Software Engineering

mainly based on **Bernd Bruegge's** book
**Object-Oriented Software Engineering
using UML, Patterns and Java**

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Software Engineering – the term

- The term "software engineering" was coined by [Anthony Oettinger](#) and then was used in 1968 as a title for the world's first conference on software engineering, sponsored and facilitated by NATO. The conference was attended by international experts on software who agreed on defining best practices for software grounded in the application of engineering. The result of the conference is a report that defines how software should be developed. The original report is publicly available.

Fifty Years of Software Engineering

- The *Online Historical Encyclopaedia of Programming Languages* now lists no less than **8945 different programming languages** [Pigott].

- Given the number and variety of sub-disciplines sheltering under the umbrella term "software engineering":

> **"There are no universal software engineering methods and techniques that are suitable for all systems and all companies. Rather, a diverse set of software engineering methods and tools has evolved over the past 50 years."**
>
> **[Pigott, D.]: 'Online Historical Encyclopaedia of Programming Languages'. [http://hopl.info (Accessed 10 April 2018)].**

Fifty Years of Software Engineering_2

- Quoting Geoffrey Elton, the eminent Cambridge historian:

    "The future is dark, the present burdensome. Only the past, dead and finished, bears contemplation. Those who look upon it have survived it; they are its product and its victors. No wonder therefore that men concern themselves with history."

- Quoting **George Santayana:**

    "Those who cannot remember the past are condemned to repeat it".

- **Fifty Years of Software Engineering or The View from Garmisch** - Brian Randell, School of Computing, Newcastle University https://arxiv.org/ftp/arxiv/papers/1805/1805.02742.pdf

Software Engineering Def_Bruegge

- A collection of **principles, methods**, **techniques, methodologies and tools** that help the production of a high-quality software system:

  - with a given budget,
  - before a given deadline,
  - while changes occurs.

Bernd Bruegge

Software Engineering_Def_IEEE

Software Engineering: Definition 2

- *The application of a systematic, disciplined, and quantifiable approach to the development, operation, and maintenance of Software; that is, the application of engineering to software*

  [IEEE, ANSI]

- Software engineering spans whole product lifecycle

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Software Engineering Def_Meyer

The production of operational software satisfying defined
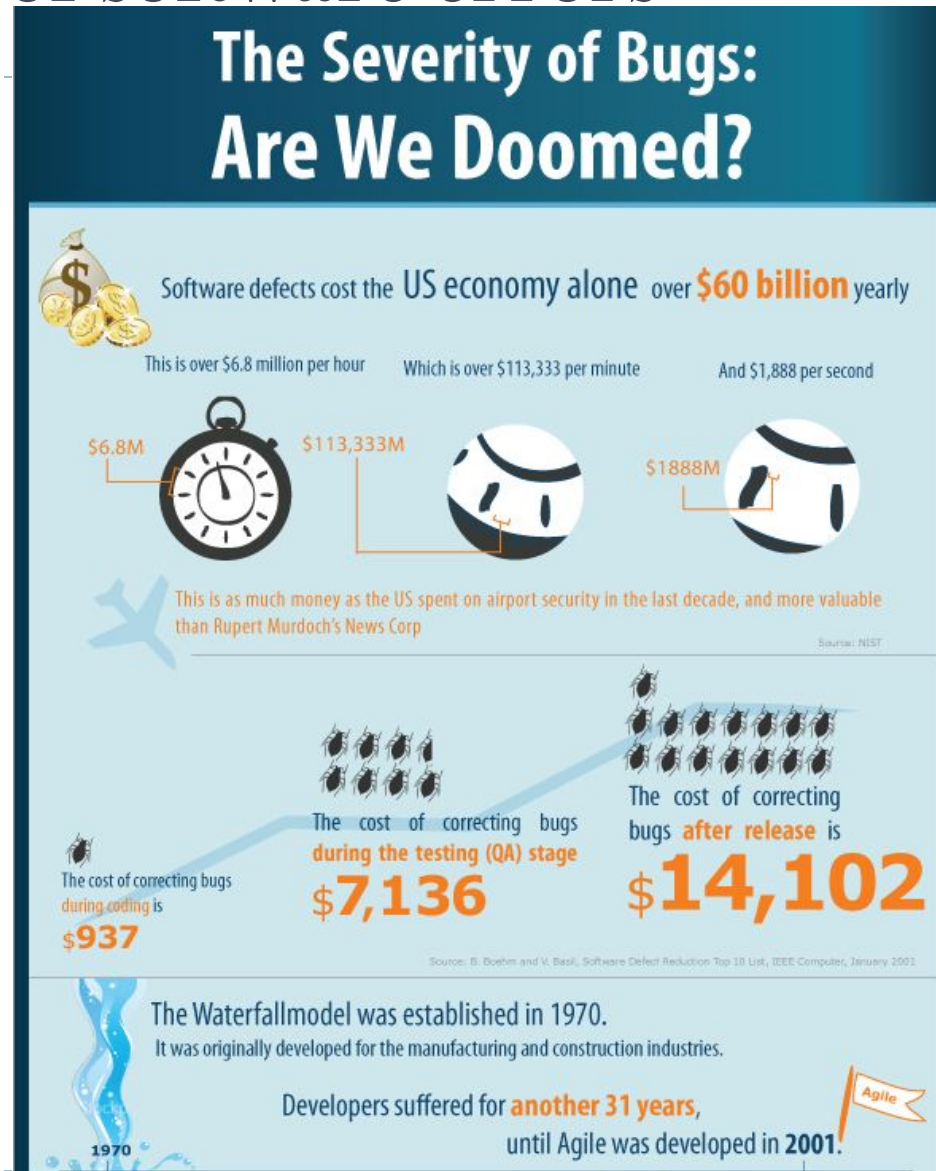   standards of quality

... includes programming, but is more than programming

As von Clausewitz did not write: "the continuation of
   programming through other means".

Bertrand Meyer ETH Zurich – SE

The costs of software errors
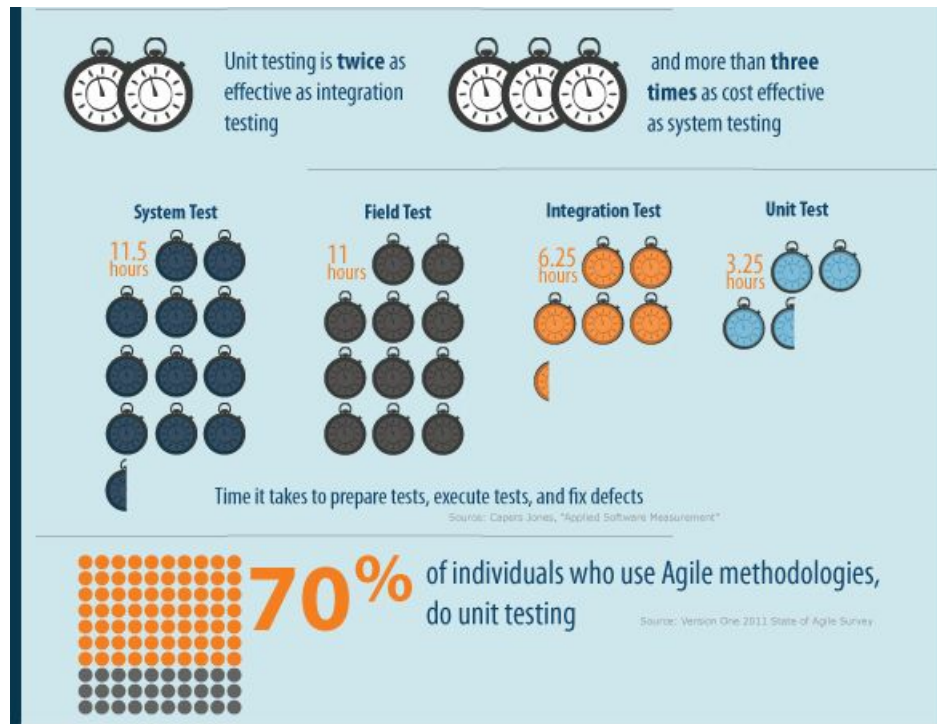
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The costs of software errors...update

- **In 2002**, software bugs cost the United States economy approximately **$59.5 billion** (Software).

- **In 2016**, that number jumped to **$1.1 trillion** (1 trillion = 1000 billion)

- In summary, the cost of poor-quality software in the US **in 2018** is approximately **$2.84 trillion**, the main components of which are seen in the following graph. If we remove the future cost of technical debt, the total becomes **$2.26 trillion**.

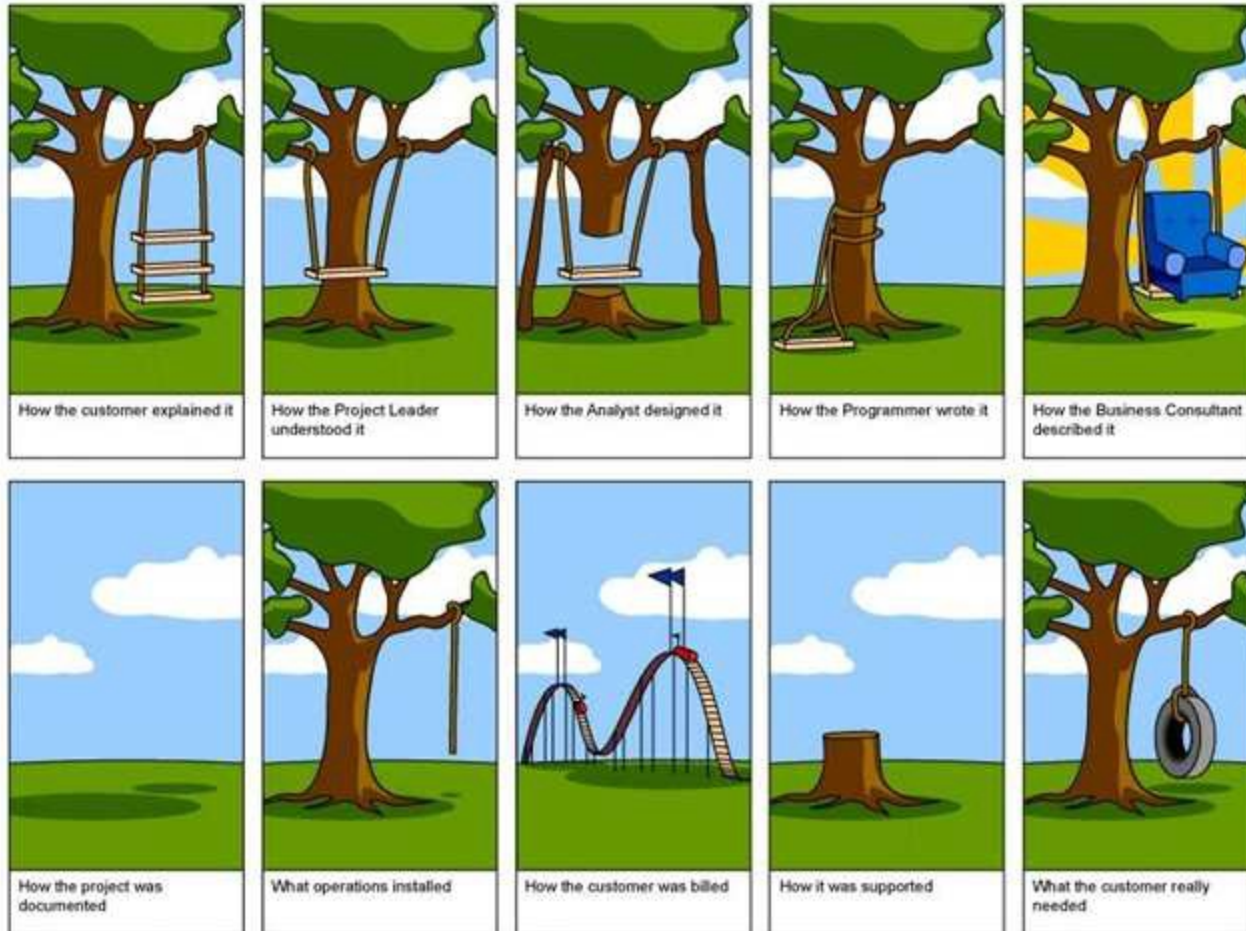- https://it-cisq.org/wp-content/uploads/2018/10/The-Cost-of-Poor-Quality-Software-in-the-US-2018-Report.pdf
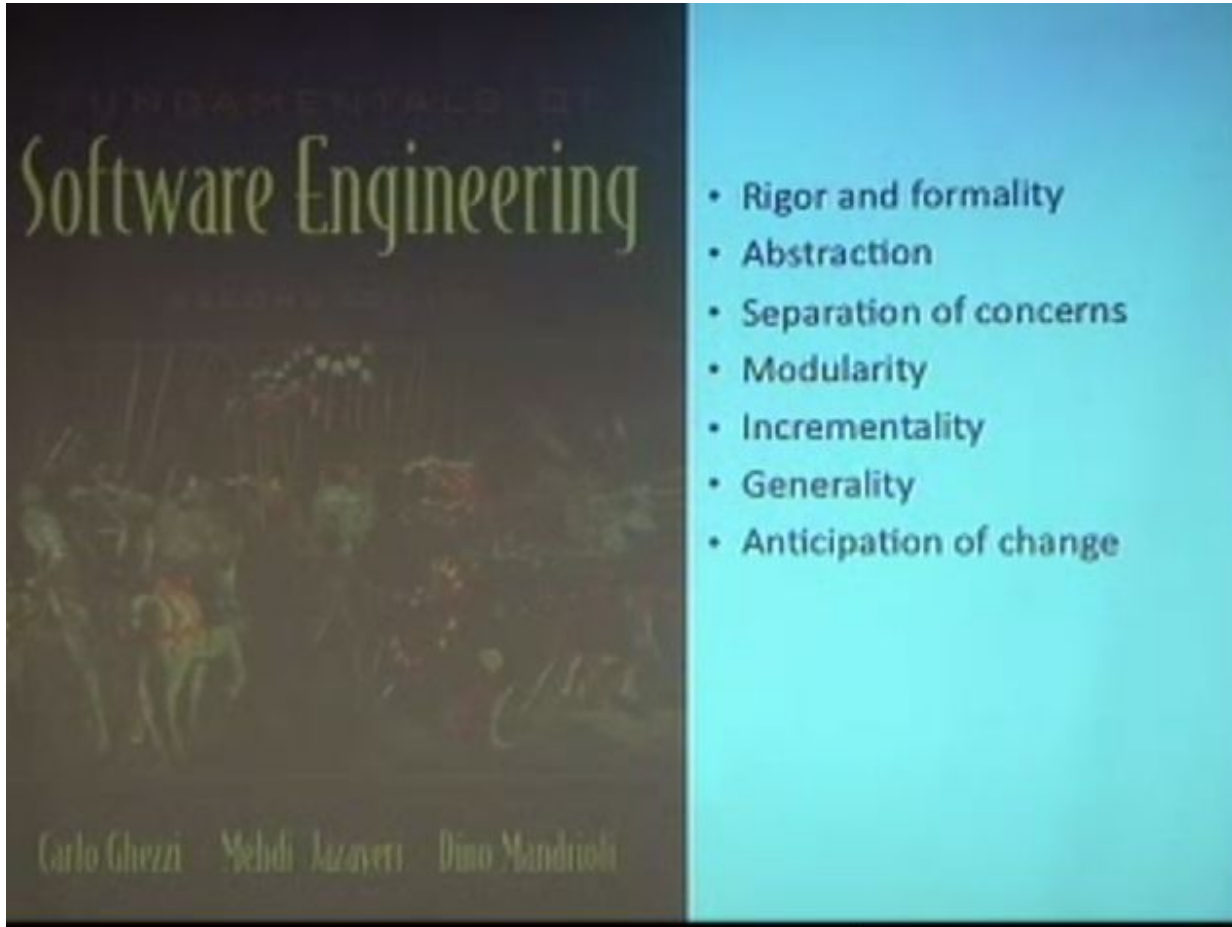
The costs of software errors_2

The first unit testing framework was written on a **plane ride**

There are now hundreds of unit testing frameworks

Agile projects are
300% more successful than non-agile projects

Source: 2011 CHAOS Manifesto from the Standish Group

Not Agile

Agile

Agile adoption is on the rise

78%
of software developers viewed Test Driven Development (TDD) as **improving programmers' productivity**

Source: Boby George, Laurie Williams, An Initial Investigation of Test Driven Development in Industry

According to developers:

It's not a bug if it's found **before QA**

It's a feature if your user **found it**

The costs of software errors_3

https://www.typemock.com/software-bugs-infographic/
https://www.codeguru.com/blog/category/programming/the-cost-of-bugs.html

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The costs of software errors_4

How the customer explained it | How the Project Leader understood it | How the Analyst designed it | How the Programmer wrote it | How the Business Consultant described it

How the project was documented | What operations installed | How the customer was billed | How it was supported | What the customer really needed

When model specification process is hasty ... rationales:

Software Engineering Principles

- Rigor and formality
- Abstraction
- Separation of concerns
- Modularity
- Incrementality
- Generality
- Anticipation of change

Carlo Ghezzi, Mehdi Jazayeri and Dino Mandrioli
see https://www.youtube.com/watch?v=8kG15VoNxhc.

Software Engineering Principles_2

The Role of Principles

Support the application of methods, techniques, and methodologies

Packages of methods and techniques

Tools

General guidelines that govern activities

Methodologies

More technical and mechanic than methods

Methods and techniques

Principles

General and abstract descriptions of desirable properties of products and processes
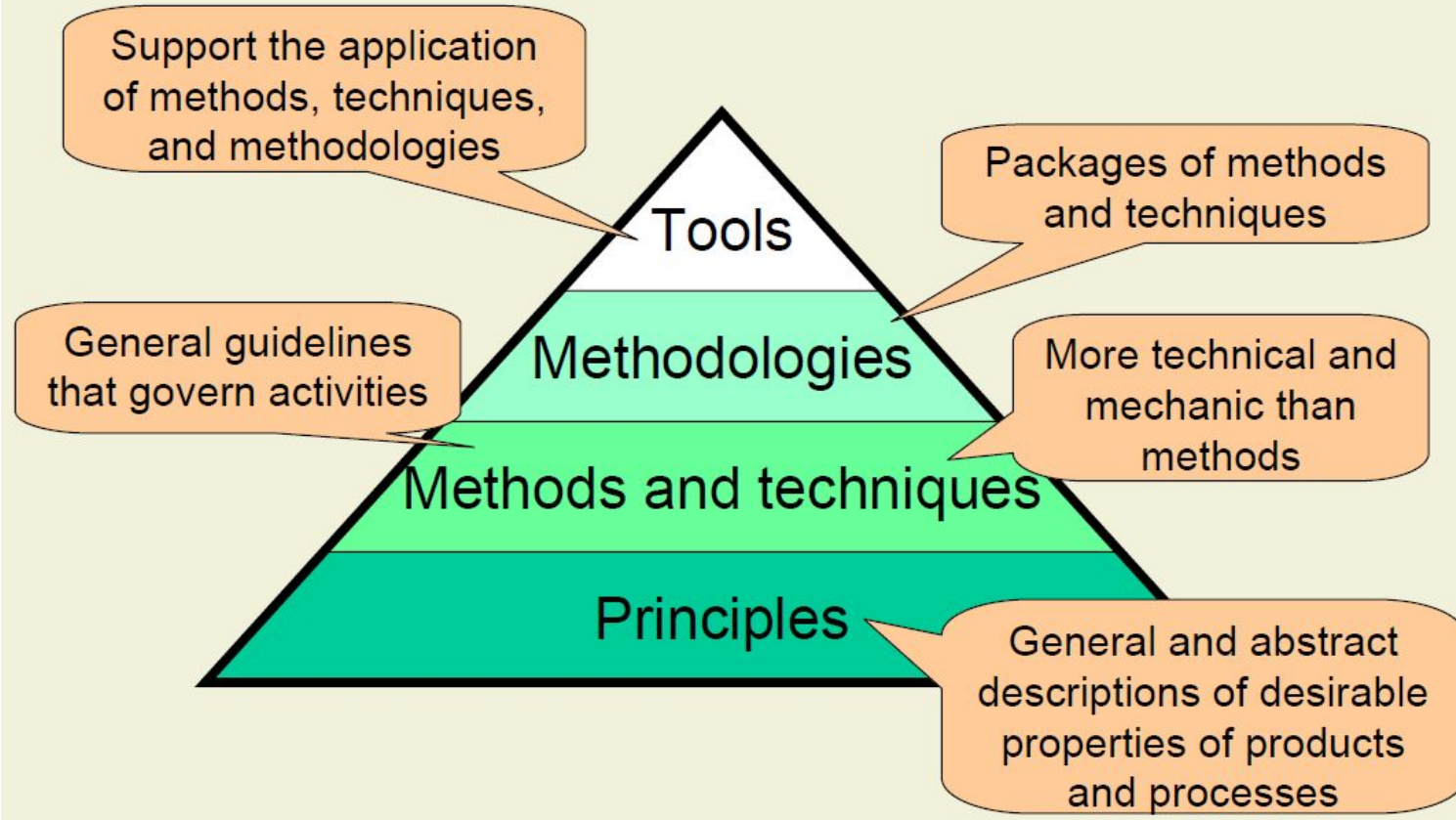
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Software Engineering Principles_3

Important Software Engineering Principles

- Rigor and formality
- Separation of concerns
- Modularity
- Abstraction
- Anticipation of change
- Generality
- Incrementality

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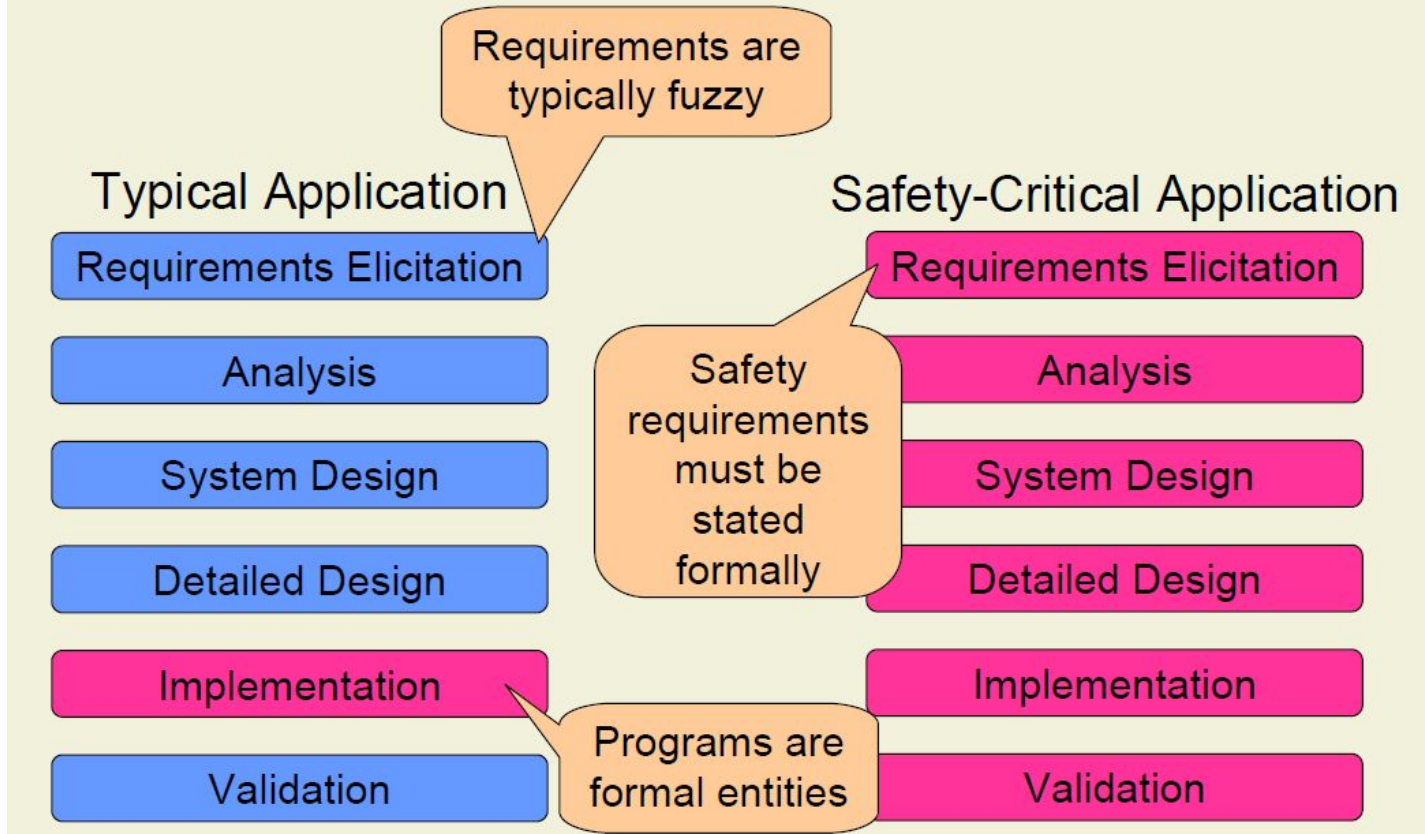# Software Engineering Principles_4

Rigor and Formality

- Rigor means **strict precision**
  - Various degrees of rigor can be achieved
  - Example: mathematical proofs
- Formality is the **highest degree of rigor**
  - Development process driven and evaluated by mathematical laws
  - Examples: refinement
  - Formality enables tool support
- Degree of rigor **depends on application**

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Software Engineering Principles_5

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Software Engineering Principles_7

Separation of Concerns

- Deal with **different aspects** of a problem **separately**
  - **Reduce complexity**
  - Functionality, reliability, performance, environment, etc.
- Many aspects are **related** and **interdependent**
  - Separate unrelated concerns
  - Consider only the relevant details of a related concern
- **Tradeoff**
  - Risk to miss global optimizations
  - Chance to make optimized decisions in the face of complexity is very limited

https://en.wikipedia.org/wiki/Separation_of_concerns

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Software Engineering Principles_7

Modularity

- Divide system into modules to **reduce complexity**

- **Decompose** a complex system into simpler pieces
- **Compose** a complex system from existing modules
- **Understand** the system in terms of its pieces
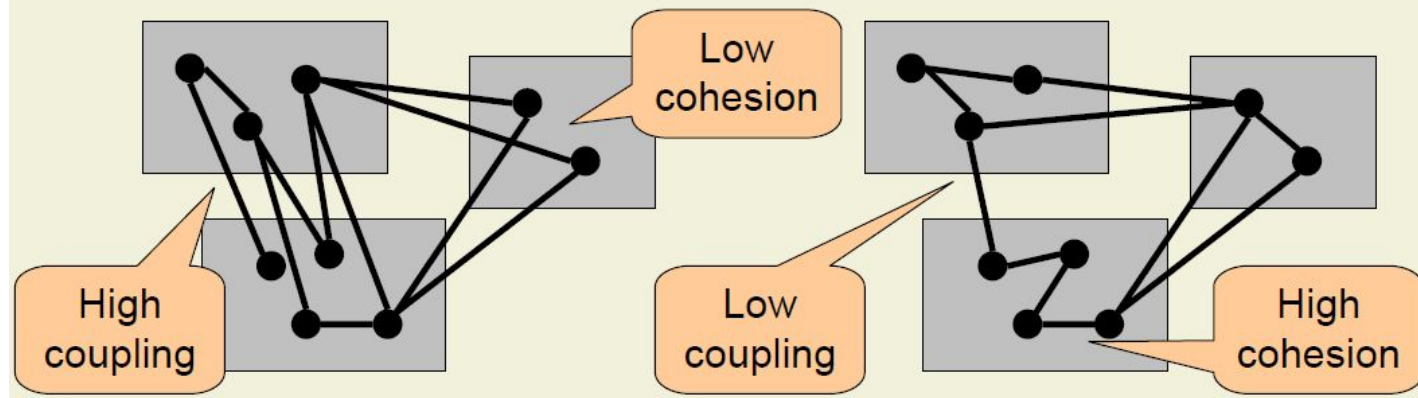- **Modify** a system by modifying only a small number of its pieces

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Software Engineering Principles_8

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Software Engineering Principles_9

Abstraction

- **Identify** the **important aspects** and **ignore** the **details**

- Abstraction in software engineering
  - **Models** of the real world (omit irrelevant details)
  - **Subtyping** and inheritance (factor out commonalities)
  - Interfaces and **information hiding** (hide implementation details)
  - Parameterization (templates)
  - Structured programming (loops, methods)
  - Layered systems (hide deeper layers in the stack)

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Software Engineering Principles_10

Anticipation of Change

- **Prepare** software **for changes**
  - **Modularization**: single out elements that are likely to change in the future
  - **Abstraction**: narrow interfaces reduce effects of a change
- Risk: developers spend too much time to make software changeable and reusable
- Software product lines
  - Many similar versions of software (e.g., for different hardware)
  - Examples: software for cell phones, sensors

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Software Engineering Principles_11

Generality

- Attempt to **find more general problem** behind problem at hand
  - Apply **standard solutions and tools**
- A general solution is more likely to be reusable
  - Examples: spreadsheets, database
- General solution may be less efficient
- Example
  - Semantic analysis: Is C a subclass of D?
  - Subclass relation is an acyclic graph
  - Use adjacency matrix and compute transitive closure

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Software Engineering Principles_12

Incrementality

- Characterizes a process which **proceeds in a stepwise fashion**
  - The desired goal is reached by creating successively closer **approximations** to it
- Examples
  - Incremental software life cycles (e.g., spiral model)
  - Prototypes, early feedback
  - Project management is inherently incremental

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What is Software Engineering?

Software engineering is **a modeling activity**.

Software engineers deal with complexity through modeling, by focusing at any one time on only the relevant details and ignoring everything else.

In the course of development, software engineers build many different models of the system and of the application domain.

What is Software Engineering?_2

SE is a problem-solving activity. Models are used to search for an acceptable solution. This search is driven by experimentation.

Software engineers do not have infinite resources and are constrained by budget and deadlines. Given the lack of a fundamental theory, they often rely on empirical methods to evaluate the benefits of different alternatives.

What is Software Engineering?_3

SE is a **knowledge acquisition activity**.

In **modeling** the **application** **and** **solution** **domain**, **software** **engineers** **collect** **data,** **organize it into information, and formalize it into knowledge**.

Knowledge acquisition is not sequential, **as** **a** **single piece of additional data can invalidate complete models**.

What is Software Engineering?_4

SE is a rationale-driven activity.

When acquiring knowledge and making decisions about the system or its application domain, software engineers also need to capture the context in which decisions were made and the rationale behind these decisions. Rationale information, represented as a set of issue models, enables software engineers to understand the implication of a proposed change when revisiting a decision. We assume that change can occur at any time.

Modeling

- **One of the basic methods of science.**

  ✔ **A model** is **an abstract representation of a system that enables us to answer questions about the system.**

  ✔ **Models** are **useful when dealing with systems that are too large, too small, too complicated, or too expensive to experience firsthand, but not only.** ☺

  ✔ **Models** **also** **allow us to visualize and understand** **systems that either no longer exist or that are only claimed to exist.**

Modeling_2

Software engineers need to:

- **understand the systems they could build,**
- **evaluate different solutions and trade-offs.**

Most systems are too complex to be understood by any one person, and most systems are expensive to build.

To address these challenges, software engineers describe important aspects of the alternative systems they investigate. In other terms, they need to build a model of the solution domain.

Modeling_3

Object-oriented methods combine the application domain and solution domain modeling activities into one.

✔ **The application domain is first modeled as a set of objects and relationships. This model is then used by the system to represent the real-world concepts it manipulates. (A train traffic control system includes train objects representing the trains it monitors. A stock trading system includes transaction objects representing the buying and selling of commodities.)**

✔ **Then, solution domain concepts are also modeled as objects.**

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Modeling_4

- **The idea of object-oriented methods is that the solution domain model is a transformation of the application domain model.**

- **Developing software translates into the activities necessary to identify and describe a system as a set of models that addresses the end user's problem.**

Problem solving

Engineering is a problem-solving activity. Engineers search for an appropriate solution, often by:
- **trial and error,**
- **evaluating alternatives empirically,**

with limited resources and incomplete knowledge.

In its simplest form, the engineering method includes:

1. **Formulate the problem.**
2. **Analyze the problem.**
3. **Search for solutions.**
4. **Decide on the appropriate solution.**
5. **Specify the solution.**

Problem solving_2

Software engineering is an engineering activity, it is not algorithmic. SE requires:

- experimentation,
- the reuse of pattern solutions,
- the incremental evolution of the system.

Object-oriented software development typically includes:

- requirements elicitation,
- analysis,
- system design,
- object design,
- implementation,
- testing

Problem solving_3

Software development **also** **includes** **activities whose purpose is to evaluate the appropriateness of the respective models**.

- **During the analysis review, the application domain model is compared with the client's reality, which in turn might change as a result of modeling**.

- **During the design review, the solution domain model is evaluated against project goals**.

Problem solving_4

- **During testing, the system is validated against the solution domain model, which might be changed by the introduction of new technologies.**

- **During project management, managers compare their model of the development process (i.e., the project schedule and budget) against reality (i.e., the delivered work products and expended resources).**

Knowledge acquisition

- A common mistake that software engineers and managers make is to assume that the acquisition of knowledge needed to develop a system is linear.

- Knowledge acquisition is a nonlinear process. The addition of a new piece of information may invalidate all the knowledge we have acquired for the understanding of a system. Even if we had already documented this understanding in documents and code ("The system is 90% coded, we will be done next week"), we must be mentally prepared to start from scratch.

Knowledge acquisition_2

- **There are several software processes that deal with this problem by avoiding the sequential dependencies inherent in the waterfall model.**

  Risk-based development attempts to anticipate surprises late in a project by identifying the high-risk components. Issue-based development attempts to remove the linearity altogether.

  Any development activity: analysis, system design, object design, implementation, testing, or delivery; can influence any other activity. In issue-based development, all these activities are executed in parallel.

Rationale

- **Assumptions that developers make about a system change constantly. Design and implementation faults discovered during testing and usability problems discovered during user evaluation trigger changes to the solution models. Changes can also be caused by new technology.**

- **A typical task of software engineers is to change a currently operational software system to incorporate this new enabling technology.**

Rationale_2

- To **change the system**, it **is not enough** **to understand its current components and behavior**;

  it is also necessary to **capture and understand** **the context in which each design decision was made**.

  This **additional knowledge** **is called the** **rationale of the system.**

- **Capturing and accessing the rationale** **of a system** **is not trivial**. **For every decision made**, **several alternatives may have been considered, evaluated, and argued**.

Rationale_3

- **Rationale represents a much larger amount of information than do the solution models. Rationale information is often not explicit.**

  Developers make many decisions based on their experience and their intuition, without explicitly evaluating different alternatives. When asked to explain a decision, developers may have to spend a substantial amount of time recovering its rationale.

  In order to deal with changing systems, software engineers must address the challenges of capturing and accessing rationale.

Software Engineering Concepts

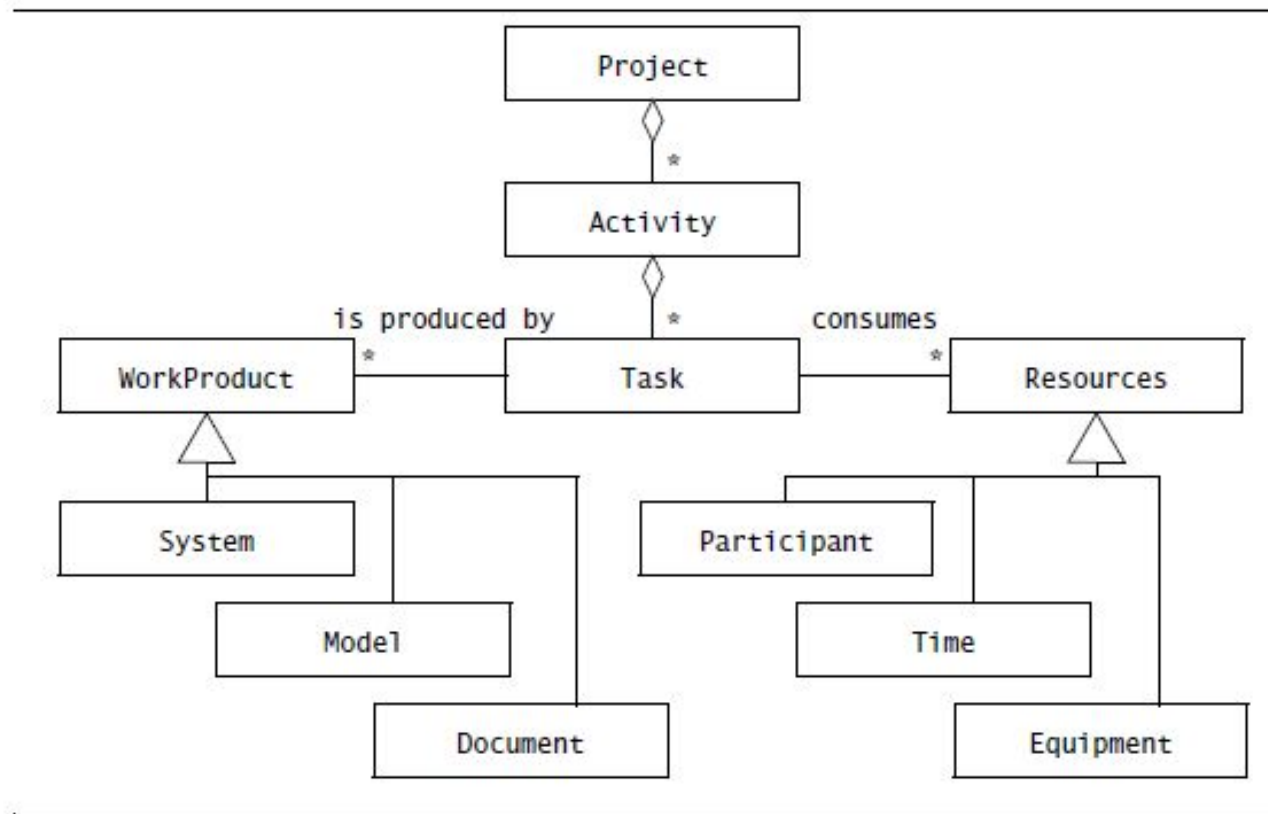## The project purpose is to develop a software system

Figure 1-1 Software engineering concepts depicted as a UML class diagram [OMG, 2009].

Participants and Roles

- **Developing a software system requires the collaboration of many people with different backgrounds and interests:**

  - **the client orders and pays for the system,**
  - **the developers construct the system,**
  - **the project manager plans and budgets the project and coordinates the developers and the client,**
  - **the end users are supported by the system.**

Participants and Roles_2

- We refer to all the persons involved in the project as participants.

- We refer to a set of responsibilities in the project or the system as a role.

- A role is associated with a set of tasks and is assigned to a participant. The same participant can fill multiple roles.

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Participants and Roles_3

- **TicketDistributor** **is** **a machine** that **distributes** **tickets for trains**. **Travelers** have the option of **selecting a ticket for** a **single trip** or for **multiple trips**, or **selecting a timecard for a day or a week**.
  The **TicketDistributor** **computes the price of the requested ticket based on the area in which the trip will take place and whether the traveler is a child or an adult**.

- The **TicketDistributor** **must be able to handle several exceptions,** such as **travelers who do not complete the transaction**, **travelers who attempt to pay with large bills**, and **resource outages**, such as **running out of tickets**, **change**, or **power**.

Systems & models

- **We use** the **term system** as **a collection of interconnected parts**.

  Modeling is a way to deal with complexity by ignoring irrelevant details. We use the term **model to refer** to **any abstraction of the system**.

  A **TicketDistributor** for **an underground train is a system**.

  Blueprints for the **TicketDistributor**, **schematics of its electrical wiring**, and **object models of its software are models of the TicketDistributor**

Systems & models_2

- **A development project is itself a system that can be modeled.**

- **The project schedule, its budget, and its planned deadlines are models of the development project.**

Example of roles in Software Engineering

Table 1-1   Examples of roles in software engineering for the TicketDistributor project.

Role	Responsibilities	Examples
Client	The client is responsible for providing the high-level requirements on the system and for defining the scope of the project (delivery date, budget, quality criteria).	Train company that contracts the TicketDistributor.
User	The user is responsible for providing domain knowledge about current user tasks. Note that the client and the user are usually filled by different persons.	Travelers
Manager	A manager is responsible for the work organization. This includes hiring staff, assigning them tasks, monitoring their progress, providing for their training, and generally managing the resources provided by the client for a successful delivery.	Alice (boss)
Human Factors Specialist	A human factors specialist is responsible for the usability of the system.	Zoe (Human Computer Interaction specialist)
Developer	A developer is responsible for the construction of the system, including specification, design, implementation, and testing. In large projects, the developer role is further specialized.	John (analyst), Marc (programmer), & Zoe (tester)[a]
Technical Writer	The technical writer is responsible for the documentation delivered to the client. A technical writer interviews developers, managers, and users to understand the system.	John

Work products

- A **work product** **is an artifact that is produced during the development, such as a document or a piece of software for other developers or for the client.**

- We **refer** **to a work product for the project's internal consumption as an internal work product.**

- We **refer** **to a work product that must be delivered to a client as a deliverable.**
  Deliverables are generally defined prior to the start of the project and specified by a contract binding the developers with the client.

Work products_2

Table 1-2 Examples of work products for the `TicketDistributor` project.

Work product	Type	Description
Specification	Deliverable	The specification describes the system from the user's point of view. It is used as a contractual document between the project and the client. The `TicketDistributor` specification describes in detail how the system should appear to the traveler.
Operation manual	Deliverable	The operation manual for the `TicketDistributor` is used by the staff of the train company responsible for installing and configuring the `TicketDistributor`. Such a manual describes, for example, how to change the price of tickets and the structure of the network into zones.
Status report	Internal work product	A status report describes at a given time the tasks that have been completed and the tasks that are still in progress. The status report is produced for the manager, Alice, and is usually not seen by the train company.
Test manual	Internal work product	The test plans and results are produced by the tester, Zoe. These documents track the known defects in the prototype `TicketDistributor` and their state of repair. These documents are usually not shared with the client.

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Activities, Tasks, and Resources

- **Activity** - **a set of tasks that is performed toward a specific purpose**. For example:

  ✔ **requirements elicitation** **is an activity whose purpose is to define with the client what the system will do**,

  ✔ **delivery is an activity whose purpose is to install the system at an operational location**,

  ✔ **management is an activity whose purpose is to monitor and control the project such that it meets its goals (e.g., deadline, quality, budget).**

Activities, Tasks, and Resources_2

- **Activities can be composed of other activities. The delivery activity includes a software installation activity and an operator training activity. Activities are also sometimes called phases.**

- **A task represents an atomic unit of work that can be managed. A manager assigns it to a developer, the developer carries it out, and the manager monitors the progress and completion of the task. Tasks consume resources, result in work products, and depend on work products produced by other tasks.**

Activities, Tasks, and Resources_3

Table 1-3 Examples of activities, tasks, and resources for the `TicketDistributor` project.

Example	Type	Description
Requirements elicitation	**Activity**	The requirements elicitation activity includes obtaining and validating requirements and domain knowledge from the client and the users. The requirements elicitation activity produces the specification work product (Table 1-2).
Develop "Out of Change" test case for `TicketDistributor`	**Task**	This task, assigned to Zoe (the tester) focuses on verifying the behavior of the ticket distributor when it runs out of money and cannot give the correct change back to the user. This activity includes specifying the environment of the test, the sequence of inputs to be entered, and the expected outputs.
Review "Access Online Help" use case for usability	**Task**	This task, assigned to John (the human factors specialist) focuses on detecting usability issues in accessing the online help features of the system.
Tariff Database	**Resource**	The tariff database includes an example of tariff structure with a train network plan. This example is a resource provided by the client for requirements and testing.

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Functional and non Functional Requirements

- **Requirements specify a set of features that the system must have.**

  ✔ **A functional requirement is a specification of a function that the system must support;**

  ✔ **a nonfunctional requirement is a constraint on the operation of the system that is not related directly to a function of the system.**

Functional and non Functional Requirements_2

- **Functional requirements**:

  ✔ the user **must be able to** purchase tickets
  ✔ the user **must be able to** access tariff information

- **Nonfunctional requirements**:

  ✔ the user **must be provided feedback** in less than one second
  ✔ the colors **used in the interface** should be consistent with the company colors

Methods, and Methodologies

- **Modeling language/notation**

- **A method is a repeatable technique that specifies the steps involved in solving a specific problem. Examples:**
  - a recipe is a method for cooking a specific dish,
  - a sorting algorithm is a method for ordering elements of a list,
  - rationale management is a method for justifying change,
  - configuration management is a method for tracking change.

Methods, and Methodologies_2

- A **methodology** **is a** **collection of methods for solving a class of problems and specifies how and when each method should be used**.

- A **seafood cookbook with a collection of recipes** **is a** **methodology for preparing seafood if it also contains advices on how ingredients should be used and what to do if not all ingredients are available**.

Software Engineering Development Activities

- **Development activities deal with the complexity by constructing and validating models of the application domain or the system.**

  Development activities include:
  - ✔ **Requirements Elicitation**
  - ✔ **Analysis**
  - ✔ **System Design**
  - ✔ **Object Design**
  - ✔ **Implementation**
  - ✔ **Testing**

Software Engineering Development Activities_2

Requirements Elicitation

- **During requirements elicitation, the client and developers define the purpose of the system. The result of this activity is a description of the system in terms of actors and use cases. Actors represent the external entities that interact with the system.**

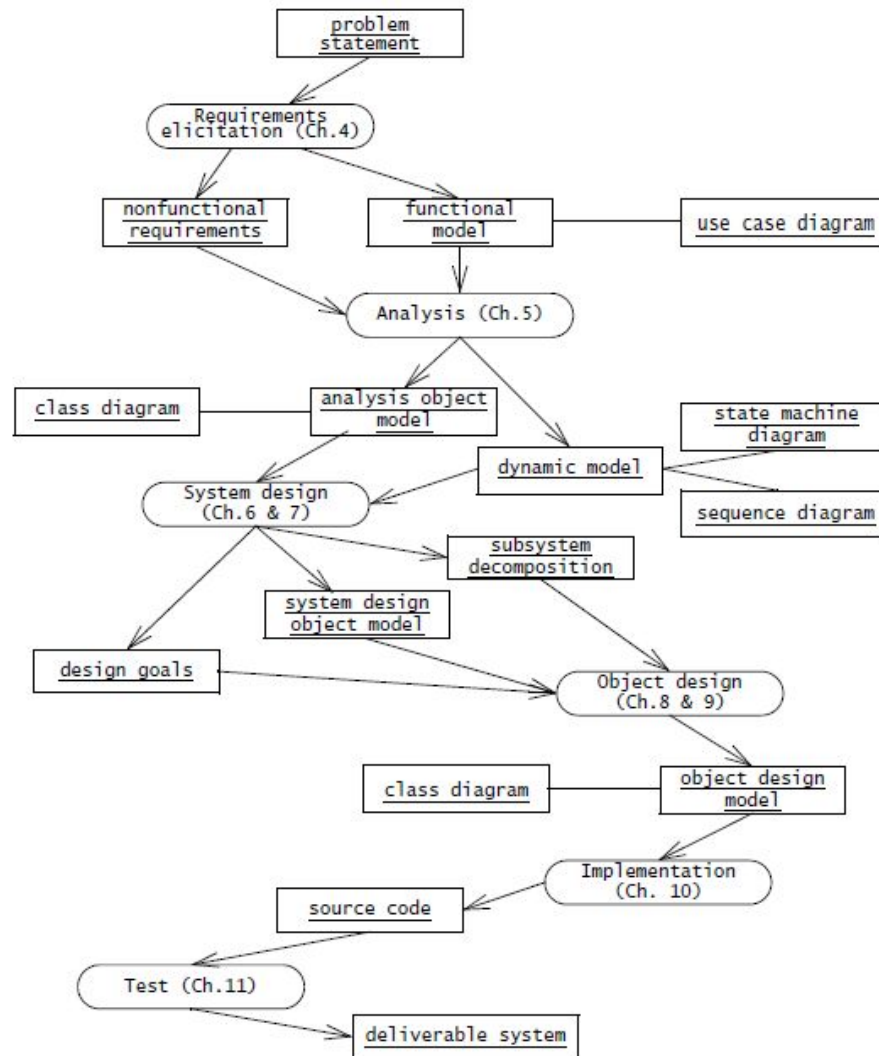# Software Engineering Development Activities_3

Figure 1-2 An overview of object-oriented software engineering development activities and their products. This diagram depicts only logical dependencies among work products. Object-oriented software engineering is iterative; that is, activities can occur in parallel and more than once.

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Software Engineering Development Activities_4

Use case name	PurchaseOneWayTicket
Participating actor	Initiated by Traveler
Flow of events	1. The Traveler selects the zone in which the destination station is located. 2. The TicketDistributor displays the price of the ticket. 3. The Traveler inserts an amount of money that is at least as much as the price of the ticket. 4. The TicketDistributor issues the specified ticket to the Traveler and returns any change.
Entry condition	The Traveler stands in front of the TicketDistributor, which may be located at the station of origin or at another station.
Exit condition	The Traveler holds a valid ticket and any excess change.
Quality requirements	If the transaction is not completed after one minute of inactivity, the TicketDistributor returns all inserted change.

Figure 1-3   An example of use case, PurchaseOneWayTicket.

Analysis

- **Developers**:

  - **aim to produce a model of the system that is correct, complete, consistent, and unambiguous,**

  - **transform the use cases produced during requirements elicitation into an object model that completely describes the system,**

  - **discover ambiguities and inconsistencies in the use case model that they resolve with the client.**

Analysis

- **The result of analysis is a system model annotated with attributes, operations, and associations.**

- **The system model can be described in terms of its structure and its dynamic interoperation.**

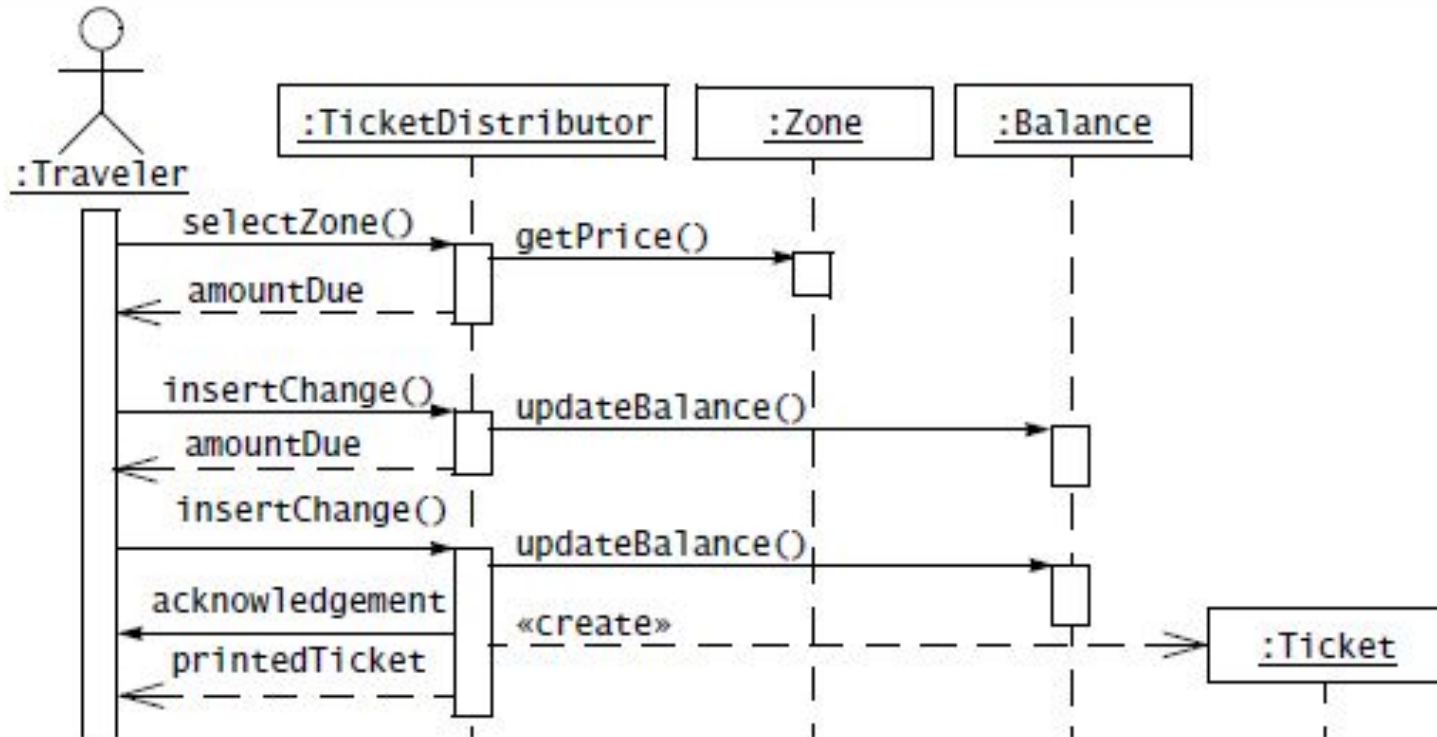# Software Engineering Development Activities_7

Figure 1-4 A dynamic model for the TicketDistributor (UML sequence diagram). This diagram depicts the interactions between the actor and the system during the PurchaseOneWayTicket use case and the objects that participate in the use case.

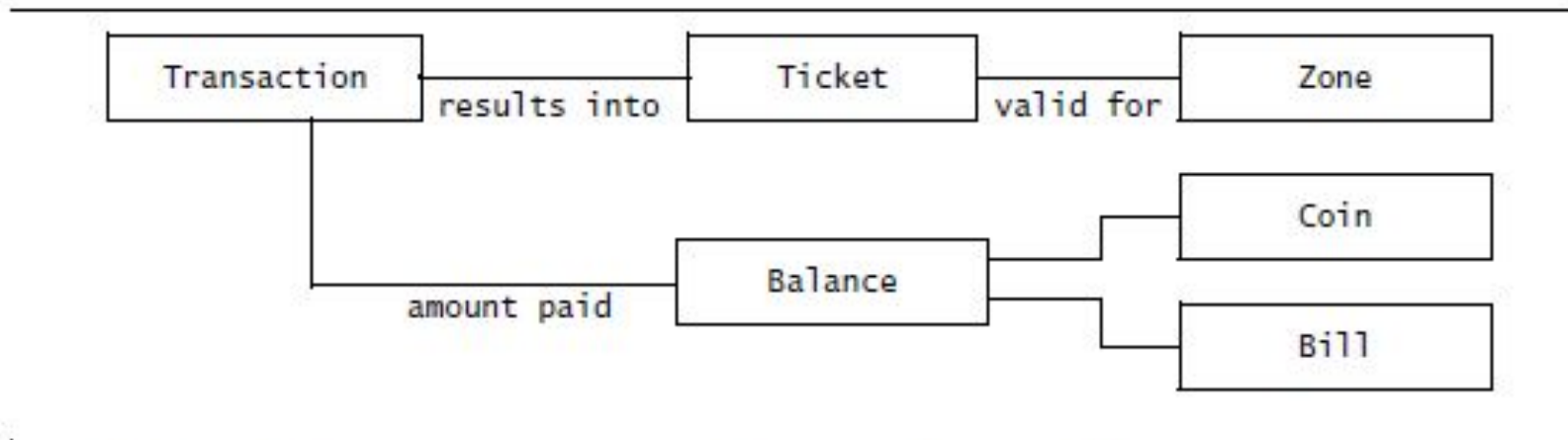# Software Engineering Development Activities_8

Figure 1-5 An object model for the TicketDistributor (UML class diagram). In the PurchaseOneWayTicket use case, a Traveler initiates a transaction that will result in a Ticket. A Ticket is valid only for a specified Zone. During the Transaction, the system tracks the Balance due by counting the Coins and Bills inserted.

System Design
- **Developers:**
  - ✔ **define** the **design goals of the project** and **decompose the system into smaller subsystems that can be realized by individual teams**,
  - ✔ **select strategies for building** the **system**, such as the **hardware/software platform on which the system will run**, **the persistent data management strategy**, **the global control flow**, **the access control policy**, **and the handling of boundary conditions**.

System Design

- ⇒ **a clear description of each of these strategies, a subsystem decomposition, and a deployment diagram representing the hardware/software mapping of the system.**

- **Whereas both analysis and system design produce models of the system under construction, only analysis deals with entities that the client can understand.**

Software Engineering Development Activities_11
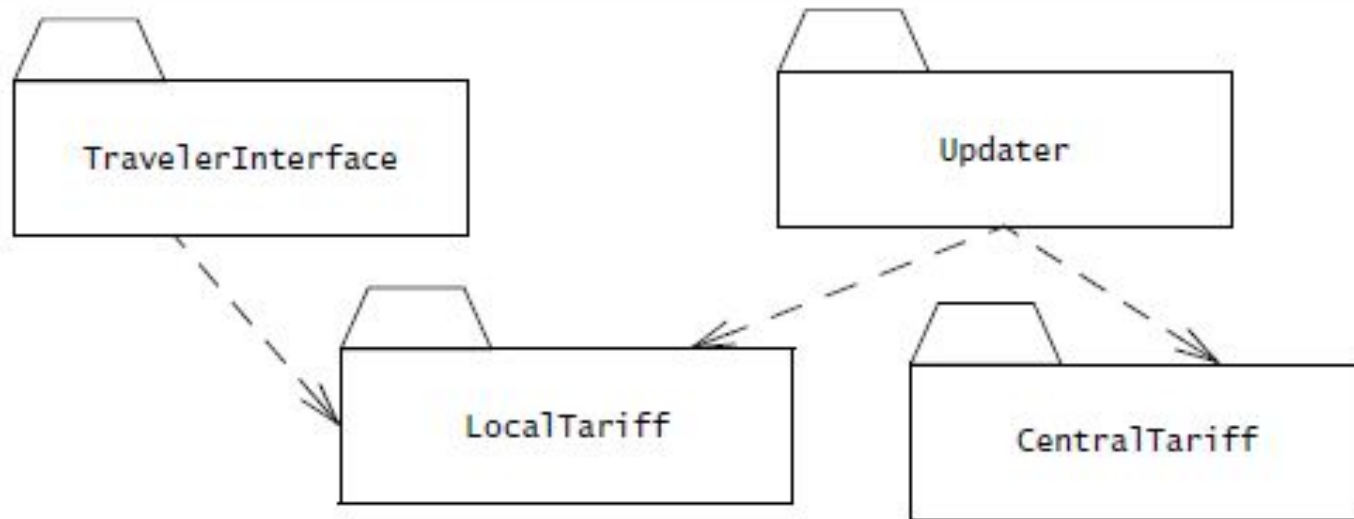
Figure 1-6 A subsystem decomposition for the TicketDistributor (UML class diagram, packages represent subsystems, dashed lines represent dependencies). The TravelerInterface subsystem is responsible for collecting input from the Traveler and providing feedback (e.g., display ticket price, returning change). The LocalTariff subsystem computes the price of different tickets based on a local database. The CentralTariff subsystem, located on a central computer, maintains a reference copy of the tariff database. An Updater subsystem is responsible for updating the local databases at each TicketDistributor through a network when ticket prices change.

Software Engineering Development Activities_12

Object Design

- **developers define solution domain objects to bridge the gap between the analysis model and the hardware/software platform defined during system design**. This includes:

  ✔ **precisely describing object and subsystem interfaces**,

  ✔ **selecting off-the-shelf components**,

  ✔ **restructuring the object model to attain design goals such as extensibility or understandability**,

  ✔ **optimizing the object model for performance**.

Software Engineering Development Activities_13

- **The result of the object design activity is a detailed object model annotated with constraints and precise descriptions for each element.**

Implementation
- **developers translate the solution domain model into source code. This includes implementing the attributes and methods of each object and integrating all the objects such that they function as a single system.**
- **spans the gap between the detailed object design model and a complete set of source code files that can be compiled.**

Software Engineering Development Activities_14

Testing

- developers **find differences** **between the system and its models by executing the system (or parts of it) with sample input data sets.**
  - ✔ **unit testing**, **developers** **compare** **the object design model with each object and subsystem.**
  - ✔ **integration testing**, **combinations of subsystems are integrated together and compared with the system design model.**

Testing

- **system testing**, **typical** and **exception cases** **are run through the system** and **compared with the requirements model**.

- **The goal of testing is to discover as many faults as possible such that they can be repaired before the delivery of the system. The planning of test phases occurs in parallel to the other development activities.**

Managing Software Development

- **Management activities focus on**:

  ✔ **planning the project,**
  ✔ **monitoring its status,**
  ✔ **tracking changes,**
  ✔ **coordinating resources**

  such that a high-quality product is delivered on time and within budget.

- **Management activities not only involve managers, but also most of the other project participants as well.**

Managing Software Development_2

- **Management activities include:**
  - ✔ **Communication**
  - ✔ **Rationale Management**
  - ✔ **Software Configuration Management**
  - ✔ **Project Management**
  - ✔ **Software Life Cycle**

- **As modern software engineering projects become more change driven, the distinction between construction activities and maintenance activities is blurred.**

Managing Software Development_3

Communication

- **is** the most critical and time-consuming activity in software engineering. Misunderstandings and omissions often lead to faults and delays that are expensive to correct later in the development,

- **includes the exchange** of models and documents about the system and its application domain, reporting the status of work products, providing feedback on the quality of work products, raising and negotiating issues, and communicating decisions.

References

- Bernd Bruegge & Allen H. Dutoit - Object-Oriented Software Engineering Using UML, Patterns, and Java – Third Edition – Prentice Hall 2010

- Ian Sommerville – Software Engineering - Ninth Edition – Addison Wesley 2011

- Ivan Marsic –Software Engineering - Rutgers University, New Brunswick, New Jersey 2012

Evaluation

- Course - written exam -   60%
- Optional:
- Partial (half semester) *evaluation* ?
- Seminar/lab activities -   40%

Lab activities - Evaluation

- **Lab is focused on:**
  - small teams working to develop software,
  - usage of models in all phases of software life cycle,
  - using appropriate tools in model construction, validation and code generation
  - constructing rigorous models complying with the requirements, design and implementation,
  - usage of design patterns,
  - code generation, viewed as model transformation,
  - system testing,
- **Teachers will discuss with all team-members about expected deliverables for the current lab**

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Program (project) evaluation and review technique, (PERT)

Once this step is complete, one can draw a Gantt chart or a network diagram.

ID	Task Name	Predecessors	Duration	Jul 23, '06							Jul 30, '06							Aug 6, '06							Aug 13, '06						
				S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	Start		0 days																												
2	a	1	4 days																												
3	b	1	5.33 days																												
4	c	2	5.17 days																												
5	d	2	6.33 days																												
6	e	3,4	5.17 days																												
7	f	5	4.5 days																												
8	g	6	5.17 days																												
9	Finish	7,8	0 days																												

A Gantt chart created using Microsoft Project (MSP). Note (1) the critical path is in red, (2) the slack is the black lines connected to non-critical activities, (3) since Saturday and Sunday are not work days and are thus excluded from the schedule, some bars on the Gantt chart are longer if they cut through a weekend.

Critical Path Method (CPM) – Microsoft Visio

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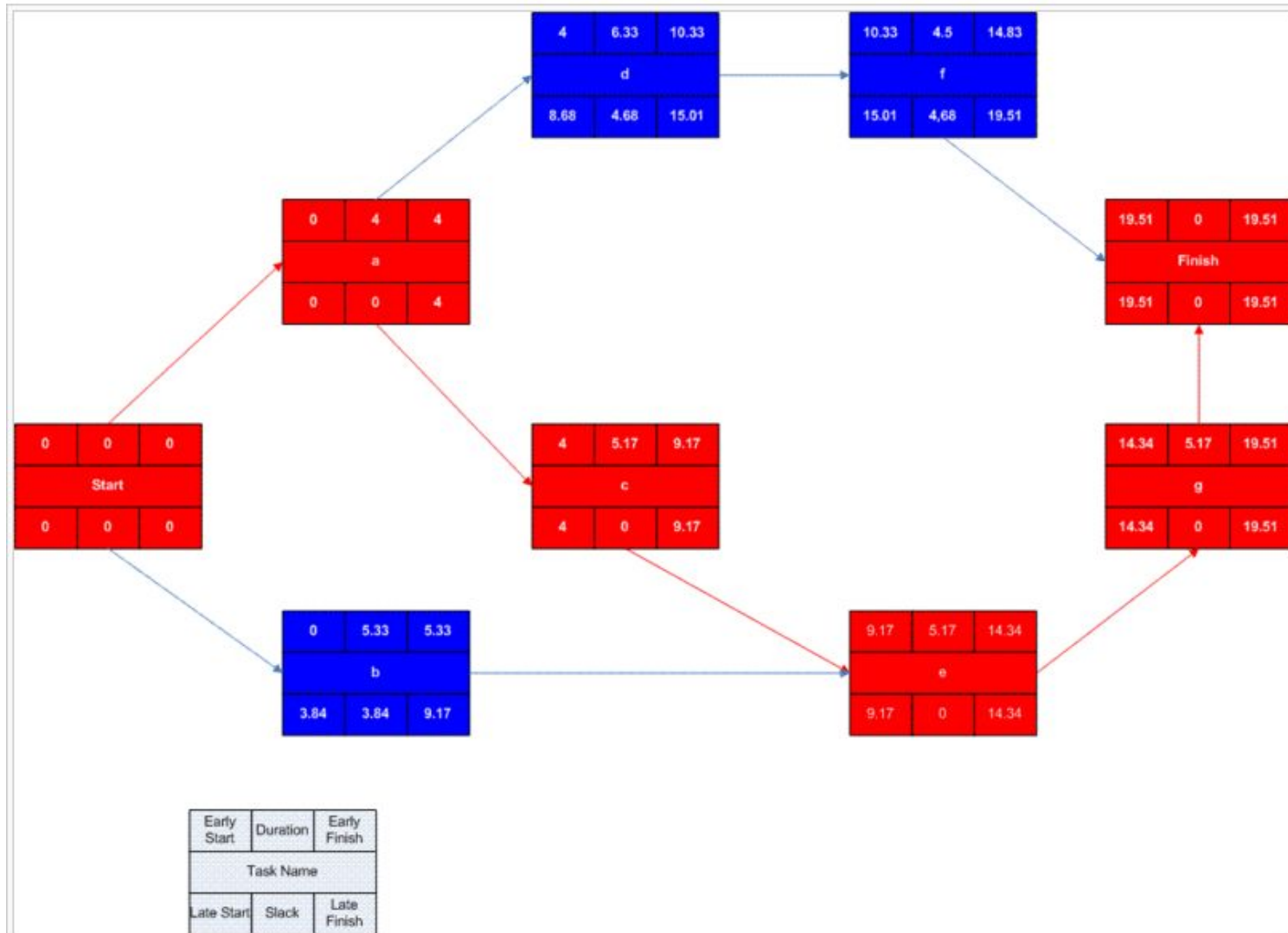
Critical Path Method (CPM) – realized with MSP
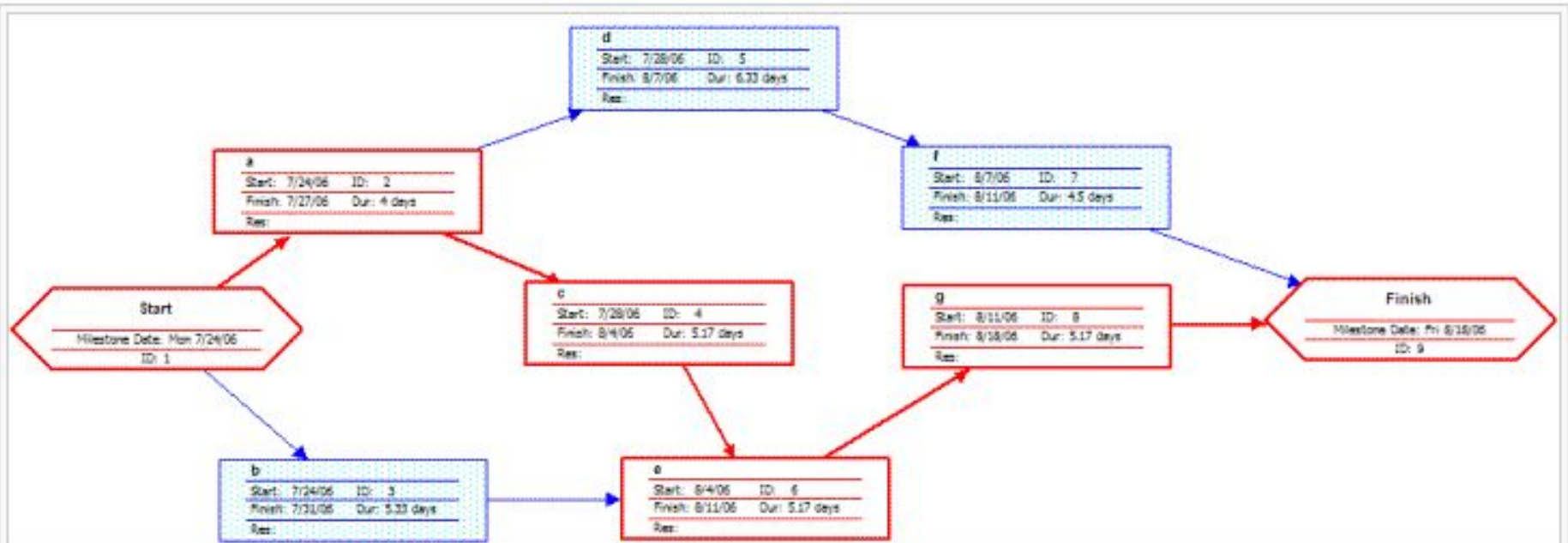
A network diagram created using Microsoft Project (MSP). Note the critical path is in red.

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Thanks for your patience!

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