SOFTWARE ENGINEERING

Week 5

System Modeling and Requirements Engineering

Prof. Dr. Muhittin GÖKMEN Yard. Doç. Dr. A. Cüneyd TANTUĞ Araş. Gör. Dr. Tolga OVATMAN
Istanbul Technical University
Computer Engineering Department

Agenda

1. System Engineering
2. Requirement Engineering
3. Software Requirements Document
4. Requirement Engineering Processes

1. System Engineering
2. Requirements Engineering
3. Requirement Engineering Processes
4. The MSG Case Study

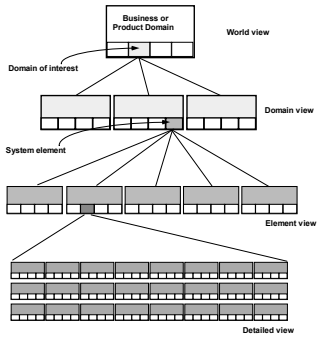
System Engineering

5.1

System Engineering

- Elements of a computer-based system
  - Software
  - Hardware
  - People
  - Database
  - Documentation
  - Procedures
- Systems
  - A hierarchy of macro-elements

The Hierarchy



System Modeling

- define the processes that serve the needs of the view under consideration.
- represent the behavior of the processes and the assumptions on which the behavior is based.
- explicitly define both exogenous and endogenous input to the model.
  - exogenous inputs link one constituent of a given view with other constituents at the same level of other levels; endogenous input links individual components of a constituent at a particular view.
- represent all linkages (including output) that will enable the engineer to better understand the view.

Business Process Engineering

- uses an integrated set of procedures, methods, and tools to identify how information systems can best meet the strategic goals of an enterprise
- focuses first on the enterprise and then on the business area
- creates enterprise models, data models and process models
- creates a framework for better information management distribution, and control

System Architectures

- Three different architectures must be analyzed and designed within the context of business objectives and goals:
  - data architecture
  - applications architecture
  - technology infrastructure
- *data architecture* provides a framework for the information needs of a business or business function
- *application architecture* encompasses those elements of a system that transform objects within the data architecture for some business purpose
- *technology infrastructure* provides the foundation for the data and application architectures

Requirements Engineering

5.2

Requirement Engineering

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

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

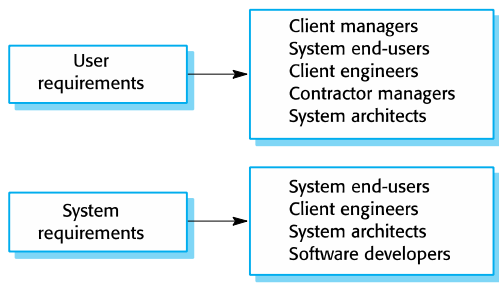
User requirement definition

1. The MHC-PMS 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 automatically 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, 20 mg, etc.) separate reports shall be created for each dose unit.
1.5 Access to all cost reports shall be restricted to authorized users listed on a management access control list.

Users of 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

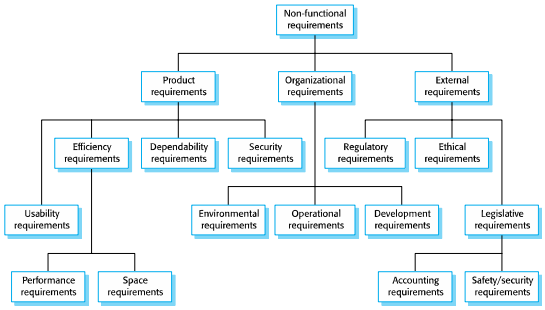
Functional Requirements

- 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.
- **Functional requirements specify what the system should do.**
- Some examples are:
  - Calculate the discount at the rate of 14% for a customer spending amount
  - Number of significant digits to which accuracy should be maintained in all numerical calculations is 4
  - A book can be deleted from the Library Management System by the Database Administrator only

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 specify the overall quality attributes the system must satisfy.**
- Some examples are:
  - The response time of the system should always be less than 5 seconds
  - The software should be developed using C language on a UNIX based system
  - Experienced officers should be able to use all the system functions after a total training of two hours. After this training, the average number of errors made by experienced officers should not exceed two per day.

Types of Non-functional Requirements



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.

Guidelines For Writing Requirements

- Invent a standard format and use it for all requirements.
- Assign a unique number and source (mostly people) for each requirement.
- 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.

An Example Requirement Document

- Click here for an example requirements document.

1. System Engineering
2. Requirements Engineering
3. Requirements Engineering Processes
4. The MSG Case Study

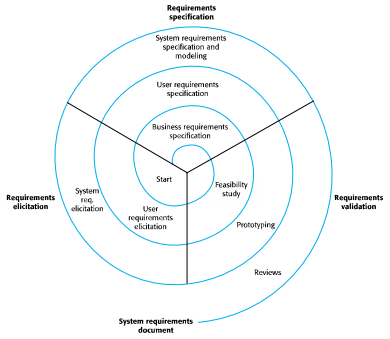
Requirements Engineering Processes

5.3

Requirements Engineering Processes

- Inception—ask a set of questions that establish …
  - basic understanding of the problem
  - the people who want a solution
  - the nature of the solution that is desired, and
  - the effectiveness of preliminary communication and collaboration between the customer and the developer
- Elicitation—elicit requirements from all stakeholders
- Elaboration—create an analysis model that identifies data, function and behavioral requirements
- Negotiation—agree on a deliverable system that is realistic for developers and customers
- Specification—can be any one (or more) of the following:
  - A written document
  - A set of models
  - A formal mathematical
  - A collection of user scenarios (use-cases)
  - A prototype
- Validation—a review mechanism that looks for
  - errors in content or interpretation
  - areas where clarification may be required
  - missing information
  - inconsistencies (a major problem when large products or systems are engineered)
  - conflicting or unrealistic (unachievable) requirements.
- Requirements management

A Spiral View Of The Requirements Engineering Process



Problems Of Requirements Analysis

- 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.

Overview of the Requirements Workflow

- First, gain an understanding of the *application domain* (or *domain*, for short)
  - The specific environment in which the target product is to operate
- Second, build a business model
  - Model the client's business processes
- Third, use the business model to determine the client's requirements
- Iterate the above steps

Definitions

- Discovering the client's requirements
  - *Requirements elicitation* (or *requirements capture*)
  - Methods include interviews and surveys
- Refining and extending the initial requirements
  - *Requirements analysis*

Understanding the Domain

- Every member of the development team must become fully familiar with the application domain
  - Correct terminology is essential
- Construct a glossary
  - A list of technical words used in the domain, and their meanings

Business Model

- A *business model* is a description of the business processes of an organization
- The business model gives an understanding of the client's business as a whole
  - This knowledge is essential for advising the client regarding computerization
- The systems analyst needs to obtain a detailed understanding of the various business processes
  - Different techniques are used, primarily interviewing

Tools For Requirements

- OSRMT – Open Source Requirements Management Tool
  www.sourceforge.net/projects/osrmt
- EasyRM – Cybernetic Intelligence
  www.eary-rm.com
- Rational Requisite Pro
  www.rational.com
- OnYourMark - Omni-Vista
  www.omni-vista.com
- RTM – Integratd Chipware
  www.chipware.com

The MSG Case Study

5.4

Initial Understanding of the Domain: MSG Case Study

- The Martha Stockton Greengage Foundation ("MSG") provides low cost mortgage loans to young couples
- The trustees commission a pilot project
  - A software product to determine how much money is available each week to purchase homes

Initial Understanding of the Domain: MSG Case Study (contd)

- A *mortgage* is a loan in which real estate is used as security
- Example: House costs $100,000
- Buyer pays a 10% deposit and borrows the balance
  - The *principal* (or *capital*) borrowed is $90,000
- Loan is to be repaid monthly over 30 years
  - Interest rate of 7.5% per annum (or 0.625% per month)

Initial Understanding of the Domain: MSG Case Study (contd)

- Each month, the borrower pays $629.30
  - Part of this is the interest on the outstanding balance
  - The rest is used to reduce the principal
- The monthly payment is therefore often referred to as *P & I* (principal and interest)

Mortgage Payments: First Month

- In the first month the outstanding balance is $90,000
  - Monthly interest at 0.625% on $90,000 is $562.50
  - The remainder of the P & I payment of $629.30, namely $66.80, is used to reduce the principal
- At the end of the first month, after the first payment has been made, only $89,933.20 is owed to the finance company

Mortgage Payments: Second Month

- In the second month the outstanding balance is $89,933.20
  - Monthly interest at 0.625% on $89,933.20 is $562.08
  - The remainder of the P & I payment of $629.30, namely $67.22, is used to reduce the principal
- At the end of the second month, after the second payment has been made, only $89,865.98 is owed to the finance company

Mortgage Payments: After 15 and 30 Years

- After 15 years (180 months) the outstanding balance is $67,881.61
  - Monthly interest at 0.625% on $67,881.61 is $424.26
  - The remainder of the P & I payment of $629.30, namely $205.04, is used to reduce the principal
- After 30 years (360 months), the entire loan will have been repaid

Insurance Premiums

- The finance company requires the borrower to insure the house
  - If the house burns down, the check from the insurance company will then be used to repay the loan
- The insurance premium is paid once a year by the finance company
  - The finance company requires the borrower to pay monthly insurance installments
  - These are deposited in an *escrow account* (a savings account)
- The annual premium is then paid from the escrow account

Real Estate Taxes

- Real-estate taxes paid on a home are treated the same way as insurance premiums
  - Monthly installments are deposited in the escrow account
  - The annual real-estate tax payment is made from that account

Borrowing Limits

- A mortgage will not be granted unless the total monthly payment (P & I plus insurance plus real-estate taxes) is less than 28% of the borrower's total income

Other Costs

- The finance company requires a lump sum up front in return for lending the money to the borrower
  - Typically, the finance company will want 2% of the principal ("2 points")
  - For the $90,000 loan, this amounts to $1,800
- There are other costs involved in buying a house
  - Legal costs
  - Various taxes
- When the deal is "closed," the closing costs (legal costs, taxes, and so on) plus the points can easily amount to $7,000

Initial Glossary

Balance: the amount of the loan still owing
Capital: synonym for principal
Closing costs: other costs involved in buying a house, such as legal costs and various taxes
Deposit: an initial installment toward the total cost of the house
Escrow account: a savings account managed by the finance company into which the weekly installments toward the annual insurance premium and annual real-estate tax payment are deposited, and from which the annual insurance premium and the annual real-estate tax payment are paid
Interest: a cost of borrowing money, computed as a fraction of the amount owing
Mortgage: a loan in which real estate is pledged as security for the loan
P & I: abbreviation for "principal and interest"
Points: a cost of borrowing money, computed as a fraction of the total amount borrowed
Principal: the lump sum borrowed
Principal and interest: an installment payment consisting of the interest plus the fraction of the principal for that installment

Figure 11.3

Initial Business Model: MSG Case Study

- At the start of each week, MSG estimates how much money will be available that week to fund mortgages
- Low-income couples can apply at any time

Initial Business Model: MSG Case Study

- An MSG Foundation staff member determines
  - Whether the couple qualifies for an MSG mortgage, and
  - Whether MSG has sufficient funds on hand to purchase the home
- If so, the mortgage is granted
  - The weekly mortgage repayment is computed according to MSG rules
- This repayment amount may vary from week to week, depending on the couple's current income

Initial Business Model: MSG Case Study

- There are three use cases
  - `Estimate Funds Available for Week`
  - `Apply for an MSG Mortgage`
  - `Compute Weekly Repayment Amount`

`Estimate Funds Available for Week` Use Case

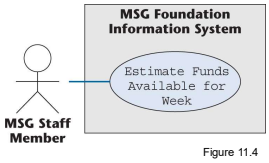


Figure 11.4

Brief Description
The `Estimate Funds Available for Week` use case enables an MSG Foundation staff member to estimate how much money the Foundation has available that week to fund mortgages.
Step-by-Step Description
Not applicable at this initial stage.

Figure 11.7

`Apply for an MSG Mortgage` Use Case

Figure 11.5

Brief Description
When a couple applies for a mortgage, the `Apply for an MSG Mortgage` use case enables an MSG Foundation staff member to determine whether they qualify for an MSG mortgage and, if so, whether funds are currently available for the mortgage.
Step-by-Step Description
Not applicable at this initial stage.

Figure 11.8

`Compute Weekly Repayment Amount` Use Case

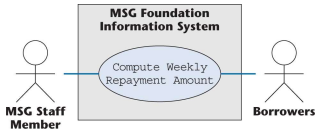


Figure 11.6

Brief Description
The `Compute Weekly Repayment Amount` use case enables an MSG Foundation staff member to compute how much borrowers have to repay each week.
Step-by-Step Description
Not applicable at this initial stage.

Figure 11.9

Who Is an Actor?

- Why is **Applicants** an actor in use case `Apply for an MSG Mortgage`?
- Applicants do not interact with the software product
  - Their answers are entered into the software product by an MSG staff member

Who Is an Actor? (contd)

- However,
  - The applicants initiate the use case
  - The applicants provide the data entered by MSG staff
  - The real actor is therefore **Applicants** — the **MSG Staff Member** is merely an agent of the applicants
- **Applicants** is therefore indeed an actor

Who Is an Actor? (contd)

- Similarly, **Borrowers** is an actor in use case `Compute Weekly Repayment Amount`
  - Again the use case is initiated by actor **Borrowers**
  - Again the information entered by MSG staff is supplied by the borrowers
- Thus, **Borrowers** is indeed an actor in the use case

`Manage an Investment` Use Case

- At this stage, no details are known regarding
  - The buying and selling of investments, or
  - How investment income becomes available for mortgages
- However, use case `Manage an Investment` is an essential part of the initial business model

`Manage an Investment` Use Case

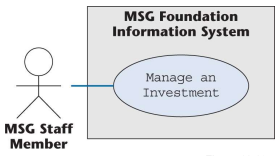


Figure 11.10

Brief Description
The `Manage an Investment` use case enables an MSG Foundation staff member to buy and sell investments and manage the investment portfolio.
Step-by-Step Description
Not applicable at this initial stage.

Figure 11.11

Use-Case Diagram of the Initial Business Model

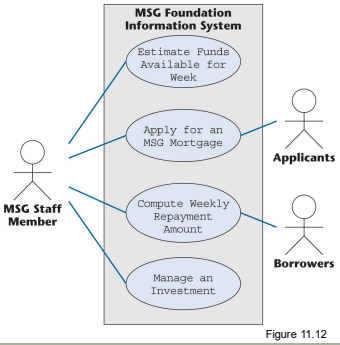


Figure 11.12

Initial Requirements: MSG Case Study

- It is unclear if all four use cases are all requirements of the product to be developed
  - What, exactly, is "a pilot project"?
- The best way to proceed is
  - Draw up the initial requirements on the basis of what the client wants, and then iterate

Initial Requirements: MSG Case Study

- Consider each use case in turn:
- `Estimate Funds Available for Week` is obviously part of the initial requirements
- `Apply for an MSG Mortgage` does not seem to have anything to do with the pilot project, so it is excluded

Initial Requirements: MSG Case Study

- `Compute Weekly Repayment Amount`, and
- `Manage an Investment`
  - Both appear to be irrelevant to the pilot project
- However, the pilot project deals with the "money that is available each week to purchase homes"
  - Some of that money comes from the weekly repayment of existing mortgages, and from income from investments
- The resulting use-case diagram is shown on the next slide

Initial Requirements: MSG Case Study

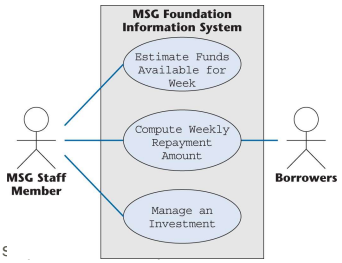


Figure 11.13

- The next s

Continuing the Requirements Workflow: MSG

- The systems analysts learn that the MSG Foundation grants a 100% mortgage to buy a home under the following conditions:
  - The couple has been legally married for at least 1 year but not more than 10 years
  - Both husband and wife are gainfully employed
  - The price of the home must be below the published median price for homes in that area for the past 12 months
  - Their income and/or savings are insufficient to afford a standard fixed-rate 30-year 90% mortgage
  - The foundation has sufficient funds to purchase the home

Conditions for an MSG Mortgage

- If the application is approved, then each week for the next 30 years the couple pays MSG
  - The total of the principal and interest payment — this never changes over the life of the mortgage; plus
  - The escrow payment, which is 1/52nd of the sum of the annual real-estate tax and the annual homeowner's insurance premium
- If this exceeds 28% of the couple's gross weekly income, MSG pays the difference as a grant
  - The couple must provide proof of their current income — the weekly payment may vary from week to week

Algorithm to Determine If Funds Are Available

- (1) At the beginning of the week, the estimated annual income from MSG investments is computed and divided by 52
- (2) The estimated annual MSG operating expenses are divided by 52
- (3) The total of the estimated mortgage payments for the week is computed

Algorithm to Determine If Funds Are Available

- (4) The total of the estimated grants for the week is computed
- (5) The amount available at the beginning of the week is then (1) – (2) + (3) – (4)
- (6) If the cost of the home is no more than (5), funds are provided to buy the home
- (7) At the end of each week, any unspent funds are invested

Requirements of the Pilot Project

- To keep the cost of the pilot project as low as possible, only those data items needed for the weekly funds computation will be included
- Only three types of data are therefore needed:
  - Investment data
  - Operating expenses data
  - Mortgage data

Investment Data

- Item number
- Item name
- Estimated annual return
- Date estimated annual return was last updated

Operating Expenses Data

- Estimated annual operating expenses
- Date estimated annual operating expenses was last updated

Mortgage Data

- Account number
- Last name of mortgagees
- Original purchase price of home
- Date mortgage was issued
- Weekly principal and interest payment
- Current combined gross weekly income
- Date combined gross weekly income was last updated

Mortgage Data (contd)

- Annual real-estate tax
- Date annual real-estate tax was last updated
- Annual homeowner's insurance premium
- Date annual homeowner's insurance premium was last updated

Reports Required for the Pilot Project

- Three types of reports are needed:
  - The results of the funds computation for the week
  - A listing of all investments (to be printed on request)
  - A listing of all mortgages (to be printed on request)

Revising the Requirements: MSG Case Study

- The initial requirements include three use cases:
  - `Estimate Funds Available for Week`
  - `Compute Weekly Repayment Amount`
  - `Manage an Investment`
- In the light of the additional information received, the initial requirements can be revised

Revising the Requirements: MSG

- Consider each element of the formula to determine how much money is available each week
- (1) *Estimated annual income from investments:*
  - Take all the investments, sum the estimated annual return on each investment, and divide the result by 52
- An additional use case, `Estimate Investment Income for Week`, is needed
  - (We still need use case `Manage an Investment` for adding, deleting, and modifying investments)

`Estimate Investment Income for Week` Use Case

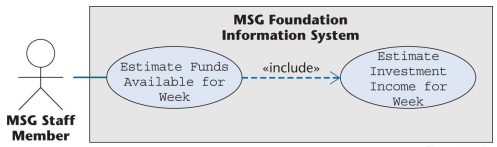


Figure 11.14

- The dashed line with the open arrowhead labeled **«include»** denotes that
  - Use case `Estimate Investment Income for Week` is part of use case `Estimate Funds Available for Week`

`Estimate Investment Income for Week` Use Case (contd)

- Description of use case

Brief Description
The `Estimate Investment Income for Week` use case enables the `Estimate Funds Available for Week` use case to estimate how much investment income is available for this week.
Step-by-Step Description
1. For each investment, extract the estimated annual return on that investment. 2. Sum the values extracted in Step 1 and divide the result by 52.

Figure 11.15

First Iteration of the Revised Use-Case Diagram

- New use case is shaded

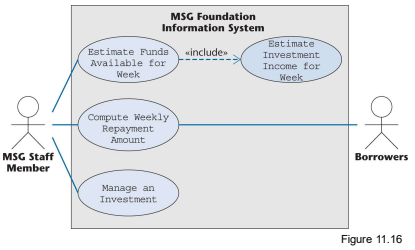


Figure 11.16

Revising the Requirements: MSG Case Study (contd)

- (2) *Estimated annual operating expenses:*
- To determine the estimated annual operating expenses two additional use cases are needed
  - Use case `Update Estimated Annual Operating Expenses` models adjustments to the value of the estimated annual operating expenses
  - Use case `Estimate Operating Expenses for Week` provides the needed estimate of the operating expenses

Update Estimated Annual Operating Expenses Use Case

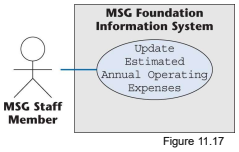


Figure 11.17

Brief Description

The `Update Estimated Annual Operating Expenses` use case enables an MSG Foundation staff member to update the estimated annual operating expenses.

Step-by-Step Description

1. Update the estimated annual operating expenses.

Figure 11.18

Estimate Operating Expenses for Week Use Case (contd)

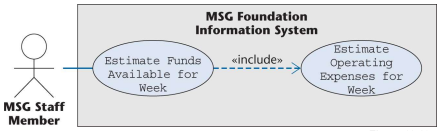


Figure 11.19

Brief Description

The `Estimate Operating Expenses for Week` use case enables the `Estimate Funds Available for Week` use case to estimate the operating expenses for the week.

Step-by-Step Description

1. Divide the estimated annual operating expenses by 52.

Figure 11.20

Second Iteration of Revised Use-Case Diagram

- The new use cases are shaded

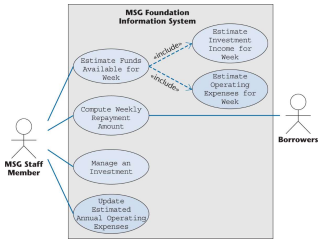


Figure 11.21

Revising the Requirements: MSG

- (3) *Total estimated mortgage payments for the week* and
- (4) *Total estimated grant payments for the week*:
  - Use case `Compute Weekly Repayment Amount` models the computation of both the estimated mortgage payment and the estimated grant payment for each mortgage separately
  - Summing these separate quantities gives
    - The total estimated mortgage payments for the week, and
    - The total estimated grant payments for the week

Revising the Requirements: MSG

- Now the use cases need to be reorganized
  - Use case `Compute Weekly Repayment Amount` also models borrowers updating their weekly income
- Split `Compute Weekly Repayment Amount` into two separate use cases
  - Use case `Estimate Payments and Grants for Week`, and
  - Use case `Update Borrowers' Weekly Income`

Estimate Payments and Grants for Week Use Case

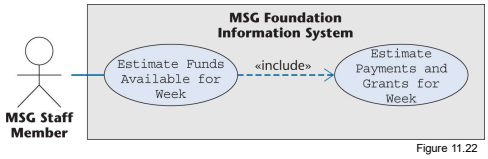


Figure 11.22

Estimate Payments and Grants for Week Use Case

Brief Description

The `Estimate Payments and Grants for Week` use case enables the `Estimate Funds Available for Week` use case to estimate the total estimated mortgage payments paid by borrowers to the MSG Foundation for this week and the total estimated grants paid by the MSG Foundation for this week.

Step-by-Step Description

1. For each mortgage:
   - 1.1 The amount to be paid this week is the total of the principal and interest payment and $\frac{1}{52}$nd of the sum of the annual real-estate tax and the annual homeowner's insurance premium.
   - 1.2 Compute 28 percent of the couple's current gross weekly income.
   - 1.3 If the result of Step 1.1 is greater than the result of Step 1.2, then the mortgage payment for this week is the result of Step 1.2, and the amount of the grant for this week is the difference between the result of Step 1.1 and the result of Step 1.2.
   - 1.4 Otherwise, the mortgage payment for this week is the result of Step 1.1 and there is no grant this week.
2. Summing the mortgage payments of Steps 1.3 and 1.4 yields the estimated mortgage payments for the week.
3. Summing the grant payments of Step 1.3 yields the estimated grant payments for the week.

Figure 11.23

Update Borrowers' Weekly Income Use Case

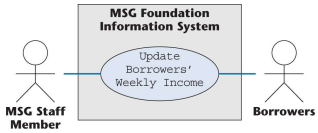


Figure 11.24

Brief Description

The `Update Borrowers' Weekly Income` use case enables an MSG Foundation staff member to update the weekly income of a couple who have borrowed money from the Foundation.

Step-by-Step Description

1. Update the borrower's weekly income.

Figure 11.25

Third Iteration of the Revised Use-Case Diagram

- The two new use cases are shaded

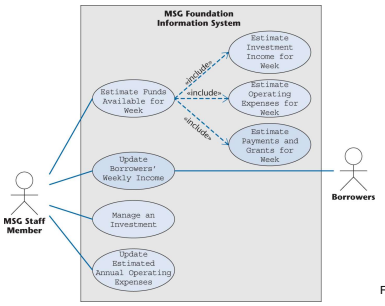


Figure 11.26

Estimate Funds Available for Week Use Case

- Use case `Estimate Funds Available for Week` models the computation that uses the data obtained from three other use cases
  - `Estimate Investment Income for Week`
  - `Estimate Operating Expenses for Week`
  - `Estimate Payments and Grants for Week`

Estimate Funds Available for Week Use Case (contd)

- Second iteration of use case

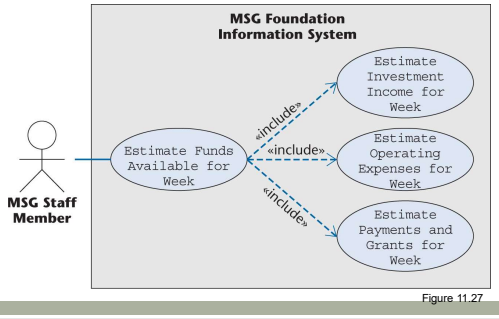


Figure 11.27

Estimate Funds Available for Week Use Case (contd)

- Second iteration of description of use case

Brief Description

The Estimate Funds Available for Week use case enables an MSG Foundation staff member to estimate how much money the Foundation has available that week to fund mortgages.

Step-by-Step Description

1. Determine the estimated income from investments for the week utilizing use case Estimate Investment Income for Week.
2. Determine the operating expenses for the week utilizing use case Estimate Operating Expenses for Week.
3. Determine the total estimated mortgage payments for the week utilizing use case Estimate Payments and Grants for Week.
4. Determine the total estimated grants for the week utilizing use case Estimate Payments and Grants for Week.
5. Add the results of Steps 1 and 3 and subtract the results of Steps 2 and 4. This is the total amount available for mortgages for the current week.

Figure 11.28

«include» Relationship

- Correct use case (top); incorrect use case (bottom)

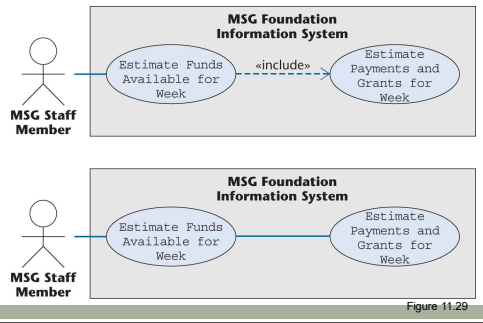


Figure 11.29

«include» Relationship (contd)

- The bottom diagram models use cases
  - Estimate Funds Available for Week, and
  - Estimate Payments and Grants for Week

  as two independent use cases
  - However, a use case models an interaction between the product itself and users of the product (actors)

«include» Relationship (contd)

- Use case Estimate Payments and Grants for Week does not interact with an actor and therefore cannot be a use case in its own right
  - Instead, it is a portion of use case Estimate Funds Available for Week, as reflected in the top diagram

The Test Workflow: MSG Case Study

- A common side-effect of the iterative and incremental life-cycle model
  - Details that correctly have been postponed somehow get forgotten
  - Two instances of this are described on the next slide

The Test Workflow: MSG Case Study

- Details of use case Manage an Investment have been overlooked, and
- Use case Manage a Mortgage to model
  - The addition of a new mortgage
  - The modification of an existing mortgage, or
  - The removal of an existing mortgage

  has been totally forgotten

  (Analogous to use case Manage an Investment)

Manage an Investment Use Case

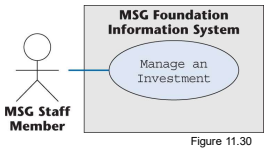


Figure 11.30

Brief Description
The Manage an Investment use case enables an MSG Foundation staff member to add and delete investments and manage the investment portfolio.
Step-by-Step Description
1. Add, modify, or delete an investment.

Figure 11.31

Manage a Mortgage Use Case

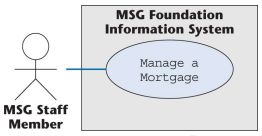


Figure 11.32

Brief Description
The Manage a Mortgage use case enables an MSG Foundation staff member to add and delete mortgages and manage the mortgage portfolio.
Step-by-Step Description
1. Add, modify, or delete a mortgage.

Figure 11.33

Fourth Iteration of the Revised Use-Case Diagram

- The new use case is shaded

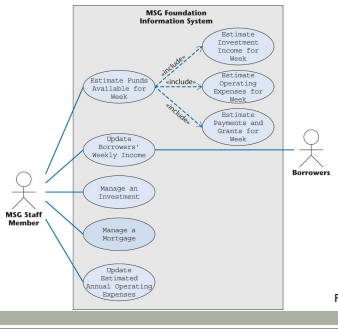


Figure 11.34

The Test Workflow: MSG Case Study

- There is a further omission
  - Use case Produce a Report to print the three reports
    - Investments report
    - Mortgages report
    - Results of weekly computation

  has also been totally forgotten

Produce a Report Use Case

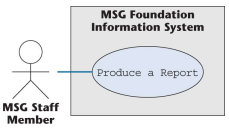


Figure 11.35

Produce a Report Use Case (contd)

Brief Description

The Produce a Report use case enables an MSG Foundation staff member to print the results of the weekly computation of funds available for new mortgages or to print a listing of all investments or all mortgages.

Step-by-Step Description

1. The following reports must be generated:
1.1 Investments report—printed on demand:
The information system prints a list of all investments. For each investment, the following attributes are printed:
Item number
Item name
Estimated annual return
Date estimated annual return was last updated
1.2 Mortgages report—printed on demand:
The information system prints a list of all mortgages. For each mortgage, the following attributes are printed:
Account number
Name of mortgagee
Original price of home
Date mortgage was issued
Principal and interest payment
Current combined gross weekly income
Date current combined gross weekly income was last updated
Annual real-estate tax
Date annual real-estate tax was last updated
Annual homeowner's insurance premium
Date annual homeowner's insurance premium was last updated
1.3 Results of the weekly computation—printed each week:
The information system prints the total amount available for new mortgages during the current week

Figure 11.36

Fifth Iteration of the Revised Use-Case Diagram

- The new use case, `Produce a Report`, is shaded

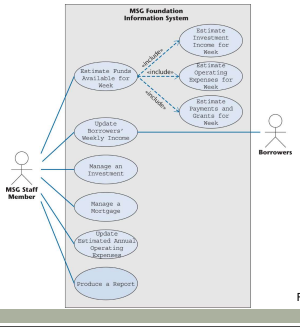


Figure 11.37

The Test Workflow: MSG Case Study

- Rechecking the revised requirements uncovers two new problems
  - A use case has been partially duplicated
  - Two of the use cases need to be reorganized

Partially Duplicated Use Case

- Use case `Manage a Mortgage`
  - One action is to modify a mortgage
- Use case `Update Borrowers' Weekly Income`
  - Only action is to update the borrowers' weekly income
- The borrowers' weekly income is an attribute of the mortgage
  - Use case `Manage a Mortgage` already includes use case `Update Borrowers' Weekly Income`
- Accordingly, use case `Update Borrowers' Weekly Income` is superfluous, and must be deleted

Sixth Iteration of the Revised Use-Case Diagram

- The modified use case is shaded

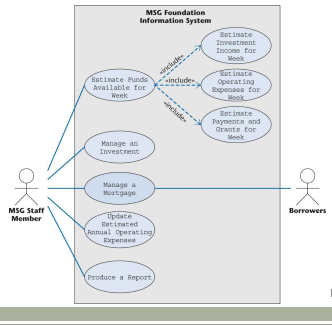


Figure 11.38

The Test Workflow: MSG Case Study

- This iteration resulted in a decrement, not an increment
- In fact, deletion occurs often
  - Whenever we make a mistake
- Sometimes we can fix an incorrect artifact
  - More frequently we have to delete an artifact

The Test Workflow: MSG Case Study

- However, when we discover a fault, we do not have to start the whole process from scratch
- First we try to fix the current iteration
- If the mistake is too serious for this to work, we backtrack to the previous iteration, and try to find a better way to go forward from there

Reorganizing Two Use Cases

- Determine the funds available for the current week
  - Use case `Estimate Funds Available for Week` models performing the calculation
  - Step 1.3 of use case `Produce a Report` models printing out the result of the computation
- There is no point in estimating the funds available unless the results are printed out

Reorganizing Two Use Cases

- The descriptions of the use cases
  - `Estimate Funds Available for Week`, and
  - `Produce a Report`

  have to be modified (the use cases do not change)

Modified Description — `Produce a Report`

Brief Description

The `Produce a Report` use case enables an MSG Foundation staff member to print a listing of all investments or all mortgages.

Step-by-Step Description

1. The following reports must be generated:
1.1 Investments report—printed on demand:
The information system prints a list of all investments. For each investment, the following attributes are printed:
Item number
Item name
Estimated annual return
Date estimated annual return was last updated
1.2 Mortgages report—printed on demand:
The information system prints a list of all mortgages. For each mortgage, the following attributes are printed:
Account number
Name of mortgagee
Original price of home
Date mortgage was issued
Principal and interest payment
Current combined gross weekly income
Date current combined gross weekly income was last updated
Annual real-estate tax
Date annual real-estate tax was last updated
Annual homeowner's insurance premium
Date annual homeowner's insurance premium was last updated

Figure 11.39

Modified Description — `Estimate Funds Available for Week`

Brief Description

The `Estimate Funds Available for Week` use case enables an MSG Foundation staff member to estimate how much money the Foundation has available that week to fund mortgages.

Step-by-Step Description

1. Determine the estimated income from investments for the week utilizing use case `Estimate Investment Income for Week`.
2. Determine the operating expenses for the week utilizing use case `Estimate Operating Expenses for Week`.
3. Determine the total estimated mortgage payments for the week utilizing use case `Estimate Payments and Grants for Week`.
4. Determine the total estimated grants for the week utilizing use case `Estimate Payments and Grants for Week`.
5. Add the results of Steps 1 and 3 and subtract the results of Steps 2 and 4. This is the total amount available for mortgages for the current week.
6. Print the total amount available for new mortgages during the current week.

Figure 11.40

The Test Workflow: MSG Case Study

- The usual reason for an «include» relationship is where one use case is part of two or more other use cases
  - Example: U.S. tax forms—avoiding triplication

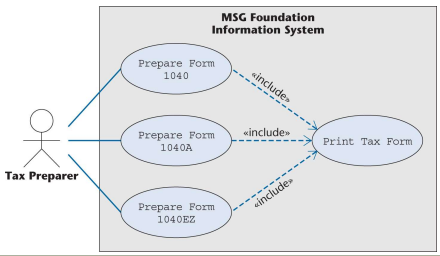


Figure 11.41

`Estimate Funds Available for Week` Use Case (contd)

- For the MSG Foundation case study
  - All of the included use cases are part of only one use case, `Estimate Funds Available for Week`
- Incorporate those three «include» use cases into use case `Estimate Funds Available for Week`
  - The resulting use-case diagram is on the next slide

Seventh Iteration of Revised Use-Case Diagram

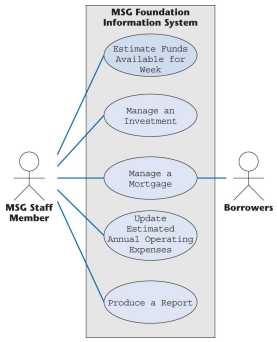


Figure 11.42

Estimate Funds Available for Week Revised Description of Use Case

Brief Description

The `Estimate Funds Available for Week` use case enables an MSG Foundation staff member to estimate how much money the Foundation has available that week to fund mortgages.

Step-by-Step Description

1. For each investment, extract the estimated annual return on that investment. Summing the separate returns and dividing the result by 52 yields the estimated investment income for the week.
2. Determine the estimated MSG Foundation operating expenses for the week by extracting the estimated annual MSG Foundation operating expenses and dividing by 52.
3. For each mortgage:
   - 3.1 The amount to be paid this week is the total of the principal and interest payment and $\frac{1}{52}$nd of the sum of the annual real-estate tax and the annual homeowner's insurance premium.
   - 3.2 Compute 28 percent of the couple's current gross weekly income.
   - 3.3 If the result of Step 3.1 is greater than the result of Step 3.2, then the mortgage payment for this week is the result of Step 3.2, and the amount of the grant for this week is the difference between the result of Step 3.1 and the result of Step 3.2.
   - 3.4 Otherwise, the mortgage payment for this week is the result of Step 3.1, and there is no grant this week.
4. Summing the mortgage payments of Steps 3.3 and 3.4 yields the estimated total mortgage payments for the week.
5. Summing the grant payments of Step 3.3 yields the estimated total grant payments for the week.
6. Add the results of Steps 1 and 4 and subtract the results of Steps 2 and 5. This is the total amount available for mortgages for the current week.
7. Print the total amount available for new mortgages during the current week.

Figure 11.43

The Test Workflow: MSG Case Study

- Now the requirements appear to be correct
  - They correspond to what the client has requested
  - They appear to satisfy the client's needs
  - There do not seem to be any more faults
- For now, everything seems to be fine

Wrap-up

This week we present

- System Engineering: How to model and understand the overall components of a software system
- Requirements Engineering: How to manage and acquire the needs of customer
- Requirement Process: What phases should be applied in effectively gathering requirements.

Next Week

- We will introduce object oriented and classical approaches in *Requirements Analysis!!!*