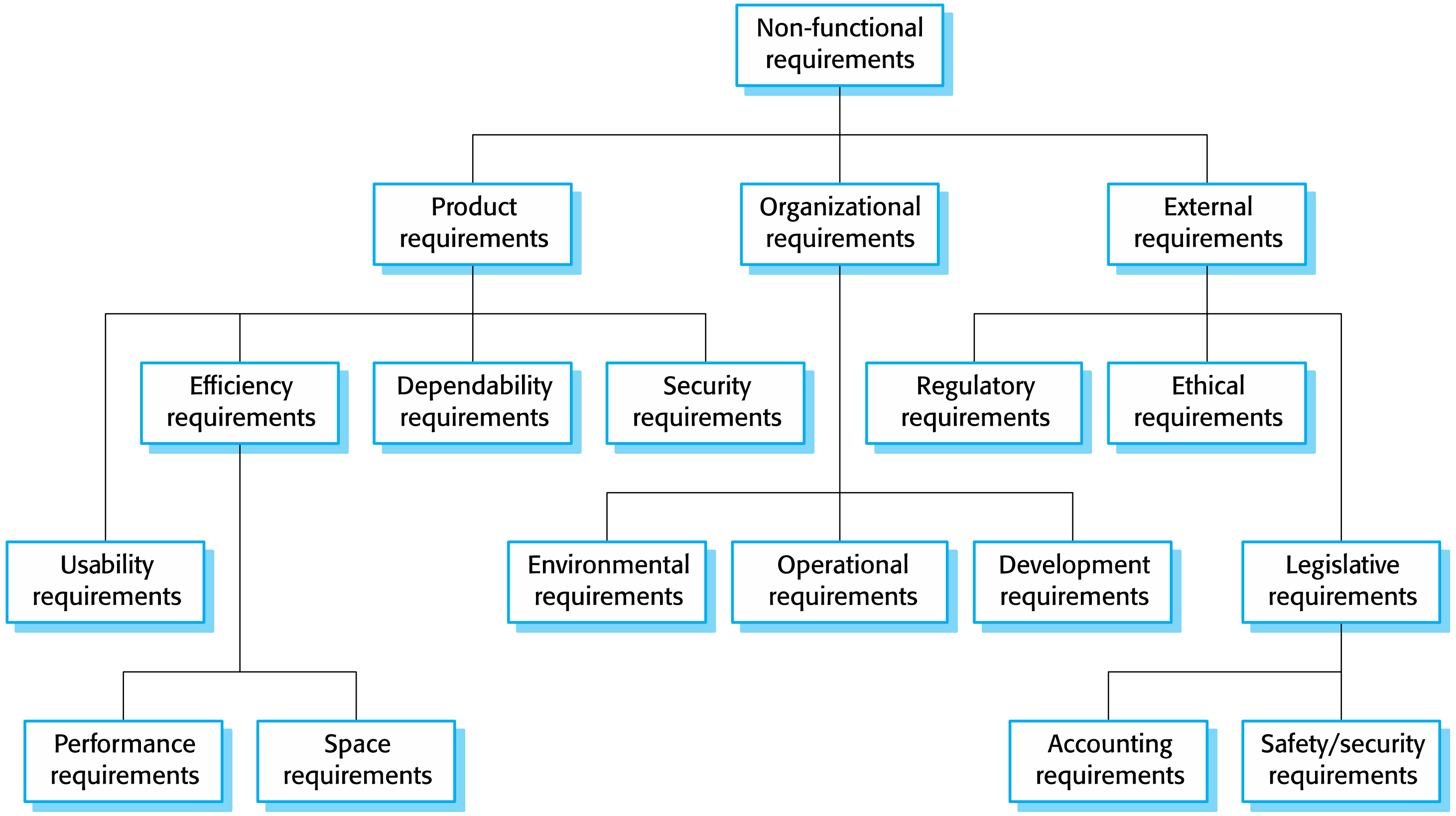
Non-functional requirements

- ✧ These define system properties and constraints e.g. reliability, response time and storage requirements. Constraints are I/O device capability, system representations, etc.
- ✧ Process requirements may also be specified mandating a particular IDE, programming language or development method.
- ✧ Non-functional requirements may be more critical than functional requirements. If these are not met, the system may be useless.

Non-functional requirements implementation

- ✧ Non-functional requirements may affect the overall architecture of a system rather than the individual components.
  - For example, to ensure that performance requirements are met, you may have to organize the system to minimize communications between components.
- ✧ A single non-functional requirement, such as a security requirement, may generate a number of related functional requirements that define system services that are required.
  - It may also generate requirements that restrict existing requirements.

Types of nonfunctional requirement



Non-functional classifications

- Product requirements
  - Requirements which specify that the delivered product must behave in a particular way e.g. execution speed, reliability, etc.
- Organisational requirements
  - Requirements which are a consequence of organisational policies and procedures e.g. process standards used, implementation requirements, etc.
- External requirements
  - Requirements which arise from factors which are external to the system and its development process e.g. interoperability requirements, legislative requirements, etc.

Examples of nonfunctional requirements in the Mentcare system

Product requirement
The Mentcare system shall be available to all clinics during normal working hours (Mon–Fri, 0830–17.30). Downtime within normal working hours shall not exceed five seconds in any one day.

Organizational requirement
Users of the Mentcare system shall authenticate themselves using their health authority identity card.

External requirement
The system shall implement patient privacy provisions as set out in HStan-03-2006-priv.

Goals and requirements

- Non-functional requirements may be very difficult to state precisely and imprecise requirements may be difficult to verify.
- Goal
  - A general intention of the user such as ease of use.
- Verifiable non-functional requirement
  - A statement using some measure that can be objectively tested.
- Goals are helpful to developers as they convey the intentions of the system users.
- In practice, customers often find it difficult to translate their goals into measurable requirements or relate their needs to the specifications
- The cost of objectively verifying measurable non-functional requirements can be very high and customers may not think these costs are justified

Usability requirements

- ✧ The system should be easy to use by medical staff and should be organized in such a way that user errors are minimized. (Goal)
- ✧ Medical staff shall be able to use all the system functions after four hours of training. After this training, the average number of errors made by experienced users shall not exceed two per hour of system use. (Testable non-functional requirement)

Metrics for specifying nonfunctional requirements

Property	Measure
Speed	Processed transactions/second User/event response time Screen refresh time
Size	Mbytes Number of ROM chips
Ease of use	Training time Number of help frames
Reliability	Mean time between failure (MTBF) Probability of unavailability Rate of failure occurrence Availability (MTBF/(MTBF+MTTR))
Robustness	Time to restart after failure Percentage of events causing failure Probability of data corruption on failure
Portability	Percentage of target dependent statements Number of target systems

Domain requirements

- ✧ The system's operational domain imposes requirements on the system.
  - For example, a train control system has to take into account the braking characteristics in different weather conditions.
- ✧ Domain requirements be new functional requirements, constraints on existing requirements or define specific computations.
- ✧ If domain requirements are not satisfied, the system may be unworkable.

Train protection system

- This is a domain requirement for a train protection system:
- The deceleration of the train shall be computed as:
  - $D_{train} = D_{control} + D_{gradient}$
  - where $D_{gradient}$ is 9.81ms2 * compensated gradient/alpha and where the values of 9.81ms2 /alpha are known for different types of train.
- It is difficult for a non-specialist to understand the implications of this and how it interacts with other requirements.

Domain requirements problems

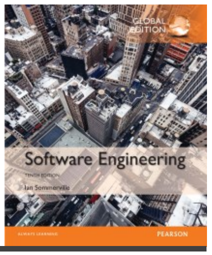
- ✧ Understandability
  - Requirements are expressed in the language of the application domain;
  - This is often not understood by software engineers developing the system.
- ✧ Implicitness
  - Domain specialists understand the area so well that they do not think of making the domain requirements explicit.

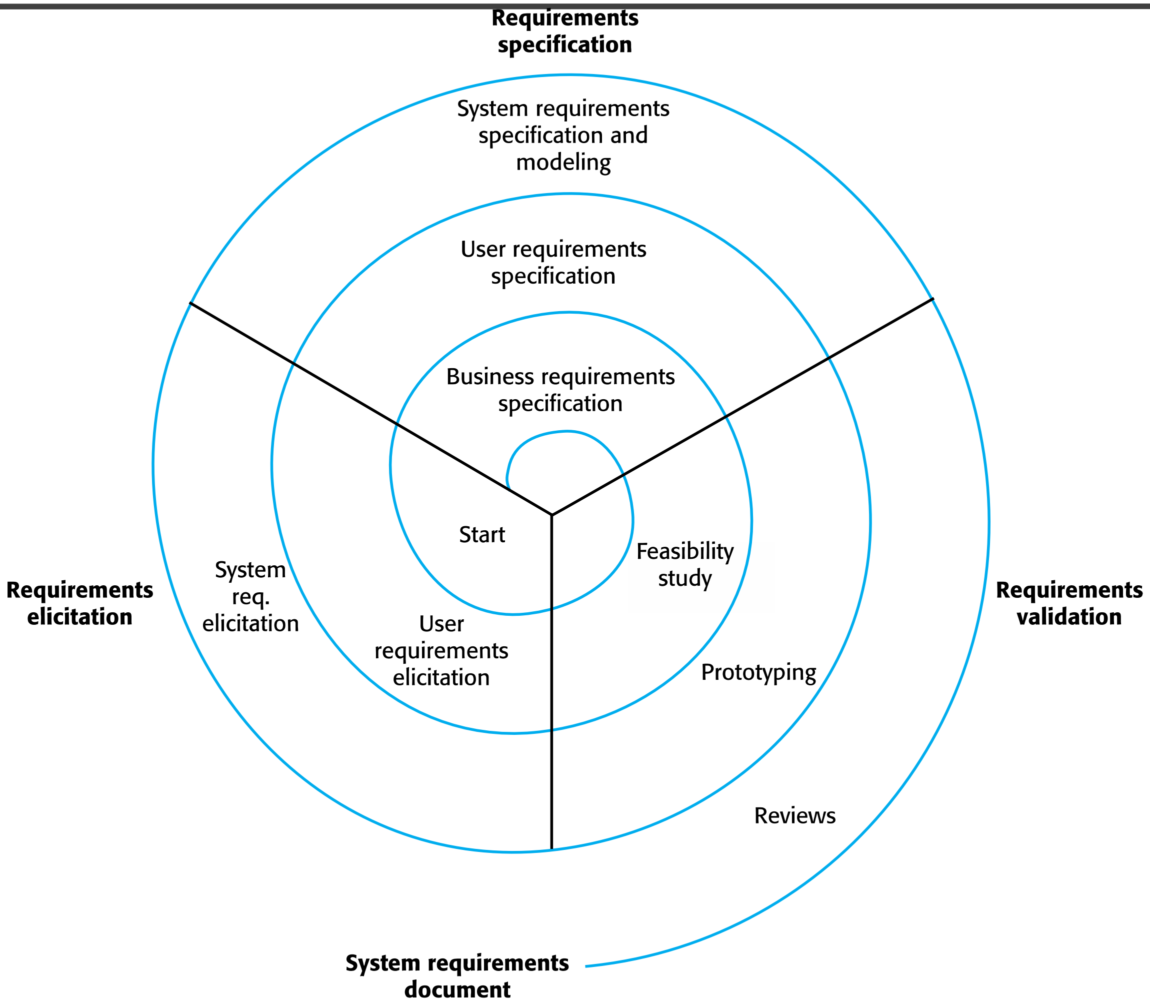
Requirements engineering processes

Requirements engineering processes

- ✧ The processes used for RE vary widely depending on the application domain, the people involved and the organisation developing the requirements.
- ✧ However, there are a number of generic activities common to all processes
  - Requirements elicitation and analysis;
  - Requirement specification;
  - Requirements validation;
  - Requirements management.
- ✧ In practice, RE is an iterative activity in which these processes are interleaved.

A spiral view of the requirements engineering process




Requirements specification
System requirements specification and modeling
User requirements specification
Business requirements specification
Start
Feasibility study
Requirements elicitation
System req. elicitation
User requirements elicitation
Prototyping
Requirements validation
Reviews
System requirements document

Requirements elicitation

Requirements elicitation and analysis

- ✧ Sometimes called requirements elicitation or requirements discovery.
- ✧ Involves technical staff working with customers to find out about the application domain, the services that the system should provide and the system's operational constraints.
- ✧ May involve end-users, managers, engineers involved in maintenance, domain experts, trade unions, etc. These are called *stakeholders.*

Requirements elicitation

Requirements elicitation

✧ Software engineers work with a range of system stakeholders to find out about the application domain, the services that the system should provide, the required system performance, hardware constraints, other systems, etc.

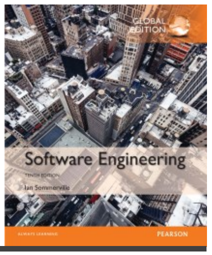
✧ Stages include:

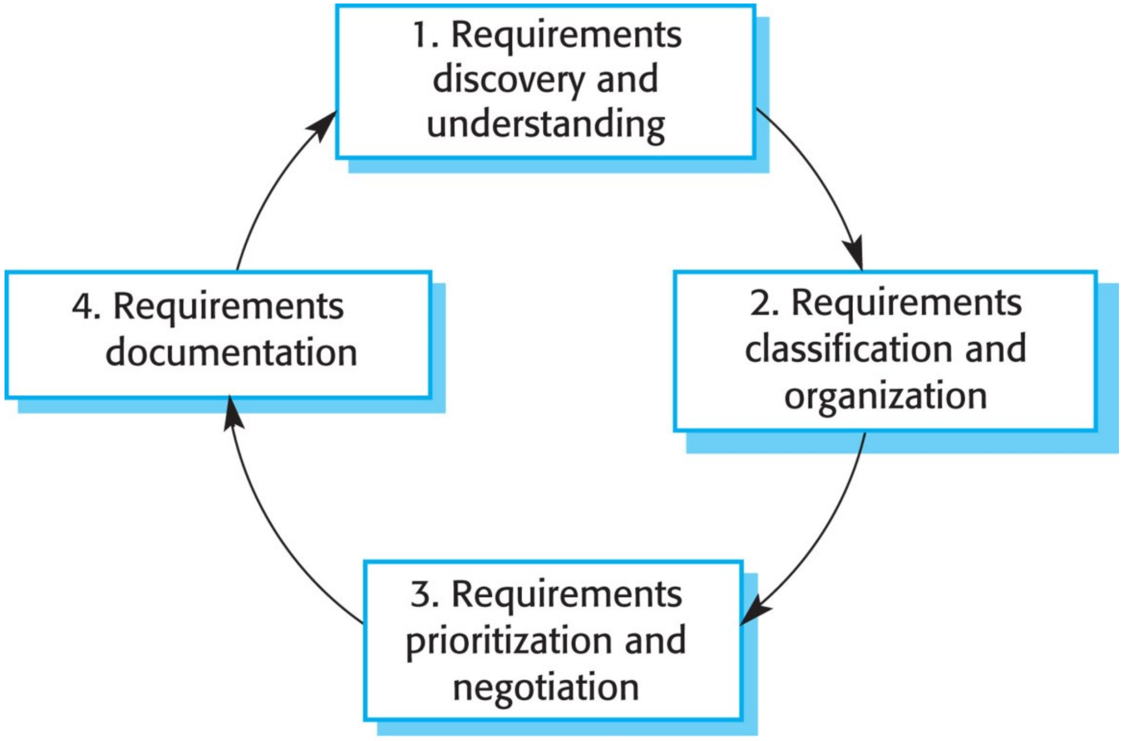
- Requirements discovery,
- Requirements classification and organization,
- Requirements prioritization and negotiation,
- Requirements specification.

Problems of requirements elicitation

- ✧ Stakeholders don't know what they really want.
- ✧ Stakeholders express requirements in their own terms.
- ✧ Different stakeholders may have conflicting requirements.
- ✧ Organisational and political factors may influence the system requirements.
- ✧ The requirements change during the analysis process. New stakeholders may emerge and the business environment may change.

The requirements elicitation and analysis process




1. Requirements discovery and understanding
2. Requirements classification and organization
3. Requirements prioritization and negotiation
4. Requirements documentation

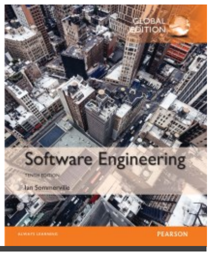
Process activities

- ✧ Requirements discovery
  - Interacting with stakeholders to discover their requirements. Domain requirements are also discovered at this stage.
- ✧ Requirements classification and organisation
  - Groups related requirements and organises them into coherent clusters.
- ✧ Prioritisation and negotiation
  - Prioritising requirements and resolving requirements conflicts.
- ✧ Requirements specification
  - Requirements are documented and input into the next round of the spiral.

Requirements discovery

- ✧ The process of gathering information about the required and existing systems and distilling the user and system requirements from this information.
- ✧ Sources of information during the requirement discovery phase include
  - Documentation,
  - System stakeholders
  - Specifications of similar systems
- ✧ Interaction is with system stakeholders from managers to external regulators.
  - Interact with stakeholders through interviews and observations
  - May use scenarios and prototypes to help stakeholders understand the system will be like
- ✧ Systems normally have a range of stakeholders.

Requirements discovery

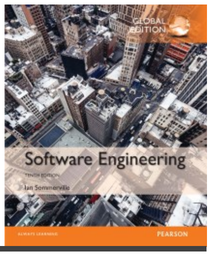


- In addition to system stakeholders, requirements may also come from the application domain and from other systems that interact with the system being specified
- The different requirement sources (stakeholders, domain, systems) can all be represented as system viewpoints with each **viewpoint** showing a subset of the requirements for the system
- The perspectives of different viewpoints are not completely independent but usually overlap so that they have **common** requirements
  - You can use **viewpoints** to structure both the discovery and the documentation of the system requirements

Interviewing

- Formal or informal interviews with stakeholders are part of most RE processes.
- Types of interview
  - Closed interviews based on pre-determined list of questions
  - Open interviews where various issues are explored with stakeholders.
- Effective interviewing
  - Be open-minded, avoid pre-conceived ideas about the requirements and are willing to listen to stakeholders.
  - Prompt the interviewee to get discussions going using a springboard question, a requirements proposal, or by working together on a prototype system.

Interviews in practice



- Normally a mix of closed and open-ended interviewing.
- Interviews are good for getting an overall understanding of what stakeholders do, how they might interact with the system & the difficulties they face with current systems
- Interviewers need to be open-minded without pre-conceived ideas of what the system should do
- You need to prompt the interviewee to talk about the system by suggesting requirements rather than simply asking them what they want.

Problems with interviews

- ✧ Application specialists may use language to describe their work that isn't easy for the requirements engineer to understand.
- ✧ Interviews are not good for understanding domain requirements
  - Requirements engineers cannot understand specific domain terminology;
  - Some domain knowledge is so familiar that people find it hard to articulate or think that it isn't worth articulating.
- ✧ Interviews are also not an effective technique for eliciting knowledge about organizational requirements and constraints because of political issues

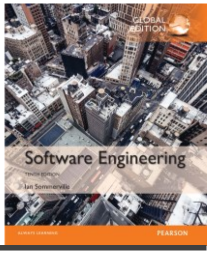
Ethnography (民族誌)

- A social scientist spends a considerable time observing and analysing how people **actually work**.
- People do not have to explain or articulate their work.
- Social and organisational factors of importance may be observed.
- 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
- Ethnographic studies have shown that **work** is usually **richer** and more **complex** and **dynamic** than suggested by simple system models.

Scope of ethnography

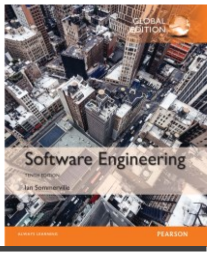
- ✧ Ethnography is particularly effective for discovering
  - Requirements that are derived from **the way that people actually work** rather than the way which process definitions suggest that they ought to work.
  - Requirements that are derived from **cooperation** and **awareness of other people's activities.**
    - Awareness of what other people are doing leads to changes in the ways in which we do things.
- ✧ Ethnography is effective for understanding **existing processes** but cannot always help to identify **innovation features** that should be added to a system.
- ✧ Ethnography studies can reveal critical process details that are often missed by other techniques. However, it is not always appropriate for discovering organizational or domain requirements. It should be used to **complement** other approaches, such as use case analysis

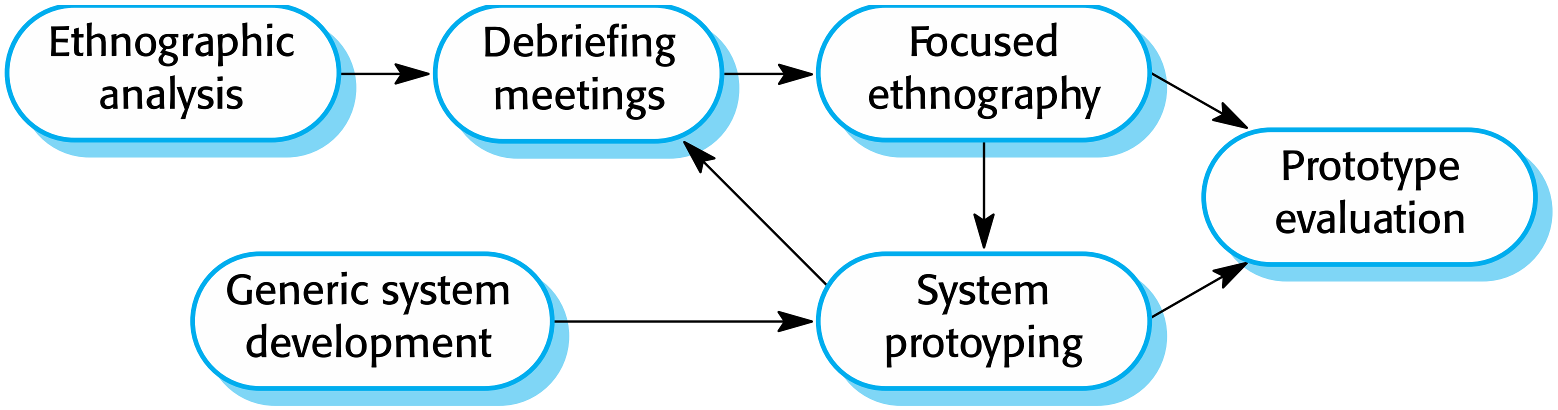
Focused ethnography



- ✧ Developed in a project studying the air traffic control process
- ✧ Combines ethnography with prototyping
  - The ethnography informs the development of prototype so that fewer prototype refinement cycles are required
  - Prototype development results in unanswered questions which focus the ethnographic analysis.
- ✧ The problem with ethnography is that it studies existing practices which may have some historical basis which is no longer relevant.

Ethnography and prototyping for requirements analysis





Stories and scenarios

✧ **Scenarios** and **user stories** are real-life **examples** of how a system can be used.

✧ Stories and scenarios are a description of how a system may be used for a particular task.

✧ Because they are based on a practical situation, stakeholders can relate to them and can comment on their situation with respect to the story.

Photo sharing in the classroom (iLearn)

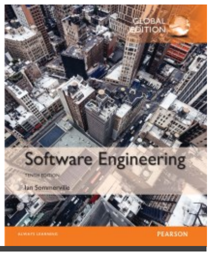
✧ Jack is a primary school teacher in Ullapool (a village in northern Scotland). He has decided that a class project should be focused around the fishing industry in the area, looking at the history, development and economic impact of fishing. As part of this, pupils are asked to gather and share reminiscences 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** as he wants pupils to take and comment on each others' 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 uses 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.

Basic Concepts of User Story

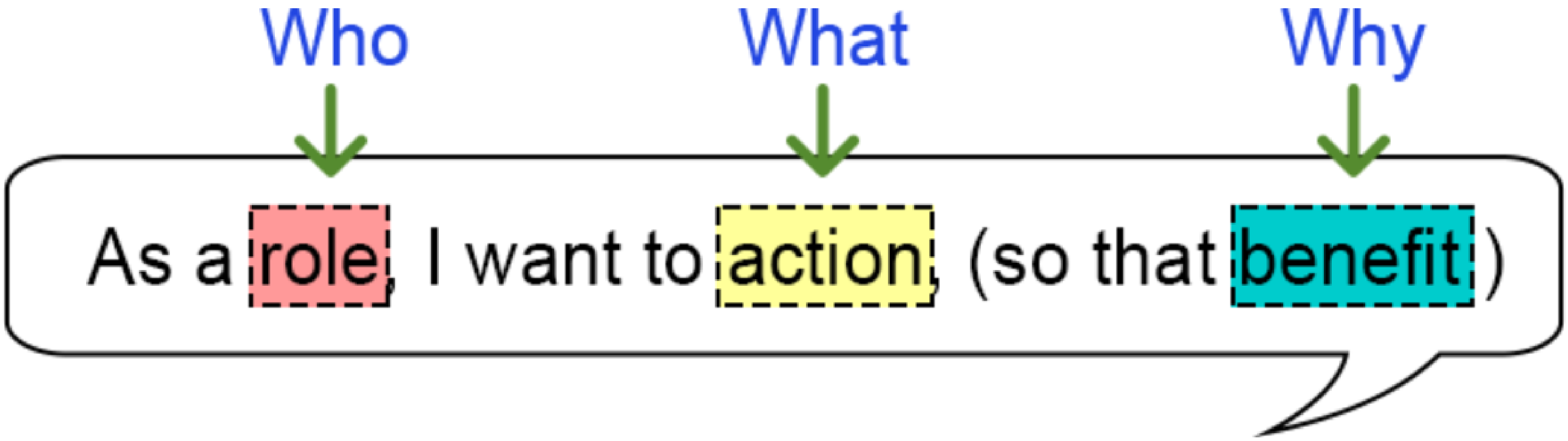
- A user story is a lightweight method for quickly capturing the "who", "what" and "why" of a product requirement
  - User stories are stated ideas of requirements that express what users need (the smallest units of user functionality in agile which can be delivered in one agile sprint)
  - User stories are "to-do" lists that help you determine the steps along the project's path
- User stories are brief, with each element often containing fewer than 10 or 15 words each
- To assess the quality of a user story, a good user story should be – INVEST.
  - If the story fails to meet one of these criteria, the team may want to reword it, or even consider a rewrite

User Story Template

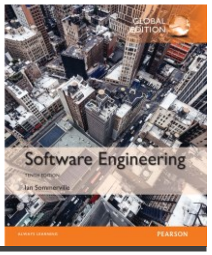


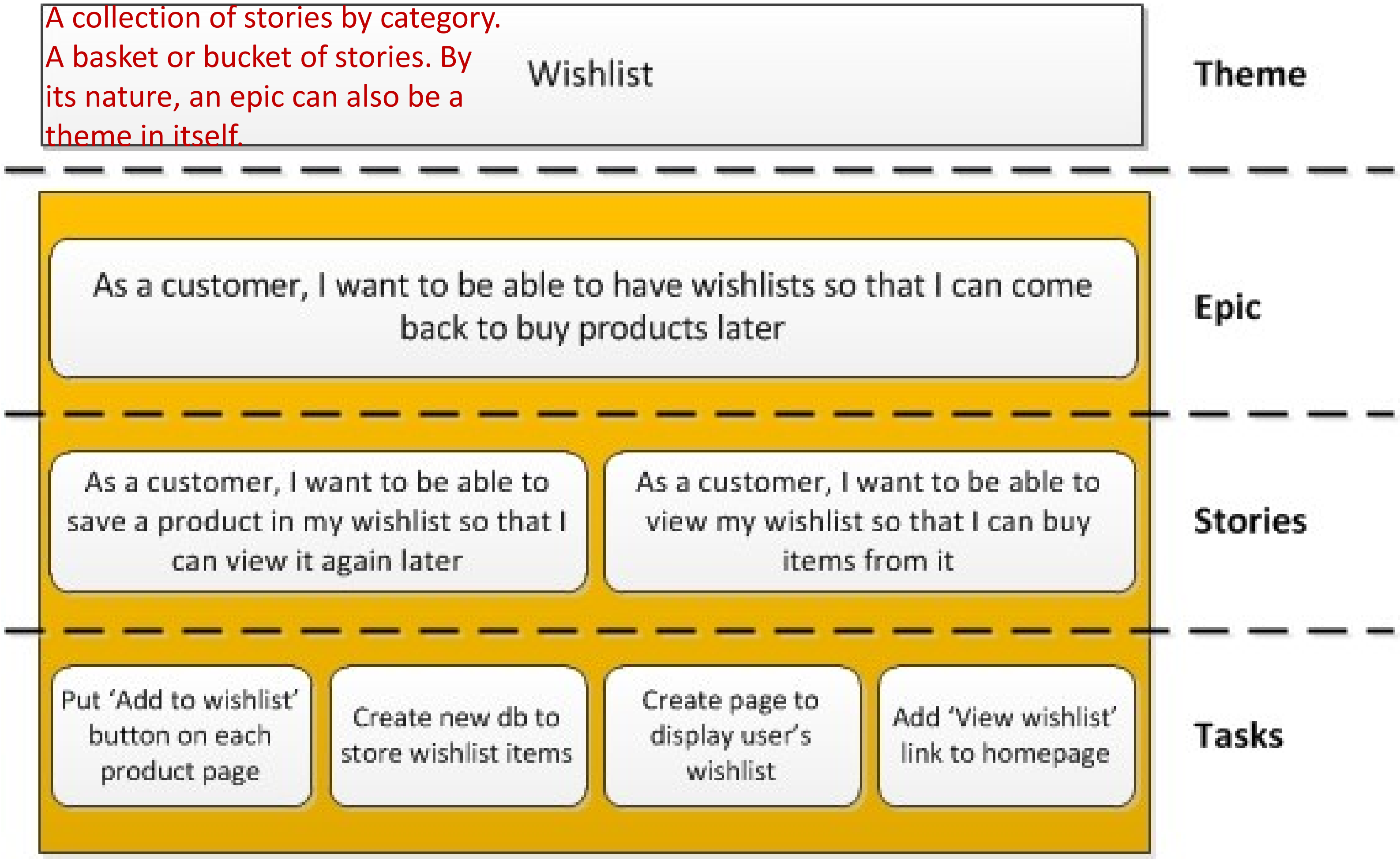
✧ User stories only capture the essential elements of a requirement:

- Who it is for?
- What it expects from the system?
- Why it is important (optional?)?



Theme, Epic, Story, and Task





A collection of stories by category. A basket or bucket of stories. By its nature, an epic can also be a theme in itself.

Wishlist
Theme
As a customer, I want to be able to have wishlists so that I can come back to buy products later
Epic
As a customer, I want to be able to save a product in my wishlist so that I can view it again later
As a customer, I want to be able to view my wishlist so that I can buy items from it
Stories
Put 'Add to wishlist' button on each product page
Create new db to store wishlist items
Create page to display user's wishlist
Add 'View wishlist' link to homepage
Tasks

https://scrumandkanban.co.uk/theme-epic-story-task/

INVEST

- ✧ A good user story should be - INVEST:
  - **Independent**: Should be self-contained in a way that allows to be released without depending on one another.
  - **Negotiable**: Only capture the essence of user's need, **leaving room for conversation**. User story should not be written like contract.
  - **Valuable**: Delivers value to end user.
  - **Estimable**: User stories have to able to be estimated so it can be properly prioritized and fit into sprints.
  - **Small**: A user story is a small chunk of work that allows it to be completed in about 3 to 4 days.
  - **Testable**: A user story has to be confirmed via pre-written acceptance criteria.

Scenarios

✧ A structured form of user story

✧ Scenarios should include

- A description of the starting situation;
- A description of the normal flow of events;
- A description of what can go wrong; (exceptions or alternative scenarios)
- Information about other concurrent activities;
- A description of the state when the scenario finishes.

✧ Scenarios may be written as text, supplemented by diagrams, screen shots, etc.

Uploading photos iLearn)

- ✧ **Initial assumption**: A user or a group of users have one or more digital photographs to be uploaded to the picture sharing site. These are saved on either a tablet or laptop computer. They have successfully logged on to KidsTakePics.
- ✧ **Normal**: The user chooses upload photos and they are prompted to **select the photos to be uploaded** on their computer and to select the project name under which the photos will be stored. They 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 has been done.

Uploading photos

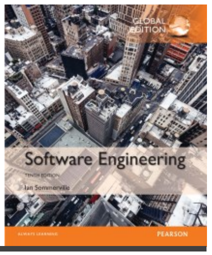
- **What can go wrong**:
- No moderator is associated with the selected project. An email is automatically generated to the school administrator asking them to nominate a project moderator. Users should be informed that there could be a delay in making their photos visible.
- Photos with the same name have already been uploaded by the same user. The user should be asked if they wish to re-upload the photos with the same name, rename the photos or cancel the upload. If they chose to re-upload the photos, the originals are overwritten. If they chose to rename the photos, a new name is automatically generated by adding a number to the existing file name.
- **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.

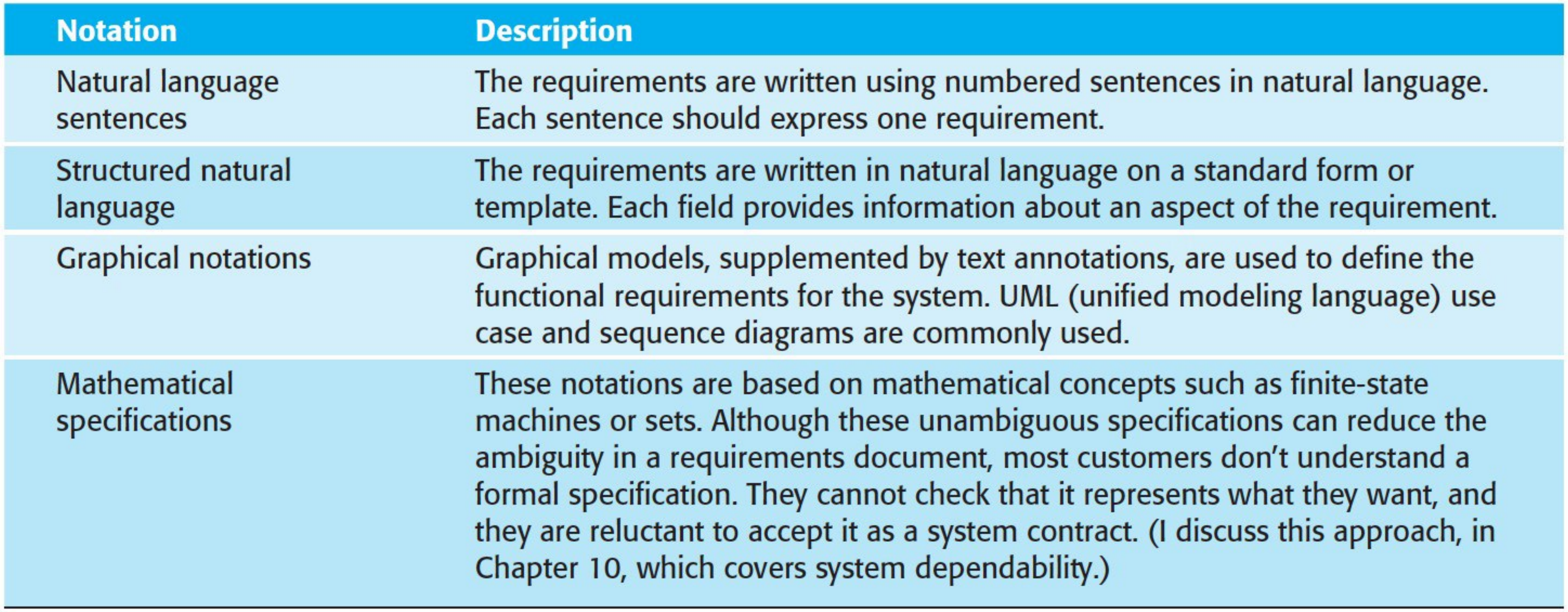
Requirements specification

Requirements specification

- ✧ The process of writing down the user and system requirements in a requirements document.
- ✧ User requirements have to be understandable by end-users and customers who do **not** have a technical background.
- ✧ System requirements are more detailed requirements and may include **more technical information**.
- ✧ The requirements may be part of a contract for the system development
  - It is therefore important that these are as **complete** as possible.

Notations for writing system requirements





Notation	Description
Natural language sentences	The requirements are written using numbered sentences in natural language. Each sentence should express one requirement.
Structured natural language	The requirements are written in natural language on a standard form or template. Each field provides information about an aspect of the requirement.
Graphical notations	Graphical models, supplemented by text annotations, are used to define the functional requirements for the system. UML (unified modeling language) use case and sequence diagrams are commonly used.
Mathematical specifications	These notations are based on mathematical concepts such as finite-state machines or sets. Although these unambiguous specifications can reduce the ambiguity in a requirements document, most customers don't understand a formal specification. They cannot check that it represents what they want, and they are reluctant to accept it as a system contract. (I discuss this approach, in Chapter 10, which covers system dependability.)

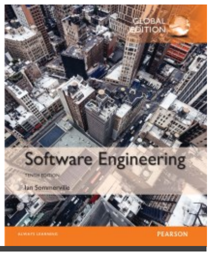
Requirements and design

✧ In principle, requirements should state what the system should do and the design should describe how it does this.

✧ In practice, requirements and design are inseparable

- A system architecture may be designed to structure the requirements;
- The system may inter-operate with other systems that generate design requirements;
  - Constrain the design and impose requirements on the new system
- The use of a specific architecture (such as N-version programming for reliability) to satisfy non-functional requirements may be a domain requirement.
  - This may be the consequence of a regulatory requirement.

Natural language specification



- ✧ Requirements are written as *natural language sentences* supplemented by diagrams and tables.
- ✧ Used for writing requirements because it is expressive, intuitive and universal. This means that the requirements can be **understood** by users and customers.
- ✧ Natural language is also potentially vague, ambiguous, and its meaning depends on the background of the reader
  - E.g. there is grammatical ambiguity of "*Dogs* must be *carried* on this escalator"

Guidelines for writing requirements

- ✧ Invent a standard format and use it for all requirements.
- ✧ Use language in a consistent way. Use shall for mandatory requirements, should for desirable requirements.
- ✧ Use text highlighting to identify key parts of the requirement.
- ✧ Avoid the use of computer jargon.
- ✧ Include an explanation (rationale) of why a requirement is necessary.

Problems with natural language

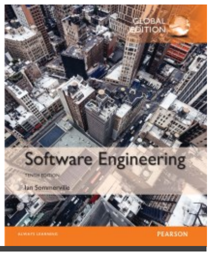
- Lack of clarity
  - Precision is difficult without making the document difficult to read.
- Requirements confusion
  - Functional and non-functional requirements tend to be **mixed-up**.
- Requirements amalgamation (合併)
  - Several different requirements may be **expressed together**.

Example requirements for the insulin pump software system

3.2 The system shall measure the blood sugar and deliver insulin, if required, every 10 minutes. *(Changes in blood sugar are relatively slow so more frequent measurement is unnecessary; less frequent measurement could lead to unnecessarily high sugar levels.)*

3.6 The system shall run a self-test routine every minute with the conditions to be tested and the associated actions defined in Table 1. *(A self-test routine can discover hardware and software problems and alert the user to the fact the normal operation may be impossible.)*

Structured specifications



- An approach to writing requirements where the freedom of the requirements writer is limited and requirements are written in a standard way.
  - Maintains most of the expressiveness and understandability of natural language but ensure that some uniformity is imposed on the specification
- This works well for some types of requirements e.g. requirements for embedded control system but is sometimes too rigid for writing business system requirements.
- Volere (Voh-liar-ray) requirements engineering method
  - Italian verb to want, or to wish
  - Recommend that user requirements be initially written on cards, one requirement per card. It suggests a number of fields on each card, such as the requirement rationale, the dependencies on other requirements, the source of the requirements, supporting materials, and so on

Form-based specifications

- ✧ Definition of the function or entity.
- ✧ Description of inputs and where they come from.
- ✧ Description of outputs and where they go to.
- ✧ Information about the information needed for the computation and other entities used.
- ✧ Description of the action to be taken.
- ✧ Pre and post conditions (if appropriate).
- ✧ The side effects (if any) of the function.

A structured specification of a requirement for an insulin pump

Insulin Pump/Control Software/SRS/3.3.2

Function Compute insulin dose: safe sugar level.

Description

Computes the dose of insulin to be delivered when the current measured sugar level is in the safe zone between 3 and 7 units.

Inputs Current sugar reading (r2); the previous two readings (r0 and r1).

Source Current sugar reading from sensor. Other readings from memory.

Outputs CompDose—the dose in insulin to be delivered.

Destination Main control loop.

A structured specification of a requirement for an insulin pump

Action

CompDose is zero if the sugar level is stable or falling or if the level is increasing but the rate of increase is decreasing. If the level is increasing and the rate of increase is increasing, then CompDose is computed by dividing the difference between the current sugar level and the previous level by 4 and rounding the result. If the result, is rounded to zero then CompDose is set to the minimum dose that can be delivered.

Requirements

Two previous readings so that the rate of change of sugar level can be computed.

Pre-condition

The insulin reservoir contains at least the maximum allowed single dose of insulin.

Post-condition r0 is replaced by r1 then r1 is replaced by r2.

Side effects None.

Tabular specification

✧ Used to supplement natural language.

✧ Particularly useful when you have to define a number of possible **alternative** courses of action.

✧ For example, the insulin pump systems bases its computations on the rate of change of blood sugar level and the tabular specification explains how to calculate the insulin requirement for different scenarios.

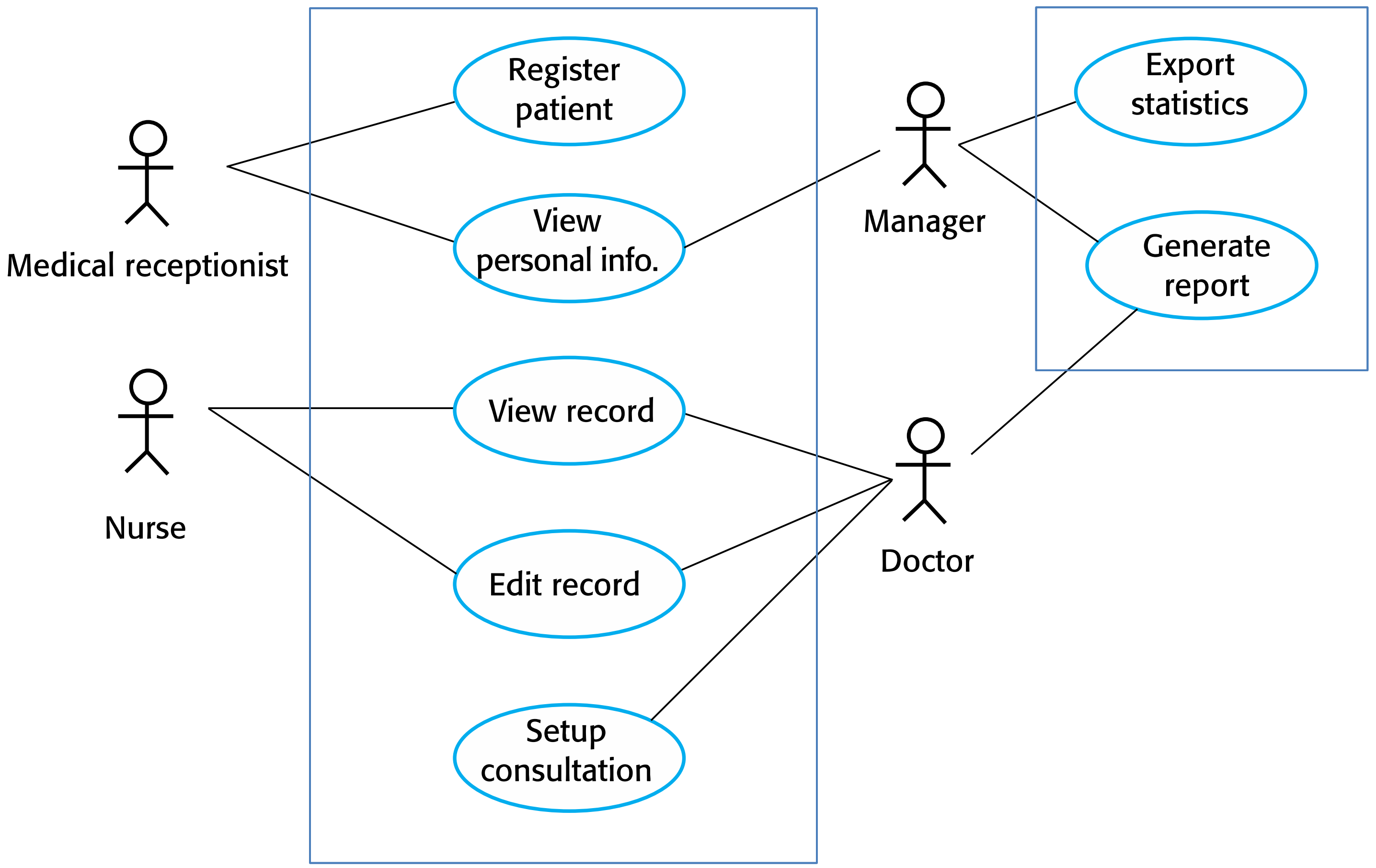
Tabular specification of computation for an insulin pump

Condition	Action
Sugar level falling (r2 < r1)	CompDose = 0
Sugar level stable (r2 = r1)	CompDose = 0
Sugar level increasing and rate of increase decreasing ((r2 – r1) < (r1 – r0))	CompDose = 0
Sugar level increasing and rate of increase stable or increasing ((r2 – r1) ≥ (r1 – r0))	CompDose = round ((r2 – r1)/4) If rounded result = 0 then CompDose = MinimumDose

Use cases

- ✧ Use-cases are a kind of scenario that are included in the UML.
- ✧ Use cases identify the actors in an interaction and which describe the interaction itself.
- ✧ A set of use cases should describe **all possible interactions** with the system.
- ✧ High-level graphical model supplemented by more detailed tabular description (see Chapter 5).
- ✧ UML sequence diagrams may be used to add detail to use-cases by showing the sequence of event processing in the system.

Use cases for the Mentcare system



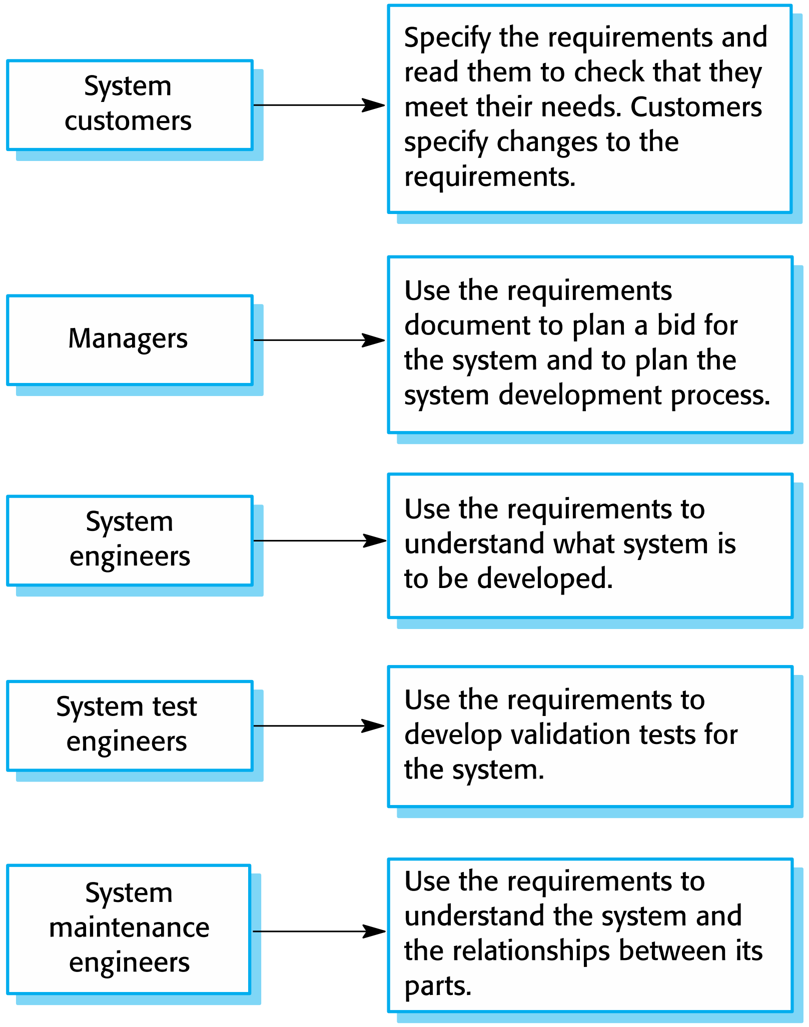
Use cases

- Scenarios and use cases are effective techniques for eliciting requirements from stakeholders who **interact directly with system**
  - Each type of interaction can be represented as a use case
- Scenarios and use cases, however, focus on interactions with the systems, they are not as effective for eliciting **constraints** or **high-level business** and **non-functional requirements** or for discovering **domain requirements**
- The UML is a **de facto standard** for object-oriented modeling, so use cases and use case-based elicitation are now widely used for **requirement elicitation**
- No hard and fast distinction between *scenarios* and *use cases*
  - Some people consider that each use case is a single scenario; others encapsulate a set of scenarios in a single use case

The software requirements document

- The software requirements document is the official statement of what the system developers should implement.
  - Software requirement document sometimes called the **software requirements specification** or SRS
- Should include both a definition of **user requirements** and a specification of the **system requirements**.
  - The diversity of possible users means that the requirements document has to be a **compromise** between communicating the requirements to customers, defining requirements in precise detail for developers and testers, and including information about possible system evolution
- **It is NOT a design document.** As far as possible, it should set of WHAT the system should do rather than HOW it should do it.

Users of a requirements document

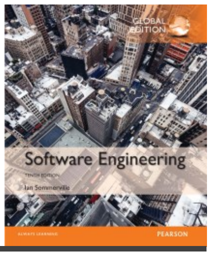


System customers
Specify the requirements and read them to check that they meet their needs. Customers specify changes to the requirements.
Managers
Use the requirements document to plan a bid for the system and to plan the system development process.
System engineers
Use the requirements to understand what system is to be developed.
System test engineers
Use the requirements to develop validation tests for the system.
System maintenance engineers
Use the requirements to understand the system and the relationships between its parts.

Requirements document variability

- Information in requirements document depends on type of system and the approach to development used.
- Systems **developed incrementally** will, typically, have less detail in the requirements document.
- Requirements documents standards have been designed e.g. IEEE standard. These are mostly applicable to the requirements for **large systems** engineering projects.

The structure of a requirements document



Chapter	Description
Preface	This should define the expected readership of the document and describe its version history, including a rationale for the creation of a new version and a summary of the changes made in each version.
Introduction	This should describe the need for the system. It should briefly describe the system's functions and explain how it will work with other systems. It should also describe how the system fits into the overall business or strategic objectives of the organization commissioning the software.
Glossary	This should define the technical terms used in the document. You should not make assumptions about the experience or expertise of the reader.
User requirements definition	Here, you describe the services provided for the user. The nonfunctional system requirements should also be described in this section. This description may use natural language, diagrams, or other notations that are understandable to customers. Product and process standards that must be followed should be specified.
System architecture	This chapter should present a high-level overview of the anticipated system architecture, showing the distribution of functions across system modules. Architectural components that are reused should be highlighted.

The structure of a requirements document

Chapter	Description
System requirements specification	This should describe the functional and nonfunctional requirements in more detail. If necessary, further detail may also be added to the nonfunctional requirements. Interfaces to other systems may be defined.
System models	This might include graphical system models showing the relationships between the system components and the system and its environment. Examples of possible models are object models, data-flow models, or semantic data models.
System evolution	This should describe the fundamental assumptions on which the system is based, and any anticipated changes due to hardware evolution, changing user needs, and so on. This section is useful for system designers as it may help them avoid design decisions that would constrain likely future changes to the system.
Appendices	These should provide detailed, specific information that is related to the application being developed; for example, hardware and database descriptions. Hardware requirements define the minimal and optimal configurations for the system. Database requirements define the logical organization of the data used by the system and the relationships between data.
Index	Several indexes to the document may be included. As well as a normal alphabetic index, there may be an index of diagrams, an index of functions, and so on.

Requirements validation

Requirements validation

- ✧ Concerned with demonstrating that the requirements define the system that the customer really wants.
- ✧ Requirements error costs are high so **validation is very important**
  - Fixing a requirements error after delivery may cost up to 100 times the cost of fixing an implementation error.

Requirements checking

- ✧ Validity. Does the system provide the functions which best support the customer's needs?
- ✧ Consistency. Are there any requirements conflicts?
- ✧ Completeness. Are all functions required by the customer included?
- ✧ Realism. Can the requirements be implemented given available budget and technology
- ✧ Verifiability. Can the requirements be checked?

Requirements validation techniques

✧ Requirements reviews

- Systematic manual analysis of the requirements.

✧ Prototyping

- Using an executable model of the system to check requirements. Covered in Chapter 2.

✧ Test-case generation

- Developing tests for requirements to check **testability**.
- If a test is difficult or impossible to design, this usually means that the requirements will be difficult to implement and should be reconsidered

Requirements reviews

- ✧ Regular reviews should be held while the requirements definition is being formulated.
- ✧ Both client and contractor staff should be involved in reviews.
- ✧ Reviews may be formal (with completed documents) or informal. Good communications between developers, customers and users can resolve problems at an early stage.

Review checks

- ✧ Verifiability
  - Is the requirement realistically testable?
- ✧ Comprehensibility
  - Is the requirement properly understood?
- ✧ Traceability
  - Is the origin of the requirement clearly stated?
- ✧ Adaptability
  - Can the requirement be changed without a large impact on other requirements?

Requirements change

Changing requirements

✧ The business and technical environment of the system always changes after installation.

- New hardware may be introduced, it may be necessary to interface the system with other systems, business priorities may change (with consequent changes in the system support required), and new legislation and regulations may be introduced that the system must necessarily abide by.

✧ The people who pay for a system and the users of that system are rarely the same people.

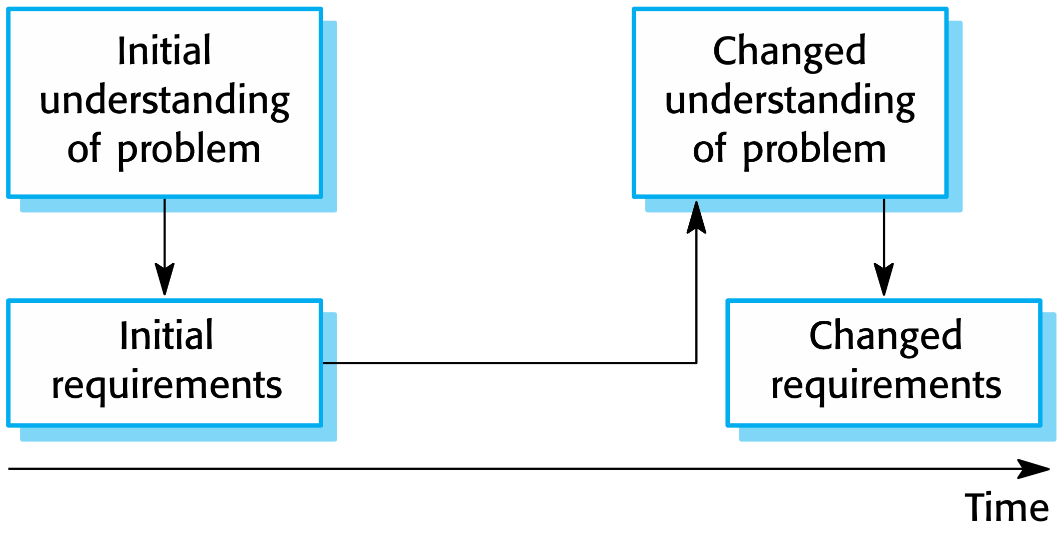
- System customers impose requirements because of organizational and budgetary constraints. These may conflict with end-user requirements and, after delivery, new features may have to be added for user support if the system is to meet its goals.

Changing requirements

✧ Large systems usually have a diverse user community, with many users having different requirements and priorities that may be conflicting or contradictory.

- The final system requirements are inevitably a compromise between them and, with experience, it is often discovered that the balance of support given to different users has to be changed.

Requirements evolution


Initial understanding of problem
Changed understanding of problem
Initial requirements
Changed requirements
Time

Requirements management

- ✧ Requirements management is the process of managing changing requirements during the requirements engineering process and system development.
- ✧ New requirements emerge as a system is being developed and after it has gone into use.
- ✧ You need to keep track of individual requirements and maintain links between dependent requirements so that you can assess the impact of requirements changes. You need to establish a formal process for making change proposals and linking these to system requirements.

Requirements management planning

✧ Establishes the level of requirements management detail that is required.

✧ Requirements management decisions:

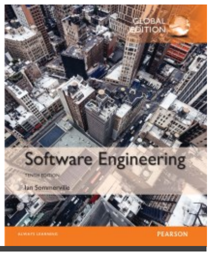
- *Requirements identification* Each requirement must be uniquely identified so that it can be cross-referenced with other requirements.
- ***A change management process*** This is the set of activities that assess the impact and cost of changes. I discuss this process in more detail in the following section.
- ***Traceability policies*** These policies define the relationships between each requirement and between the requirements and the system design that should be recorded.
- *Tool support* Tools that may be used range from specialist requirements management systems to spreadsheets and simple database systems.

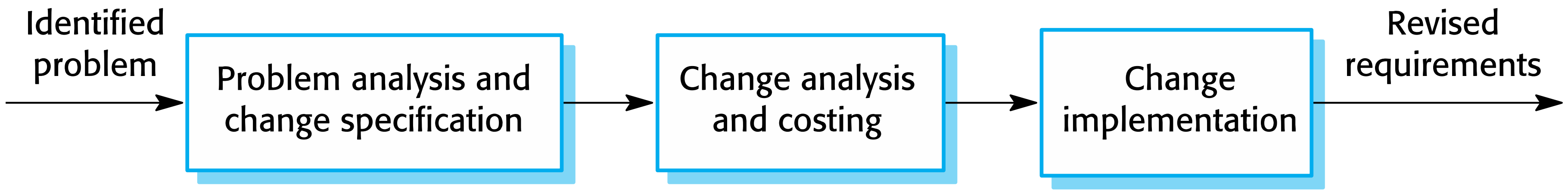
Requirements change management

✧ Deciding if a requirements change should be accepted

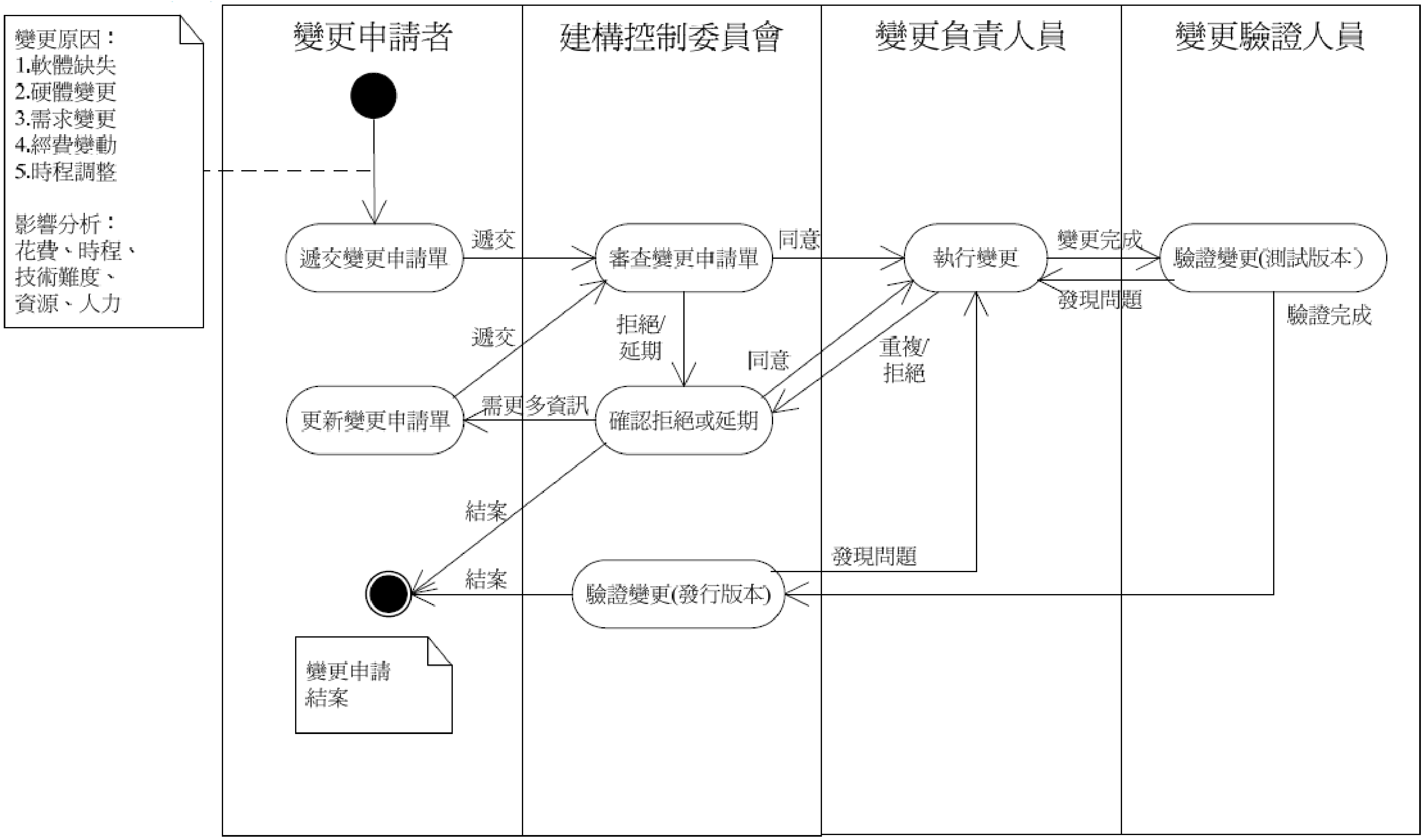
- *Problem analysis and change specification*
  - During this stage, the problem or the change proposal is analyzed to check that it is valid. This analysis is fed back to the change requestor who may respond with <u>a more specific requirements change proposal</u>, or decide to <u>withdraw the request</u>.
- *Change analysis and costing*
  - The effect of the proposed change is assessed using **traceability information** and general knowledge of the system requirements. Once this analysis is completed, <u>a decision is made whether or not to proceed with the requirements change</u>.
- *Change implementation*
  - <u>The **requirements document** and, where necessary, **the system design and implementation**, are modified</u>. Ideally, the document should be organized so that changes can be easily implemented.

Requirements change management




Identified problem
Problem analysis and change specification
Change analysis and costing
Change implementation
Revised requirements

Requirements Change Process (more detailed)



Key points

- ✧ Requirements for a software system set out what the system should do and define constraints on its operation and implementation.
- ✧ Functional requirements are statements of the services that the system must provide or are descriptions of how some computations must be carried out.
- ✧ Non-functional requirements often constrain the system being developed and the development process being used.
- ✧ They often relate to the emergent properties of the system and therefore apply to the system as a whole.

Key points

- ✧ The requirements engineering process is an iterative process that includes requirements elicitation, specification and validation.
- ✧ Requirements elicitation is an iterative process that can be represented as a spiral of activities – requirements discovery, requirements classification and organization, requirements negotiation and requirements documentation.
- ✧ You can use a range of techniques for requirements elicitation including interviews and ethnography. User stories and scenarios may be used to facilitate discussions.

Key points

- ✧ Requirements specification is the process of formally documenting the user and system requirements and creating a software requirements document.
- ✧ The software requirements document is an agreed statement of the system requirements. It should be organized so that both system customers and software developers can use it.

Key points

✧ Requirements validation is the process of checking the requirements for validity, consistency, completeness, realism and verifiability.

✧ Business, organizational and technical changes inevitably lead to changes to the requirements for a software system. Requirements management is the process of managing and controlling these changes.