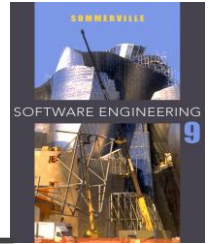


Chapter 3 – Agile Software Development

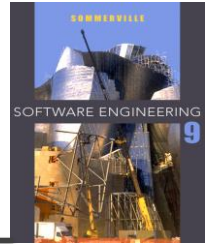
Lecture 1



Topics covered

- ✧ Agile methods
- ✧ Plan-driven and agile development
- ✧ Extreme programming
- ✧ Agile project management
- ✧ Scaling agile methods

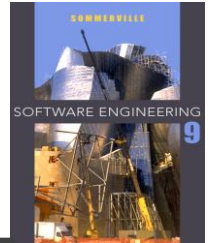
Plan-Driven



- ✧ Software development processes that plan on completely specifying the requirements and then designing, building, and testing the system are **not geared to rapid software development.**
- ✧ **As the requirements change** or as requirements problems are discovered, **the system design or implementation has to be reworked and retested.**
- ✧ As a consequence, **a conventional waterfall** or specification-based process **is usually prolonged** and the final software is delivered to the customer long after it was originally specified.

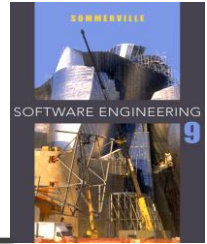
- ✧ For some types of software, such as **safety-critical control systems**, where a complete analysis of the system is essential, **a plan-driven approach is the right one.**
- ✧ However, **in a fast-moving business environment, this can cause real problems.** By the time the software is available for use, the original **reason for its procurement may have changed** so radically that the software is effectively useless.
- ✧ Therefore, **for business systems in particular, development processes that focus on rapid software development and delivery are essential.**

Rapid software development



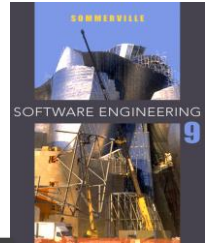
- ✧ **Rapid development and delivery** is now **often the most important requirement** for software systems
 - Businesses operate in a **fast –changing requirement** and it is practically **impossible to produce a set of stable software requirements**
 - **Software has to evolve quickly** to reflect changing business needs.
- ✧ Rapid software development
 - Specification, design and implementation are **inter-leaved**
 - **no detailed system specification, and design documentation is minimized or generated automatically by the programming environment**
 - **The user requirements document only defines the most important characteristics of the system.**
 - System is developed as a **series of versions** with **stakeholders involved in version evaluation**
 - **User interfaces** are often developed using an **IDE and graphical toolset**.

plan-driven approaches



- ✧ involve a **significant overhead** in **planning, designing, and documenting** the system.
- ✧ **This overhead is justified**
 - when the work of **multiple development teams** has to be coordinated,
 - **when the system is a critical system,**
 - and when many **different people will be involved in maintaining** the software over its lifetime.
- ✧ However, when this heavyweight, plan-driven development approach is applied to **small and medium-sized business systems,**
 - **More time is spent** on how the system should be developed than on program development and testing.
 - As the system **requirements change,** rework is essential and, in principle at least, **the specification and design has to change with the program.**

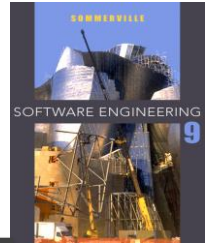
Agile methods



- ✧ Dissatisfaction with the overheads involved in software design methods of the 1980s and 1990s led to the creation of agile methods. These methods:
 - **Focus on the code rather than the design**
 - Are **based on an iterative approach** to software development
 - Are intended to **deliver working software quickly** and **evolve this quickly** to meet changing requirements.

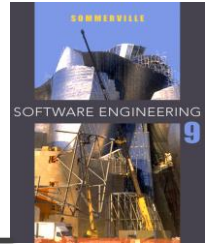
- ✧ **The aim of agile methods is to reduce overheads in the software process (e.g. by limiting documentation) and to be able to respond quickly to changing requirements** without excessive rework.

Agile manifesto (agreed on by many of the leading developers of these methods)



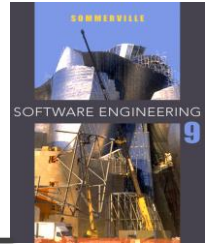
- ✧ *We are uncovering better ways of developing software by doing it and helping others do it. Through this work **we have come to value:***
 - ***Individuals and interactions over processes and tools***
 - ***Working software over comprehensive documentation***
 - ***Customer collaboration over contract negotiation***
Responding to change over following a plan
- ✧ *That is, while there is value in the items on the right, **we value the items on the left more.***

The principles of agile methods

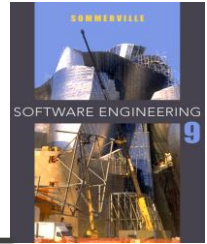


Principle	Description
Customer involvement	Customers should be closely involved throughout the development process. Their role is provide and prioritize new system requirements and to evaluate the iterations of the system.
Incremental delivery	The software is developed in increments with the customer specifying the requirements to be included in each increment.
People not process	The skills of the development team should be recognized and exploited. Team members should be left to develop their own ways of working without prescriptive processes.
Embrace change	Expect the system requirements to change and so design the system to accommodate these changes.
Maintain simplicity	Focus on simplicity in both the software being developed and in the development process. Wherever possible, actively work to eliminate complexity from the system.

Agile method applicability

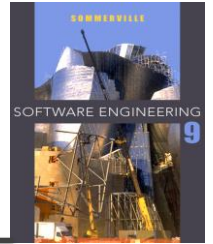


- ✧ Product development where a software company is developing a **small or medium-sized product for sale.**
- ✧ **Custom system development** within an organization, where there is a **clear commitment from the customer to become involved** in the development process and where there are **not a lot of external rules and regulations** that affect the software.
- ✧ Because of their focus on small, tightly-integrated teams, **there are problems in scaling agile methods to large systems.**
- ✧ Also because of **the need for security, safety, and dependability analysis in critical systems**, agile methods **require significant modification before** they can be routinely **used for critical systems engineering.**



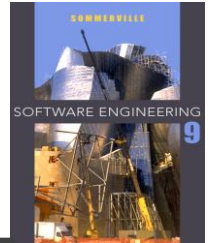
Problems with agile methods

- ✧ It can be **difficult to keep the interest of customers** who are involved in the process.
- ✧ Team members may be unsuited to the intense involvement that characterizes agile methods (e.g **do not interact well with other team members**).
- ✧ **Prioritizing changes can be difficult** where there are multiple stakeholders (Typically, **each stakeholder gives different priorities to different changes**).
- ✧ Maintaining simplicity requires extra work. Under pressure from delivery schedules, **the team members may not have time to carry out desirable system simplifications**.
- ✧ **Contracts may be a problem** as with other approaches to iterative development.



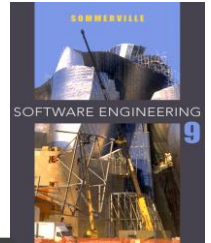
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- ✧ Consequently, agile methods have to rely on contracts in which the **customer pays for the time required for system development** rather than the development of a specific set of requirements.

Agile methods and software maintenance



- ✧ Most organizations **spend more on maintaining existing software than they do on new software development.**
- ✧ So, if **agile methods** are to be successful, **they have to support maintenance as well as original development.**
- ✧ Two key issues:
 - Are systems that are developed using an agile approach **maintainable**, given the emphasis in the development process of **minimizing formal documentation?**
 - **Can agile methods be used effectively for evolving a system** in response to customer change requests?
- ✧ Problems may arise **if original development team** cannot be maintained.

Plan-driven and agile development



✧ Plan-driven development

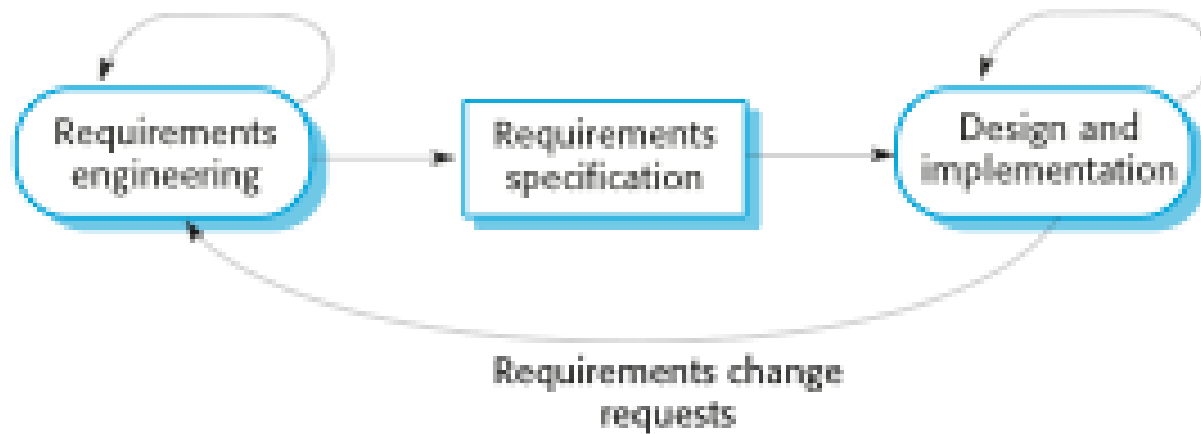
- A plan-driven approach to software engineering is **based around separate development stages** with the **outputs to be produced at each of these stages planned in advance**.
- Not necessarily waterfall model – plan-driven, incremental development is possible
- Iteration occurs within activities.

✧ Agile development

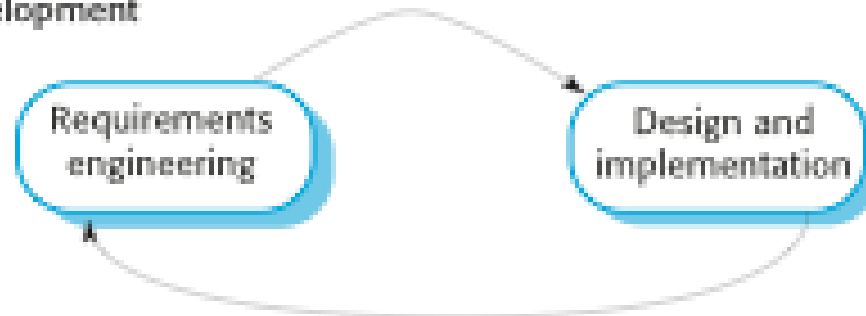
- Specification, design, implementation and testing are **inter-leaved** and the **outputs from the development process are decided through a process of negotiation** during the software development process.

Plan-driven and agile specification

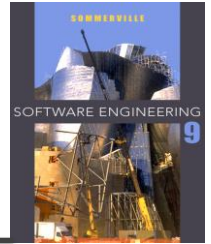
Plan-based development



Agile development

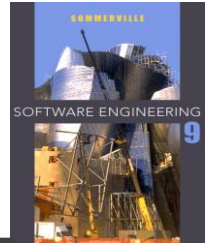


Technical, human, organizational issues



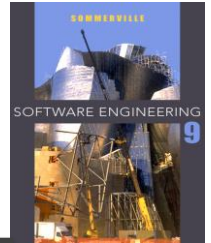
- ✧ Most projects include **elements of plan-driven and agile processes**. Deciding on the balance depends on:
- **Is it important to have a very detailed specification and design** before moving to implementation? If so, you probably need to use a plan-driven approach.
 - Is an incremental delivery strategy, where you deliver the software to customers and get **rapid feedback from them, realistic**? If so, consider using agile methods.
 - **How large is the system** that is being developed? Agile methods are most effective when the system can be developed with a **small co-located team who can communicate informally**. This **may not be possible for large systems** that require larger development teams so a plan-driven approach may have to be used.

Technical, human, organizational issues



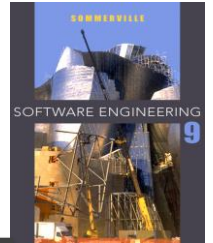
- What **type of system** is being developed?
 - Plan-driven approaches may be required for systems that require a lot of analysis before implementation (e.g. **real-time system with complex timing requirements**).
- What is the **expected system lifetime**?
 - **Long-lifetime systems** may require **more design documentation** to communicate the original intentions of the system developers to the support team.
- **What technologies are available** to support system development?
 - **Agile methods rely on good tools** to keep track of an evolving design
- **How is the development team organized**?
 - If the development **team is distributed** or if part of the development is being **outsourced**, then you may **need to develop design documents** to communicate across the development teams.

Technical, human, organizational issues



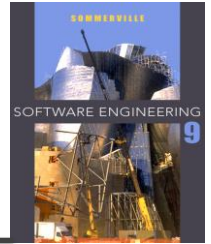
- Are there **cultural or organizational issues** that may affect the system development?
 - Traditional engineering organizations have a culture of plan-based development, as this is the norm in engineering.
- **How good are the designers and programmers** in the development team?
 - It is sometimes argued that **agile methods require higher skill levels than plan-based approaches** in which programmers simply translate a detailed design into code
- **Is the system subject to external regulation?**
 - If a system has to be approved by an external regulator (**e.g. the FAA approve software that is critical to the operation of an aircraft**) then you will probably be required to produce detailed documentation as part of the system safety case.

Extreme programming



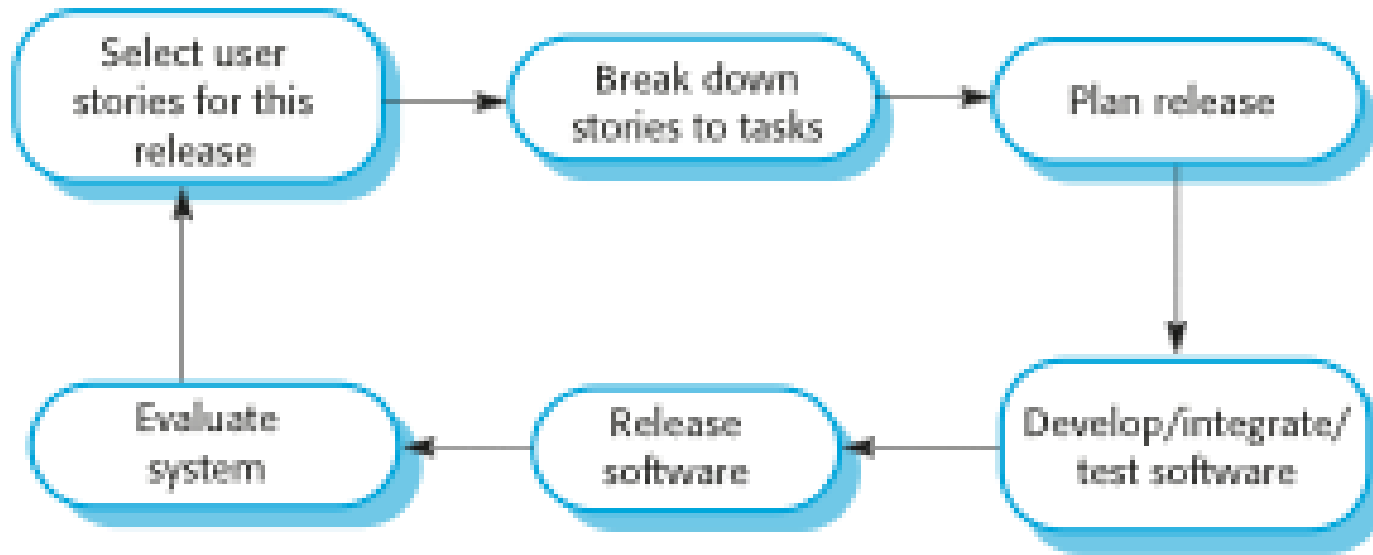
- ✧ Perhaps the **best-known and most widely** used agile method.
- ✧ Extreme Programming (XP) takes an **‘extreme’ approach to iterative development.**
 - **New versions may be built several times per day;**
 - Increments are **delivered to customers every 2 weeks;**
 - **All tests must be run** for every build and the build is only accepted if tests run successfully.

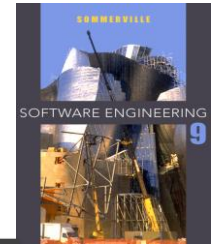
XP and agile principles



- ✧ Incremental development is supported through **small, frequent system releases.**
- ✧ Customer involvement **means full-time customer engagement with the team.**
- ✧ People not process through pair programming, **collective ownership and a process that avoids long working hours.**
- ✧ **Change supported** through regular system releases.
- ✧ **Maintaining simplicity** through **constant refactoring of code.**

The extreme programming release cycle

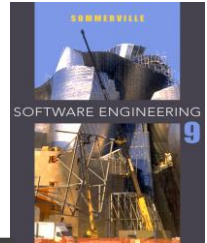




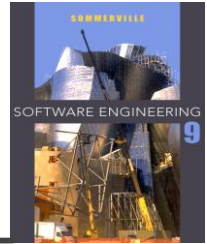
Extreme programming practices (a)

Principle or practice	Description
Incremental planning	Requirements are recorded on story cards and the stories to be included in a release are determined by the time available and their relative priority . The developers break these stories into development 'Tasks' . See Figures 3.5 and 3.6.
Small releases	The minimal useful set of functionality that provides business value is developed first. Releases of the system are frequent and incrementally add functionality to the first release.
Simple design	Enough design is carried out to meet the current requirements and no more .
Test-first development	An automated unit test framework is used to write tests for a new piece of functionality before that functionality itself is implemented .
Refactoring	All developers are expected to refactor the code continuously as soon as possible code improvements are found. This keeps the code simple and maintainable.

Extreme programming practices (b)



Pair programming	Developers work in pairs , checking each other's work and providing the support to always do a good job.
Collective ownership	The pairs of developers work on all areas of the system, so that no islands of expertise develop and all the developers take responsibility for all of the code . Anyone can change anything.
Continuous integration	As soon as the work on a task is complete, it is integrated into the whole system. After any such integration, all the unit tests in the system must pass.
Sustainable pace	Large amounts of overtime are not considered acceptable as the net effect is often to reduce code quality and medium term productivity
On-site customer	A representative of the end-user of the system (the customer) should be available full time for the use of the XP team . In an extreme programming process, the customer is a member of the development team and is responsible for bringing system requirements to the team for implementation.



Requirements scenarios

- ✧ In XP, a customer or user is part of the XP team and is responsible for making decisions on requirements.
- ✧ **User requirements are expressed as scenarios or user stories.**
- ✧ These are **written on cards** and the development team **break them down into implementation tasks**. These tasks are the **basis of schedule and cost estimates**.
- ✧ **The customer chooses the stories** for inclusion in the next release **based on their priorities and the schedule estimates**.

A 'prescribing medication' story

Prescribing medication

The record of the patient must be open for input. Click on the medication field and select either 'current medication', 'new medication' or 'formulary'.

If you select 'current medication', you will be asked to check the dose; if you wish to change the dose, enter the new dose then confirm the prescription.

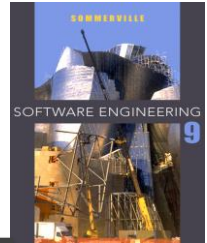
If you choose, 'new medication', the system assumes that you know which medication you wish to prescribe. Type the first few letters of the drug name. You will then see a list of possible drugs starting with these letters. Choose the required medication. You will then be asked to check that the medication you have selected is correct. Enter the dose then confirm the prescription.

If you choose 'formulary', you will be presented with a search box for the approved formulary. Search for the drug required then select it. You will then be asked to check that the medication you have selected is correct. Enter the dose then confirm the prescription.

In all cases, the system will check that the dose is within the approved range and will ask you to change it if it is outside the range of recommended doses.

After you have confirmed the prescription, it will be displayed for checking. Either click 'OK' or 'Change'. If you click 'OK', your prescription will be recorded on the audit database. If you click 'Change', you reenter the 'Prescribing medication' process.

Examples of task cards for prescribing medication



Task 1: Change dose of prescribed drug

Task 2: Formulary selection

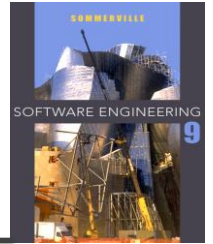
Task 3: Dose checking

Dose checking is a safety precaution to check that the doctor has not prescribed a dangerously small or large dose.

Using the formulary id for the generic drug name, lookup the formulary and retrieve the recommended maximum and minimum dose.

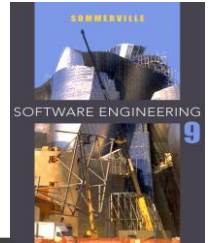
Check the prescribed dose against the minimum and maximum. If outside the range, issue an error message saying that the dose is too high or too low. If within the range, enable the 'Confirm' button.

XP and change



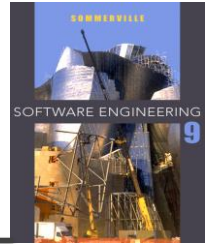
- ✧ **Conventional wisdom** in software engineering is to **design for change**. It is worth spending time and effort anticipating changes as this reduces costs later in the life cycle.
- ✧ XP, however, **maintains that this is not worthwhile** as changes cannot be reliably anticipated.
- ✧ Rather, **it proposes constant code improvement** (refactoring) to make changes easier when they have to be implemented.

Refactoring



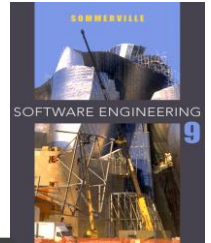
- ✧ Programming team **look for possible software improvements** and **make these improvements** even where there is **no immediate need** for them.
- ✧ This **improves the understandability** of the software and so **reduces the need for documentation**.
- ✧ **Changes are easier to make** because the code is well-structured and clear.
- ✧ However, some changes requires **architecture refactoring** and this is much **more expensive**.

Examples of refactoring

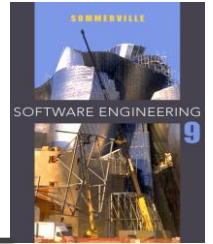


- ✧ **Re-organization of a class hierarchy** to remove duplicate code.
- ✧ **Tidying up and renaming attributes** and methods to make them easier to understand.
- ✧ The **replacement of inline code** with calls to methods that have been included in a program library.

Key points

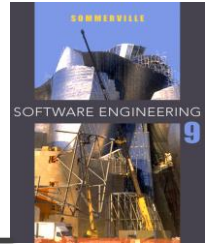


- ✧ Agile methods are incremental development methods that focus on rapid development, frequent releases of the software, reducing process overheads and producing high-quality code. They involve the customer directly in the development process.
- ✧ The decision on whether to use an agile or a plan-driven approach to development should depend on the type of software being developed, the capabilities of the development team and the culture of the company developing the system.
- ✧ Extreme programming is a well-known agile method that integrates a range of good programming practices such as **frequent releases of the software, continuous software improvement and customer participation in the development team.**



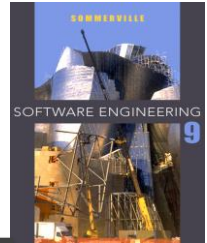
Chapter 3 – Agile Software Development

Lecture 2



Testing in XP

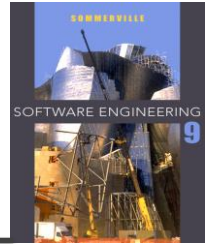
- ✧ Testing is central to XP and XP has developed an approach where **the program is tested after every change has been made.**
- ✧ XP testing features:
 - Test-first development.
 - Incremental test development **from scenarios.**
 - **User involvement** in test development and validation.
 - **Automated test harnesses** are used to run all component tests each time that a new release is built.



Test-first development

- ✧ Writing tests before code **clarifies the requirements** to be implemented.
- ✧ **Tests are written as programs** rather than data so that they **can be executed automatically**. The test includes a check that it has executed correctly.
 - Usually relies on a **testing framework such as Junit**.
- ✧ **All previous and new tests are run automatically** when new functionality is added, thus checking that the **new functionality has not introduced errors**.

Customer involvement



- ✧ The role of the customer in the testing process is **to help develop acceptance tests for the stories** that are to be implemented in the next release of the system.
- ✧ **The customer** who is part of the team **writes tests as development proceeds**. All new code is therefore validated to ensure that it is what the customer needs.
- ✧ However, people adopting the customer role **have limited time available** and so cannot work full-time with the development team. **They may feel that providing the requirements was enough** of a contribution and so may be reluctant to get involved in the testing process.

Test case description for dose checking

Test 4: Dose checking

Input:

1. A number in mg representing a single dose of the drug.
2. A number representing the number of single doses per day.

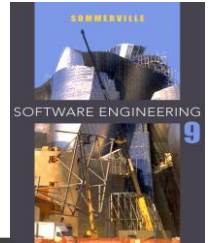
Tests:

1. Test for inputs where the single dose is correct but the frequency is too high.
2. Test for inputs where the single dose is too high and too low.
3. Test for inputs where the single dose * frequency is too high and too low.
4. Test for inputs where single dose * frequency is in the permitted range.

Output:

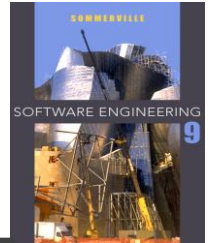
OK or error message indicating that the dose is outside the safe range.

Test automation



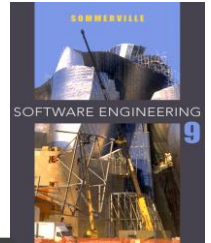
- ✧ Test automation means that **tests are written as executable components** before the task is implemented
 - These testing components should be stand-alone, should **simulate the submission of input to be tested and should check that the result meets the output specification.**
 - An **automated test framework** (e.g. Junit) is a system that **makes it easy**
 - to write **executable tests** and
 - **submit a set of tests for execution.**
- ✧ As testing is automated, **there is always a set of tests that can be quickly and easily executed**
 - Whenever any functionality is added to the system, the tests can be run and problems that the new code has introduced can be caught immediately

XP testing difficulties



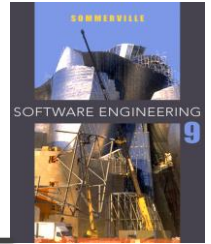
- ✧ Programmers **prefer programming to testing** and sometimes they take short cuts when writing tests. For example, **they may write incomplete tests** that do not check for all possible exceptions that may occur.
- ✧ **Some tests can be very difficult to write incrementally.** For example, in a complex user interface, it is often difficult to write unit tests for the code that implements the ‘display logic’ and workflow between screens.
- ✧ **It difficult to judge the completeness of a set of tests.** Although you may have a lot of system tests, your test set **may not provide complete coverage.**

Pair programming

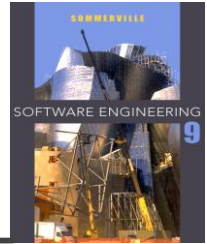


- ✧ In XP, programmers work in pairs, **sitting together to develop code.**
- ✧ This helps develop **common ownership of code** and **spreads knowledge** across the team.
- ✧ It serves as **an informal review process** as each line of code is looked at by more than 1 person.
- ✧ It **encourages refactoring** as the whole team can benefit from this.
- ✧ Measurements suggest that **development productivity** with pair programming is **similar to that of two people working independently.**

Pair programming

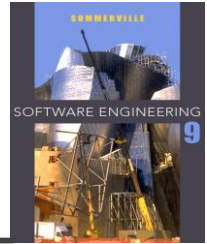


- ✧ In pair programming, **programmers sit together** at the same workstation to develop the software.
- ✧ **Pairs are created dynamically** so that all team members work with each other during the development process.
- ✧ The **sharing of knowledge** that happens during pair programming is very important as **it reduces the overall risks to a project when team members leave**.
- ✧ Pair programming is **not necessarily inefficient** and there is evidence that a pair working together is more efficient than 2 programmers working separately.



Advantages of pair programming

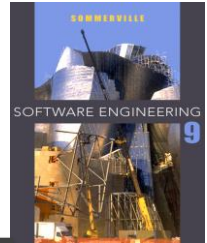
- ✧ It supports the idea of **collective ownership** and responsibility for the system.
 - **Individuals are not held responsible for problems** with the code. Instead, the team has collective responsibility for resolving these problems.
- ✧ It acts as an **informal review process** because each line of code is looked at by at least two people.
- ✧ It helps **support refactoring**, which is a process of software improvement.
 - Where pair programming and collective ownership are used, others benefit immediately from the refactoring so they are likely to support the process.



Agile project management

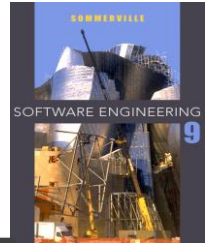
- ✧ The **principal responsibility** of software project managers is to **manage the project so that the software is delivered on time and within the planned budget** for the project.
- ✧ The **standard approach** to project management is **plan-driven**. Managers draw up a plan for the project showing what should be delivered, when it should be delivered and who will work on the development of the project deliverables.
- ✧ Plan-based approach really **requires a manager to have a stable view of everything that has to be developed** and the development processes.

Agile project management requires a different approach



- ✧ However, **it does not work well with agile methods** where the **requirements are developed incrementally**; where the **software is delivered in short, rapid increments**; and where **changes to the requirements and the software are the norm**
- ✧ Agile project management **requires a different approach**, which is **adapted to incremental development** and the particular strengths of agile methods.

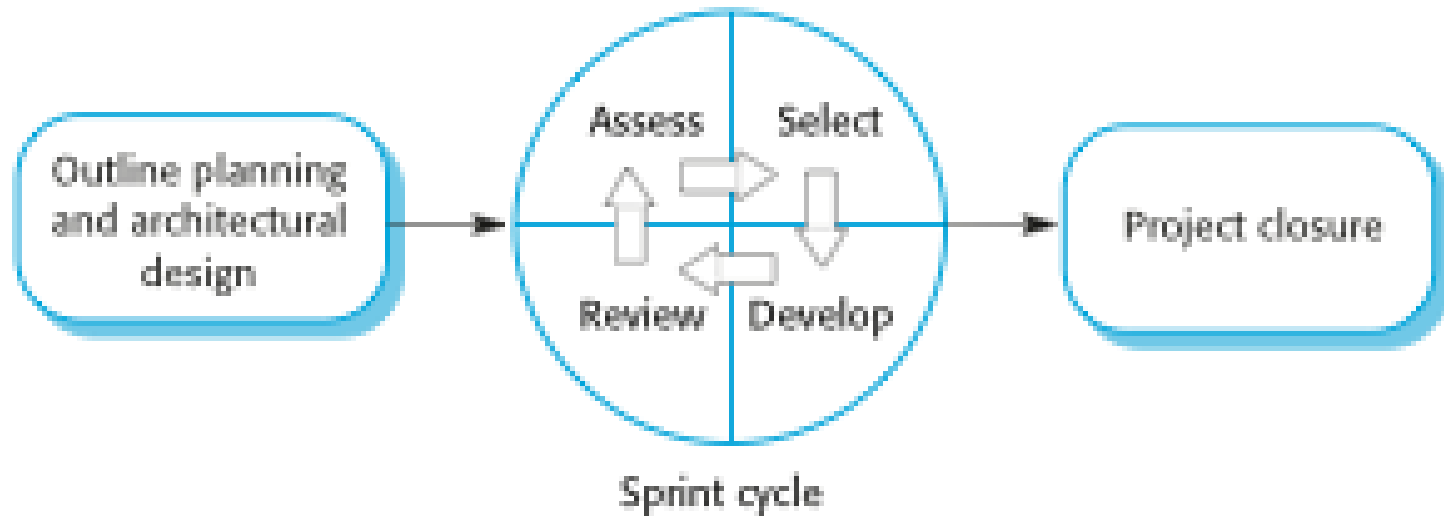
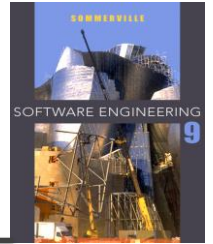
Scrum



- ✧ The Scrum approach is a **general agile method**
- ✧ but its **focus is on managing iterative development** rather than specific agile practices.
- ✧ Scrum **does not prescribe the use of programming practices** such as pair programming and test-first development.
- ✧ There are three phases in Scrum.
 - **The initial phase** is an outline planning phase where you **establish the general objectives** for the project and **design the software architecture**.
 - This is followed by a series of **sprint cycles**, where each cycle develops an increment of the system.
 - **The project closure phase** wraps up the project, **completes required documentation** such as system help frames and **user manuals** and **assesses the lessons learned from the project**.

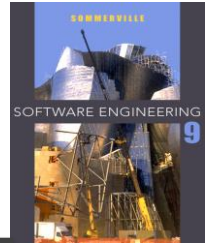


The Scrum process

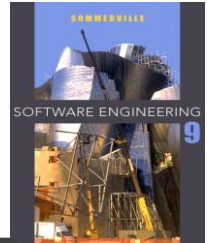


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- ✧ The **innovative feature of Scrum** is its central phase, namely the sprint cycles.
 - ✧ A Scrum sprint **is a planning unit** in which
 - the work to be done is **assessed**,
 - **features are selected for development**,
 - **and the software is implemented.**
 - ✧ At the end of a sprint, the completed functionality is delivered to stakeholders.

The Sprint cycle: Key characteristics



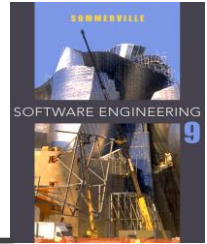
- ✧ Sprints are **fixed length**, normally 2–4 weeks. They correspond to the development of a release of the system in XP.
- ✧ **The starting point for planning is the product backlog**, which is **the list of work to be done** on the project.
- ✧ During the assessment phase of the sprint, **the backlog is reviewed, and priorities and risks are assigned**. The **customer is closely involved** in this process and **can introduce new requirements or tasks** at the beginning of each sprint.
- ✧ **The selection phase involves all of the project team** who work **with the customer** to select the features and functionality to be developed during the sprint.



The Sprint cycle

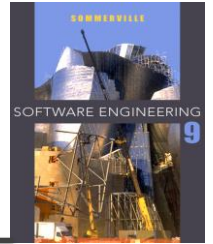
- ✧ **Once these are agreed**, the team organize themselves to develop the software.
- ✧ During this stage **the team is isolated from the customer** and the organization, with all **communications channelled through the so-called 'Scrum master'**.
- ✧ The role of the **Scrum master is to protect** the development team from **external distractions**.
- ✧ **Unlike XP** , Scrum does not make specific suggestions on how to write requirements, test-first development, etc
- ✧ **At the end of the sprint, the work done is reviewed and presented to stakeholders.** The next sprint cycle then begins.

Teamwork in Scrum



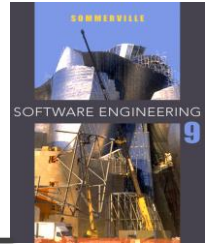
- ✧ The idea behind Scrum is that the **whole team should be empowered to make decisions**
- ✧ so the term ‘**project manager**’, has been deliberately avoided.
- ✧ **The ‘Scrum master’ is a facilitator** who
 - arranges daily meetings,
 - tracks the backlog of work to be done,
 - records decisions,
 - measures progress against the backlog and
 - communicates with customers and management outside of the team.
- ✧ The whole team attends **short daily meetings** where all team **members share information, describe their progress** since the last meeting, **problems that have arisen and what is planned** for the following day.
 - This means that **everyone on the team knows what is going on** and, if problems arise, can **re-plan short-term work** to cope with them.

Scrum benefits



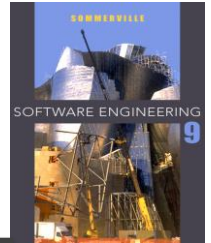
- ✧ The **product is broken** down into a set of manageable and understandable **chunks**.
- ✧ **Unstable requirements do not hold up progress**.
- ✧ The **whole team have visibility of everything** and consequently team communication is improved.
- ✧ **Customers see on-time delivery of increments** and gain feedback on how the product works.
- ✧ **Trust between customers and developers is established** and a positive culture is created in which everyone expects the project to succeed.

Scaling agile methods

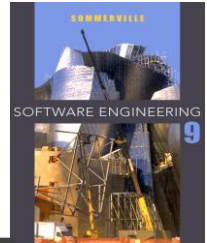


- ✧ Agile methods have proved to be **successful for small and medium sized projects** that can be developed by a small **co-located team (Perhaps working in the same room and communicate informally)**.
- ✧ It is sometimes argued that **the success of these methods comes because of improved communications** which is possible when everyone is working together.
- ✧ **Scaling up agile methods** involves changing these to cope with larger, **longer projects** where there are **multiple development teams, perhaps working in different locations**.

Large systems development

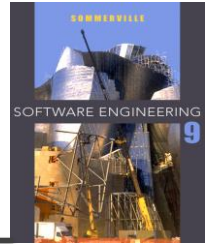


- ✧ Large systems are usually collections of separate, communicating systems, where separate teams develop each system. Frequently, these teams are working in different places, sometimes in different time zones.
- ✧ Large systems are ‘brownfield systems’, that is they include and interact with a number of existing systems. Many of the system requirements are concerned with this interaction and so don’t really lend themselves to flexibility and incremental development.
- ✧ Where several systems are integrated to create a system, a significant fraction of the development is concerned with system configuration rather than original code development.



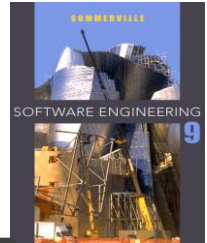
Large system development

- ✧ Large systems and their development processes are **often constrained by external rules and regulations**
 - ➔ **limiting the way that they can be developed.**
- ✧ Large systems have a **long procurement and development time.**
 - ➔ It is **difficult to maintain coherent teams** who know about the system over that period as, inevitably, **people move on to other jobs and projects.**
- ✧ Large systems usually **have a diverse set of stakeholders.**
 - ➔ It is practically **impossible to involve all of these different stakeholders** in the development process.



Scaling out and scaling up

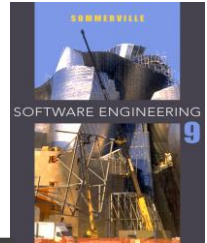
- ✧ ‘Scaling up’ is concerned with using agile methods for developing **large software systems** that cannot be developed by a small team.
- ✧ ‘Scaling out’ is concerned with **how agile methods can be introduced across a large organization** with many years of software development experience.
- ✧ When scaling agile methods **it is essential to maintain agile fundamentals**
 - **Flexible planning, frequent system releases, continuous integration, test-driven development and good team communications.**



Scaling up to large systems

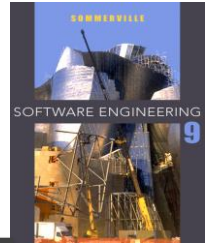
- ✧ For large systems development, **it is not possible to focus only on the code of the system.**
- ✧ You need to do more **up-front design and system documentation**
- ✧ **Cross-team communication mechanisms** have to be designed and used.
- ✧ This should involve **regular phone and video conferences** between team members and frequent, short electronic meetings where teams update each other on progress.
- ✧ **Continuous integration**, where **the whole system is built** every time any developer checks in a change, is practically impossible.
- ✧ However, **it is essential to maintain frequent system**

Scaling out to large companies



- ✧ **Project managers** who do not have experience of agile methods **may be reluctant to accept the risk of a new approach.**
- ✧ Large organizations often have **quality procedures and standards** that all projects are expected to follow and, because of their bureaucratic nature, **these are likely to be incompatible with agile methods.**
- ✧ Agile methods seem to **work best when team members** have a relatively **high skill level.** However, within large organizations, there are likely to be a wide range of skills and abilities.
- ✧ There may be **cultural resistance to agile methods,** especially in those organizations that have a long history of using conventional systems engineering processes.

Key points



- ✧ A particular strength of extreme programming is the development of automated tests before a program feature is created. All tests must successfully execute when an increment is integrated into a system.
- ✧ The Scrum method is an agile method that provides a project management framework. It is centred round a set of sprints, which are fixed time periods when a system increment is developed.
- ✧ Scaling agile methods for large systems is difficult. Large systems need up-front design and some documentation.