Module 13 - Programming and Languages

General Notes

Programs and Programming

What is Programming?

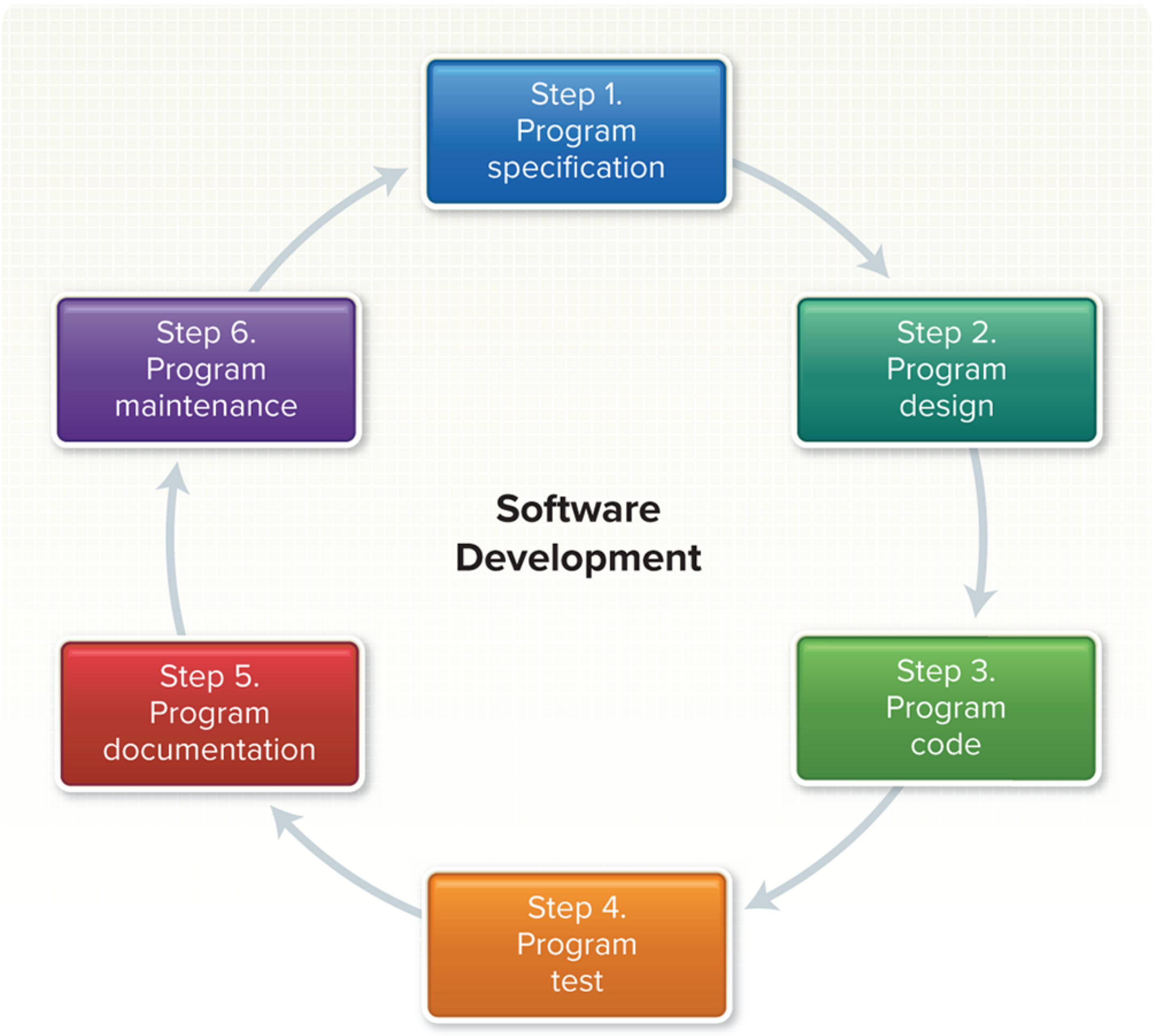
- Programming is a problem-solving procedure.
- It involves creating a list of instructions for the computer to follow, processing data into information.

What is a Program?

- A program is a list of instructions for the computer to follow to accomplish a task.
- Programs can be pre-written (e.g., application programs) or custom-made.
    - This is one of the first things that needs to be decided in programming.
- Examples of programs include word processors and spreadsheets.

- We use word processors to create documents and spreadsheets to analyze data.

Programming Process


Step 1. Program specification
Step 2. Program design
Step 3. Program code
Step 4. Program test
Step 5. Program documentation
Step 6. Program maintenance
Software Development

- Also known as software development.
- Follows a six-step process called the **Software Development Life Cycle (SDLC)**.

Software Development Lifecycle Steps

1. **Program specification**: Determine objectives, outputs, inputs, and processing requirements.
2. **Program design**: Create a solution using programming techniques such as top-down program design, pseudocode, flowcharts, and logic structures.

3. **Program code**: Write or code the program using a programming language.
4. **Program test**: Test or debug the program for syntax and logic errors.
5. **Program documentation**: Formalize the written description and processes used in the program.
6. **Program maintenance**: Review completed programs for accuracy, efficiency, standardization, and ease of use, making changes as needed.

Professionals in Programming

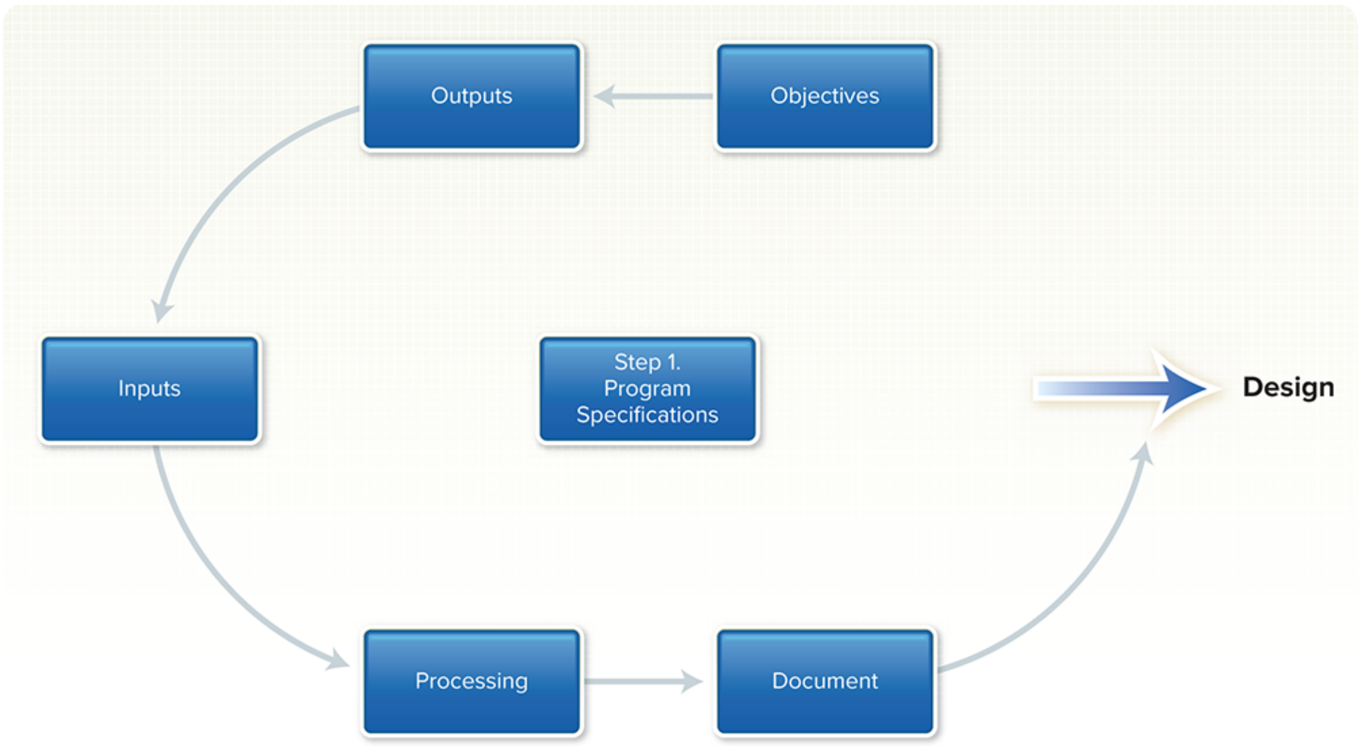
- Software engineers or programmers use the SDLC process.
- These professionals often work with systems analysts or directly with users.

Conclusion

Programming is a problem-solving procedure that involves creating a list of instructions for a computer to process data into information. Programs can be application-based or custom-made. The programming process, also known as software development, follows a six-step process called the Software Development Life Cycle (SDLC). The SDLC involves specification, design, coding, testing, documentation, and maintenance. Professionals in programming are often software engineers or programmers who work with systems analysts or directly with users.

Step 1: Program Specification

Program Specification



- Program specification is a process that involves specifying five items, which are:
    1. Program objectives
    2. Desired output
    3. Input data required
    4. Processing requirements
    5. Documentation
- It is also known as program definition or program analysis.

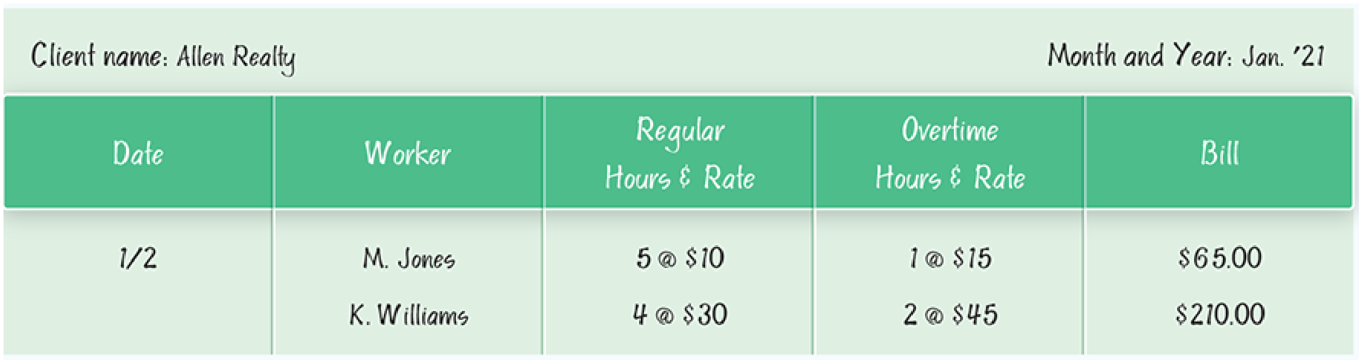
Program Objectives

Program objectives are the problems that need to be solved through programming.

- The end user needs to make a clear statement of the problem they want to solve.
- An example could be creating a time-and-billing system to record the time spent on different jobs for different clients of Advantage Advertising.

Desired Output

- Desired output should be specified before input.
- The end user should list what they want to get out of the computer system and how they want the output to look.
  - They should sketch or write a description of the output that they want.
  - For example, if they want a time-and-billing report, they might create a table of time spent on different jobs or bills for clients.



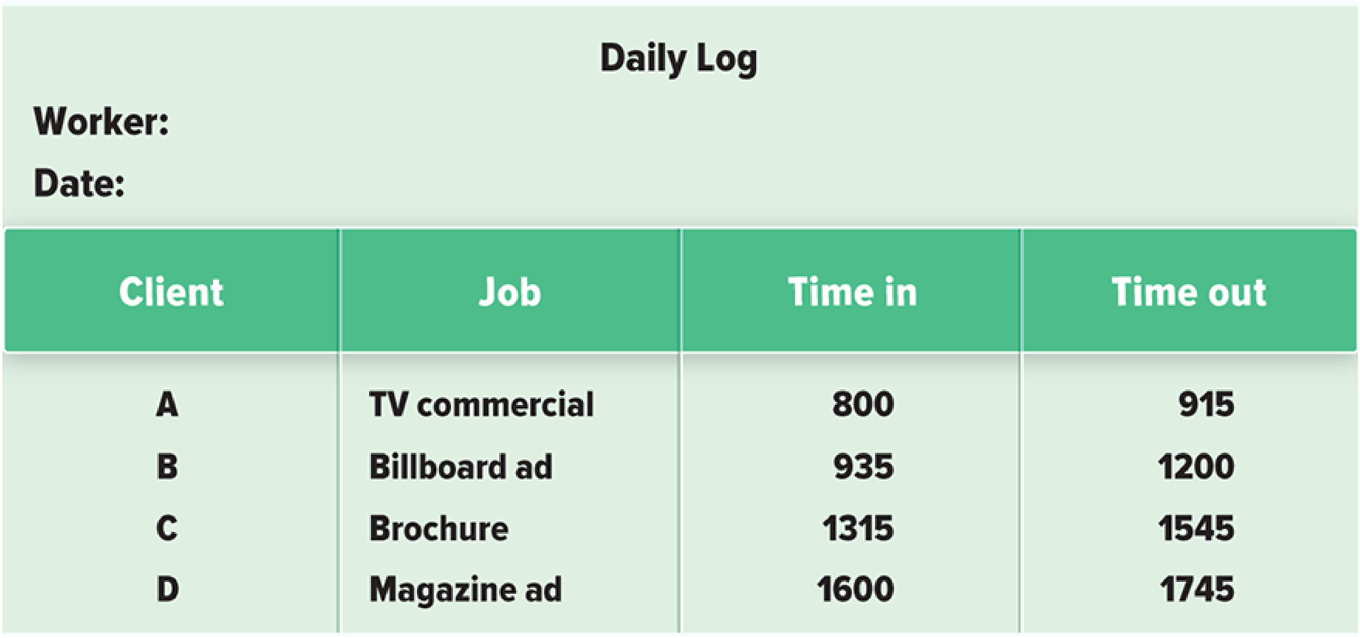
Client name: Allen Realty — Month and Year: Jan. '21

Date	Worker	Regular Hours & Rate	Overtime Hours & Rate	Bill
1/2	M. Jones	5 @ $10	1 @ $15	$65.00
	K. Williams	4 @ $30	2 @ $45	$210.00

Input Data

Once the desired output is known, the input data and the source of this data can be determined.

- For example, for a time-and-billing report, one source of data could be time cards that are usually logs or statements of hours worked submitted either electronically or on paper forms.



Daily Log

Worker:
Date:

Client	Job	Time in	Time out
A	TV commercial	800	915
B	Billboard ad	935	1200
C	Brochure	1315	1545
D	Magazine ad	1600	1745

Processing Requirements

- Processing requirements define the processing tasks that must happen for input data to be processed into output.
- For Advantage Advertising, one of the processing tasks for the program could be adding the hours worked for different jobs for different clients.

Program Specifications Document

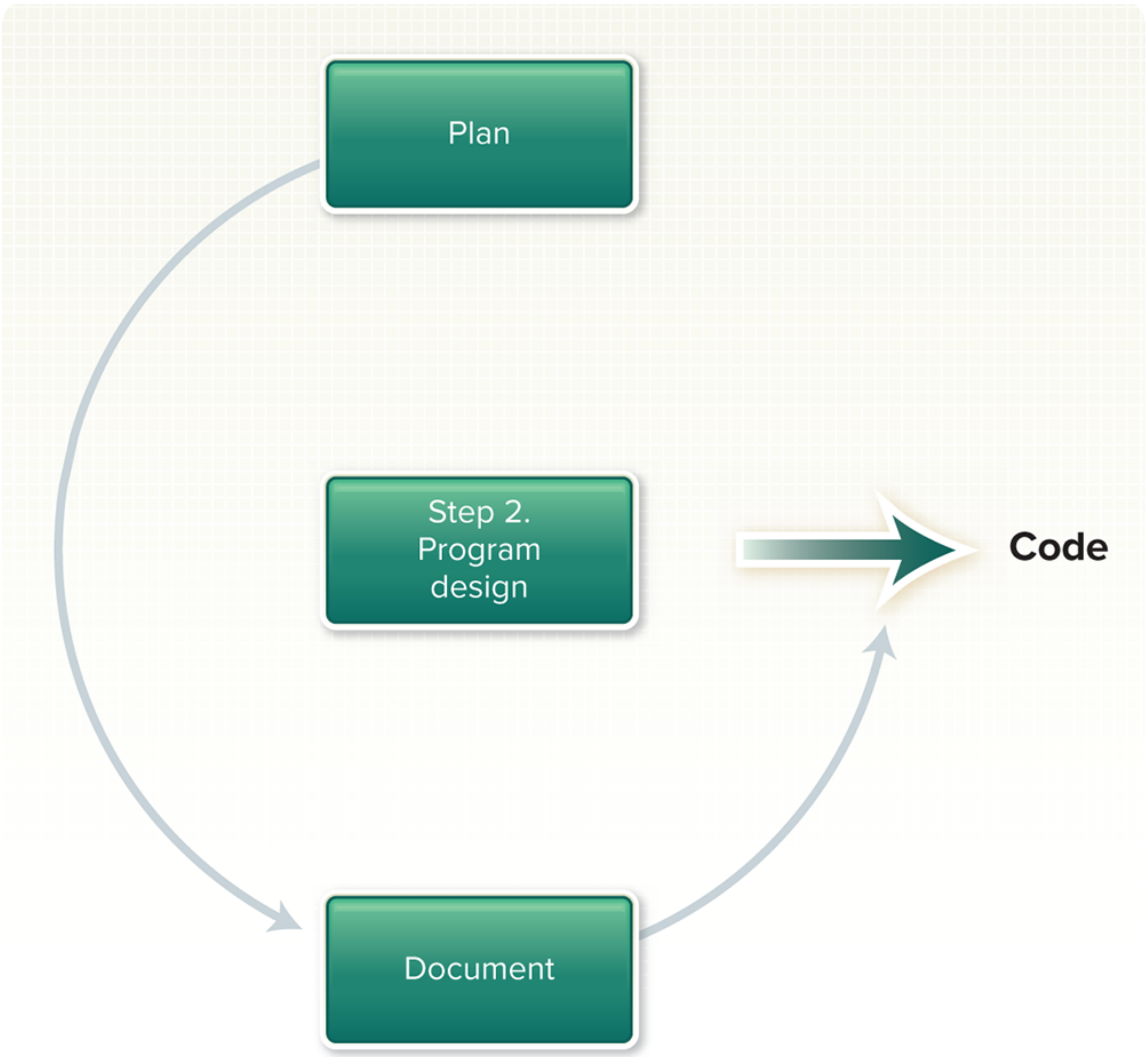
Documentation is essential for program specifications. Program objectives, desired outputs, input data, and processing requirements should all be recorded. This leads to the next step, program design.

Concept Check

- Program specification is the process of specifying program objectives, desired output, input data, processing requirements, and documentation.
- The first procedure is determining program objectives, which involves making a clear statement of the problem that needs to be solved. Desired outputs should be determined before input to help clarify the end goal.
- Processing requirements define the tasks that must be performed to process input data into output. Program specifications should be documented for ongoing reference and future use.

Step 2: Program Design

Program Design

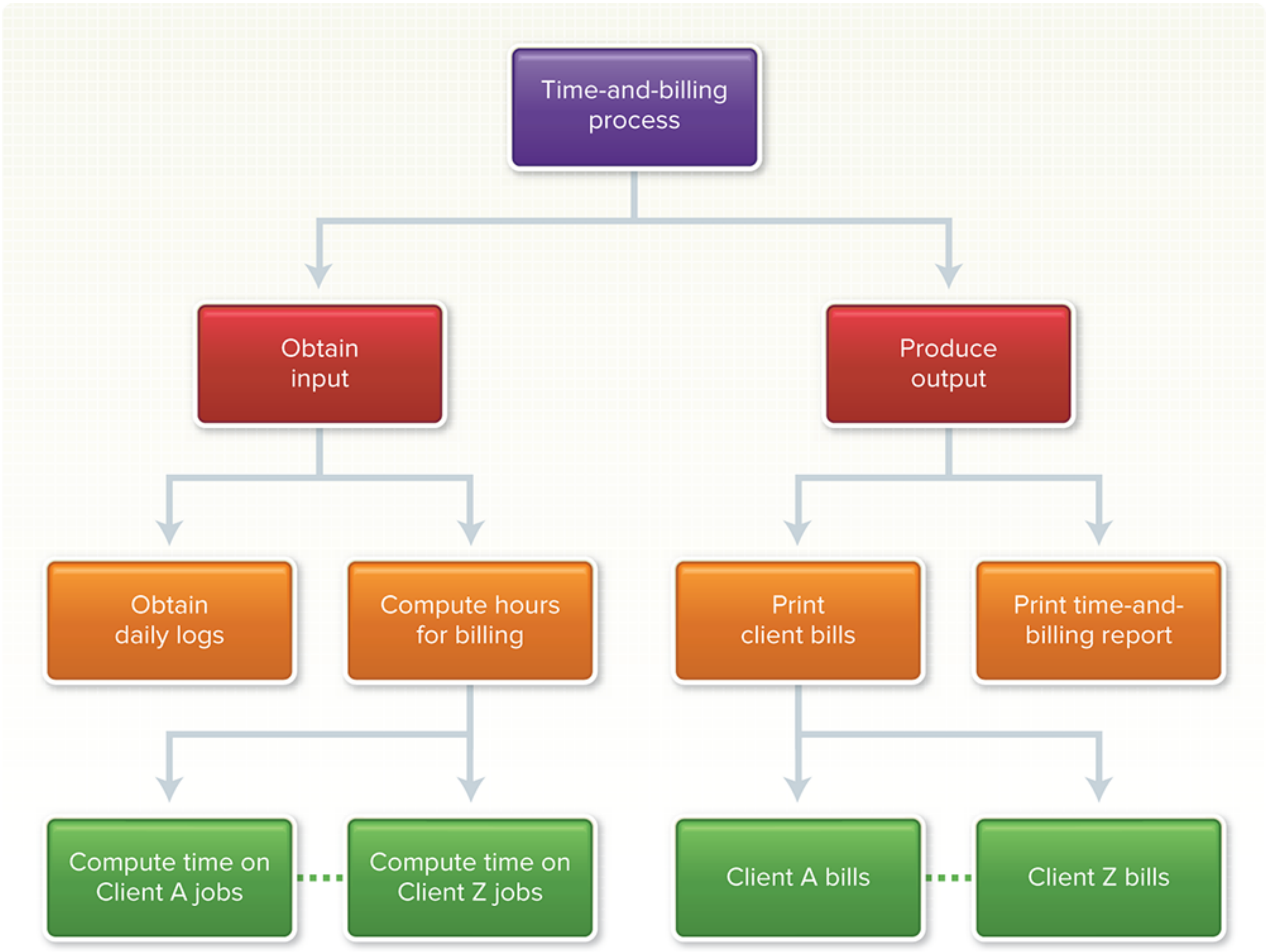


- Program design follows program specification.
- Use a structured programming technique for this step.
- Structured programming techniques include:
    1. Top-down program design
    2. Pseudocode
    3. Flowcharts
    4. Logic structures

Top-Down Program Design

- First determine outputs and inputs for the program.
- Use top-down program design to identify program's processing steps (**program modules**, or just **modules**).
    - Each module is made up of logically related program statements
- Each module should have a single function.

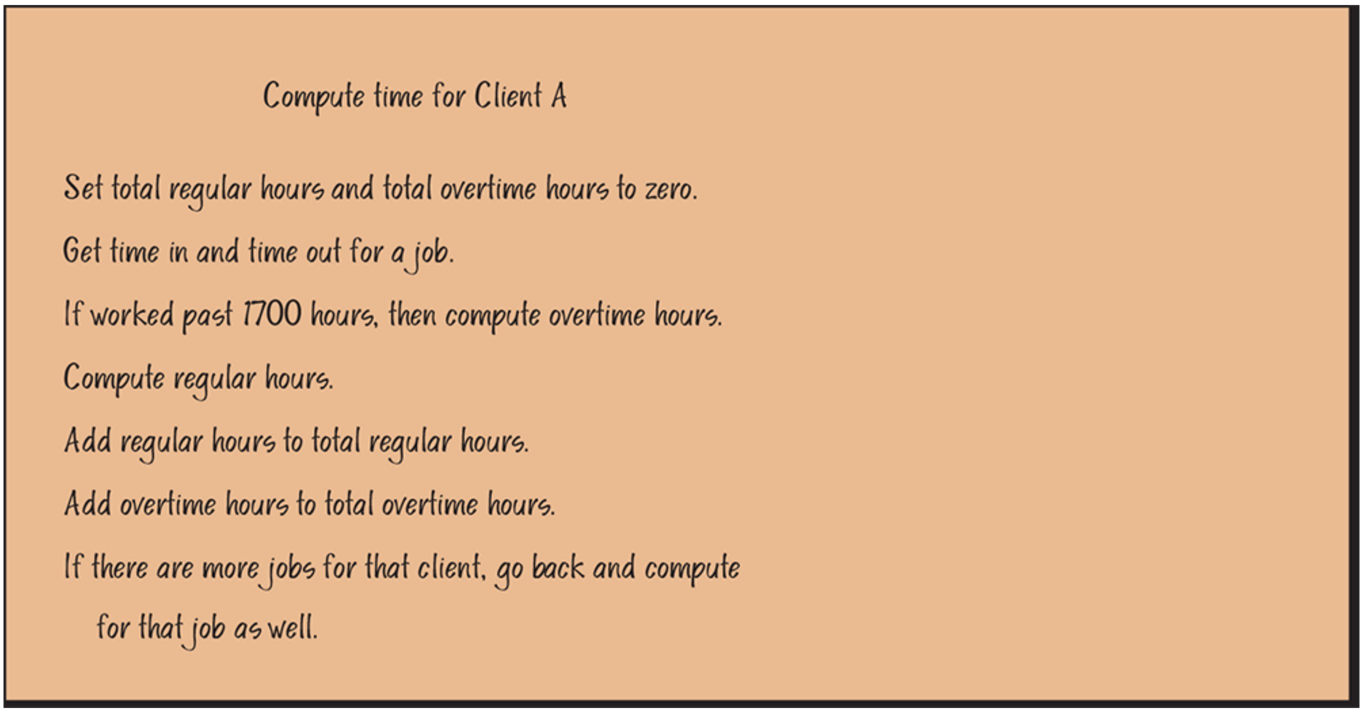
Example Top-Down Program Design



Pseudocode

- Outline of the logic of the program.
- Summary of the program before it is written.

Example Pseudocode



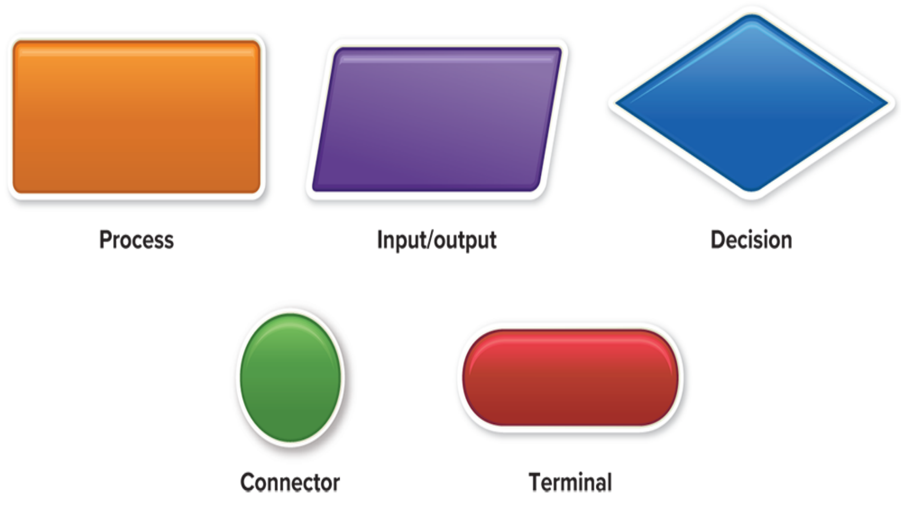
```
Compute time for Client A

Set total regular hours and total overtime hours to zero.
Get time in and time out for a job.
If worked past 1700 hours, then compute overtime hours.
Compute regular hours.
Add regular hours to total regular hours.
Add overtime hours to total overtime hours.
If there are more jobs for that client, go back and compute
   for that job as well.
```

Flowcharts

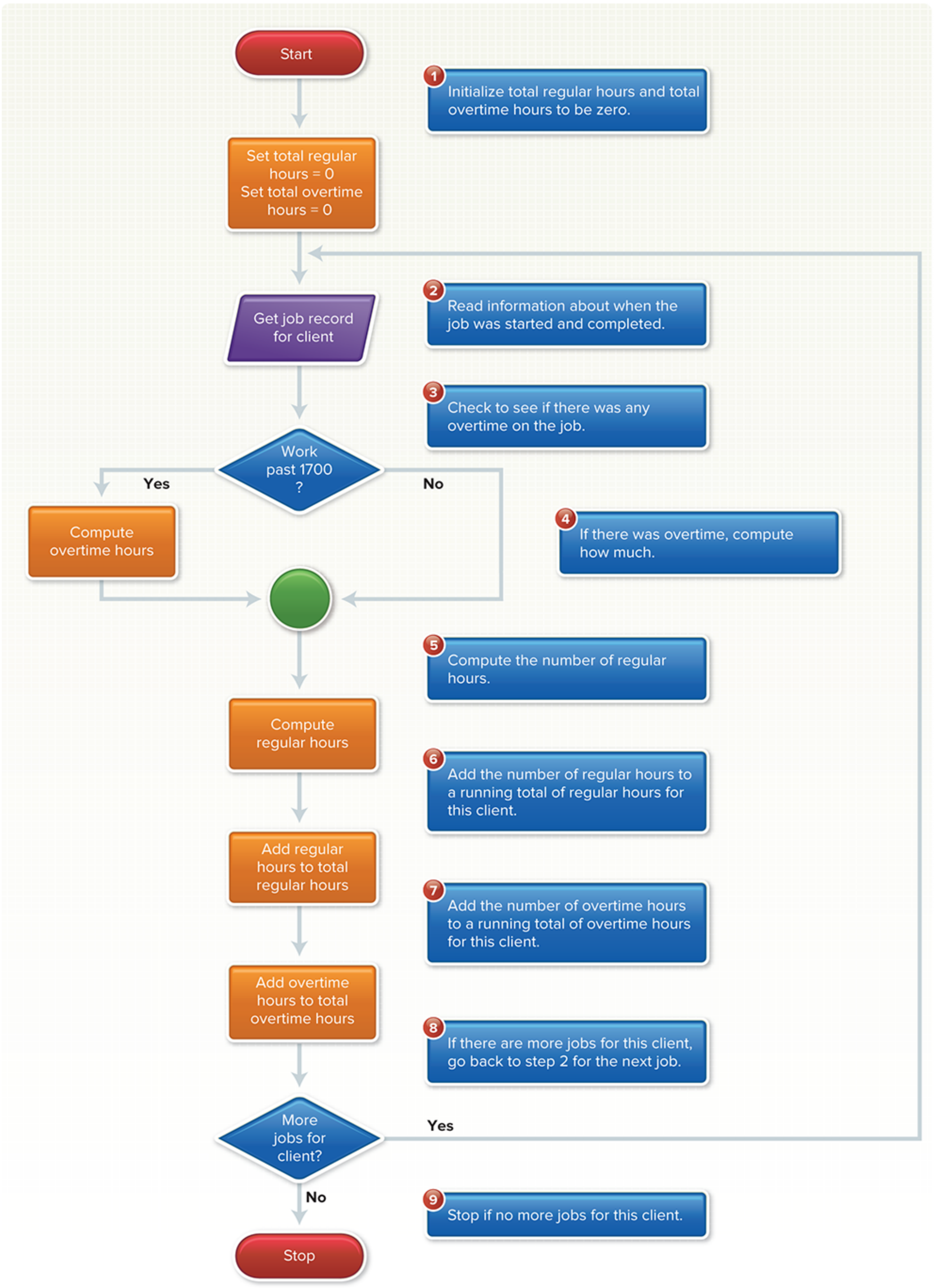
- Program flowcharts present the detailed sequence of steps needed to solve a programming problem.
- Standard flowchart symbols:
  - **Process**
  - **Input/output**
  - **Decision**
  - **Connector**
  - **Terminal**
- Flowcharts express the logic for program modules.

Flowchart Symbols

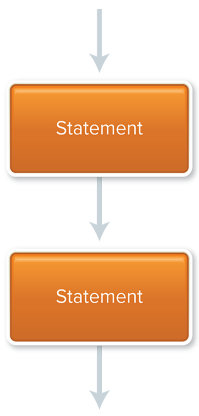


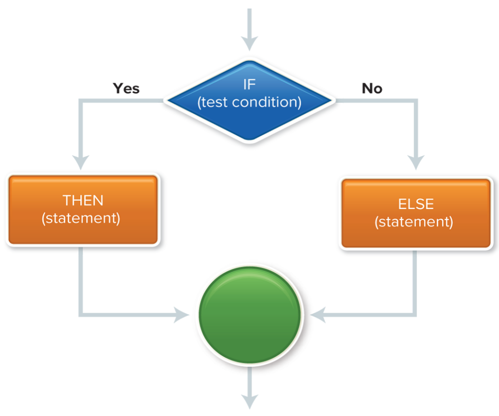
Example Flowchart

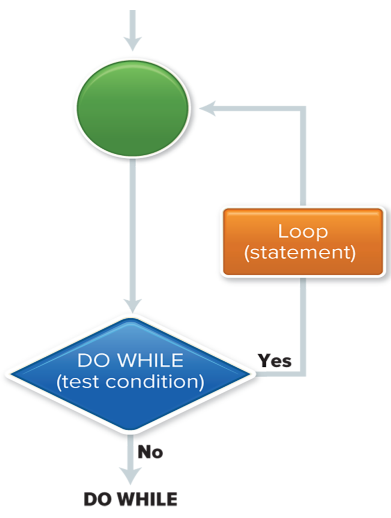
This flowchart expresses all the logic for just one module–*“Compute time on Client A jobs”*–in the top-down program design.


Start
Set total regular hours = 0 Set total overtime hours = 0
Get job record for client
Work past 1700 ?
Yes
No
Compute overtime hours
Compute regular hours
Add regular hours to total regular hours
Add overtime hours to total overtime hours
More jobs for client?
Yes
No
Stop
1 Initialize total regular hours and total overtime hours to be zero.
2 Read information about when the job was started and completed.
3 Check to see if there was any overtime on the job.
4 If there was overtime, compute how much.
5 Compute the number of regular hours.
6 Add the number of regular hours to a running total of regular hours for this client.
7 Add the number of overtime hours to a running total of overtime hours for this client.
8 If there are more jobs for this client, go back to step 2 for the next job.
9 Stop if no more jobs for this client.

Logic Structures

- The best way to link various parts of the flowchart is by using a combination of three **logic structures**:
  - **Sequential**
    - One program statement follows another
    - 

  - **Selection *(IF-THEN-ELSE)***
    - A decision must be made and the outcome determines which of two paths to follow.
    - 

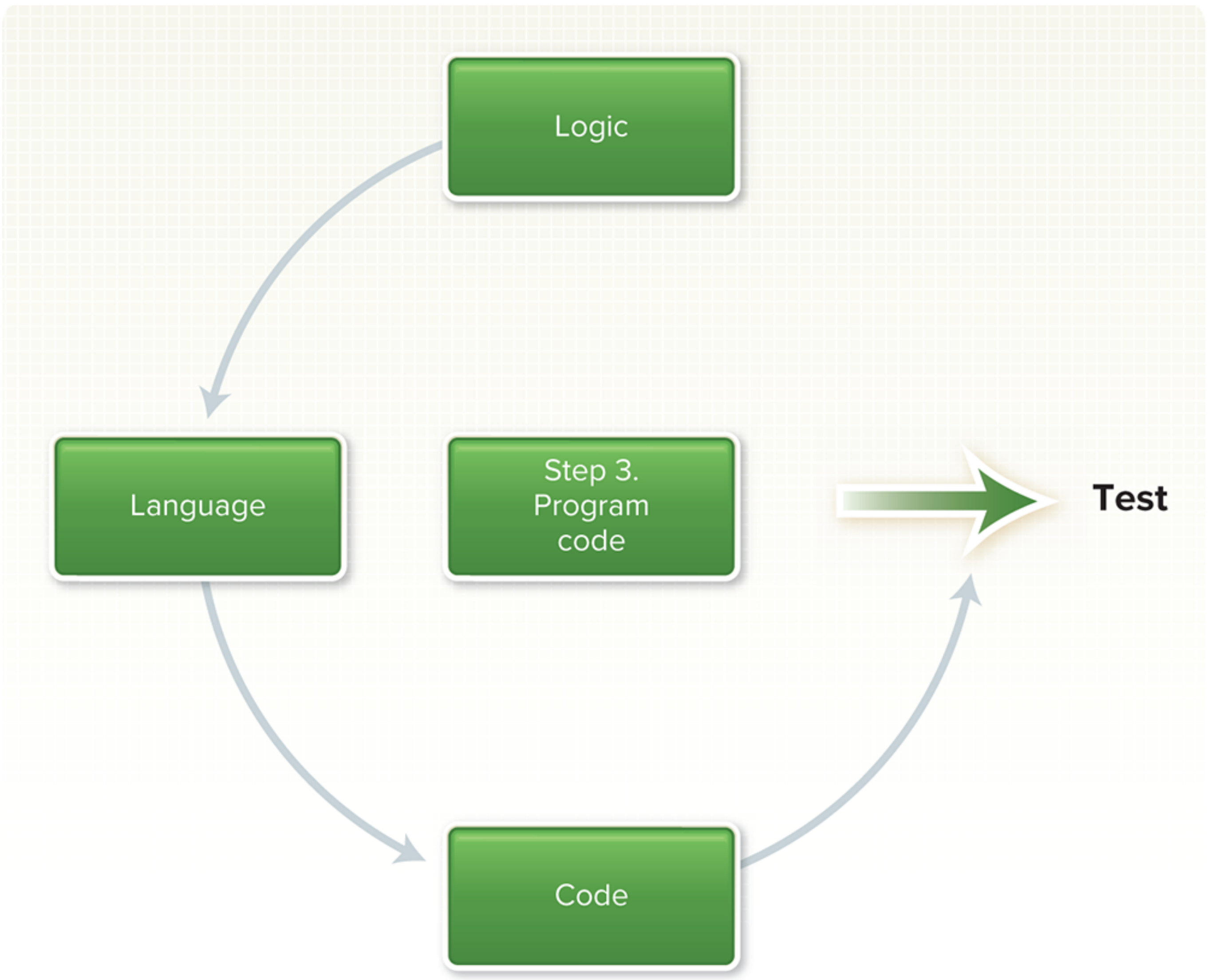
  - **Repetition structures**
    - A loop that repeats until a specific condition is met.
    - Also known as the **loop structure**.
    - 

Conclusion

- Program design is a crucial step in creating effective software.
- Structured programming techniques, such as top-down program design, pseudocode, flowcharts, and logic structures, help to organize and clarify the logic of a program.
- Using these techniques can improve the readability, maintainability, and overall quality of the resulting software.

Step 3: Program Code

What is coding?



- Coding is the process of writing a program using the logic developed in the program design step.
- It is also known as "program code" which instructs the computer on what to do.

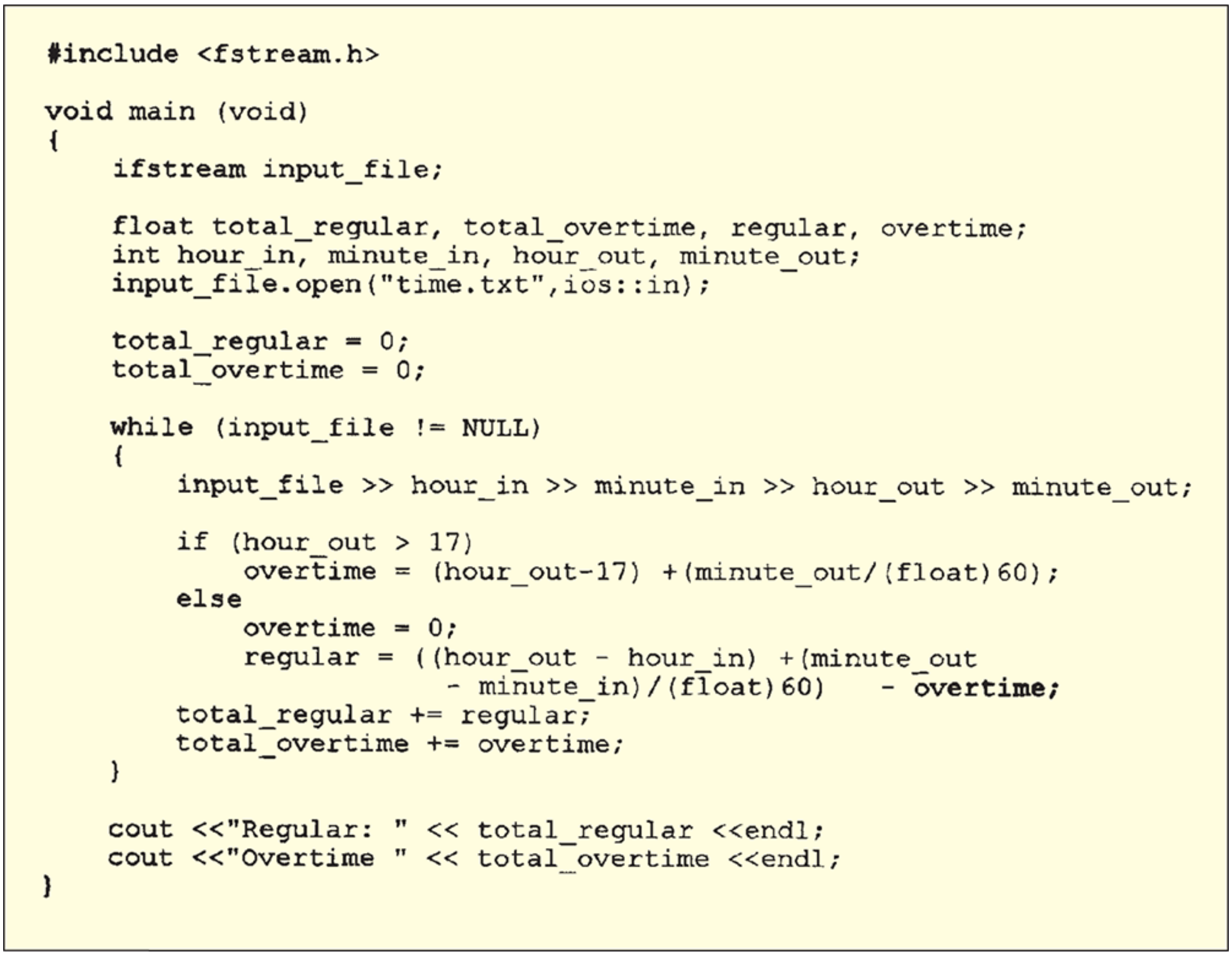
The Good Program

- A good program should be reliable, catch obvious and common input errors, and produce correct output.
- It should be well-documented and understandable by programmers other than the person who wrote it.
- Structured programming is one of the best ways to write effective programs, using the logic structures described in **Step 2: Program Design**.

Programming Languages

- A programming language uses a collection of symbols, words, and phrases to instruct a computer to perform specific operations.
- Programming languages process data and information for a wide variety of different types of applications.
- Examples of widely-used programming languages include
    - `C++`
    - `C#`
    - `Java`
    - `JavaScript`
    - `Python`
    - `Swift`

Example C++ Code



```
#include <fstream.h>

void main (void)
{
    ifstream input_file;

    float total_regular, total_overtime, regular, overtime;
    int hour_in, minute_in, hour_out, minute_out;
    input_file.open("time.txt",ios::in);

    total_regular = 0;
    total_overtime = 0;

    while (input_file != NULL)
    {
        input_file >> hour_in >> minute_in >> hour_out >> minute_out;

        if (hour_out > 17)
            overtime = (hour_out-17) +(minute_out/(float)60);
        else
            overtime = 0;
            regular = ((hour_out - hour_in) +(minute_out
                        - minute_in)/(float)60)    - overtime;
        total_regular += regular;
        total_overtime += overtime;
    }

    cout <<"Regular: " << total_regular <<endl;
    cout <<"Overtime " << total_overtime <<endl;
}
```

Table Summary:

Language	Description
C++	Extends C to use objects or program modules that can be reused and interchanged between programs
C#	A programming language designed by Microsoft to extend C++ for developing applications in the Windows environment
Java	Primarily used for Internet applications; similar to C++; runs with a variety of operating systems
JavaScript	Embedded into web pages to provide dynamic and interactive content
Python	General-purpose programming language that is simple and easy to learn. Frequently used in introductory programming courses
Swift	Uses graphical user interface and special code for touch screen interfaces to create apps for Apple iOS devices

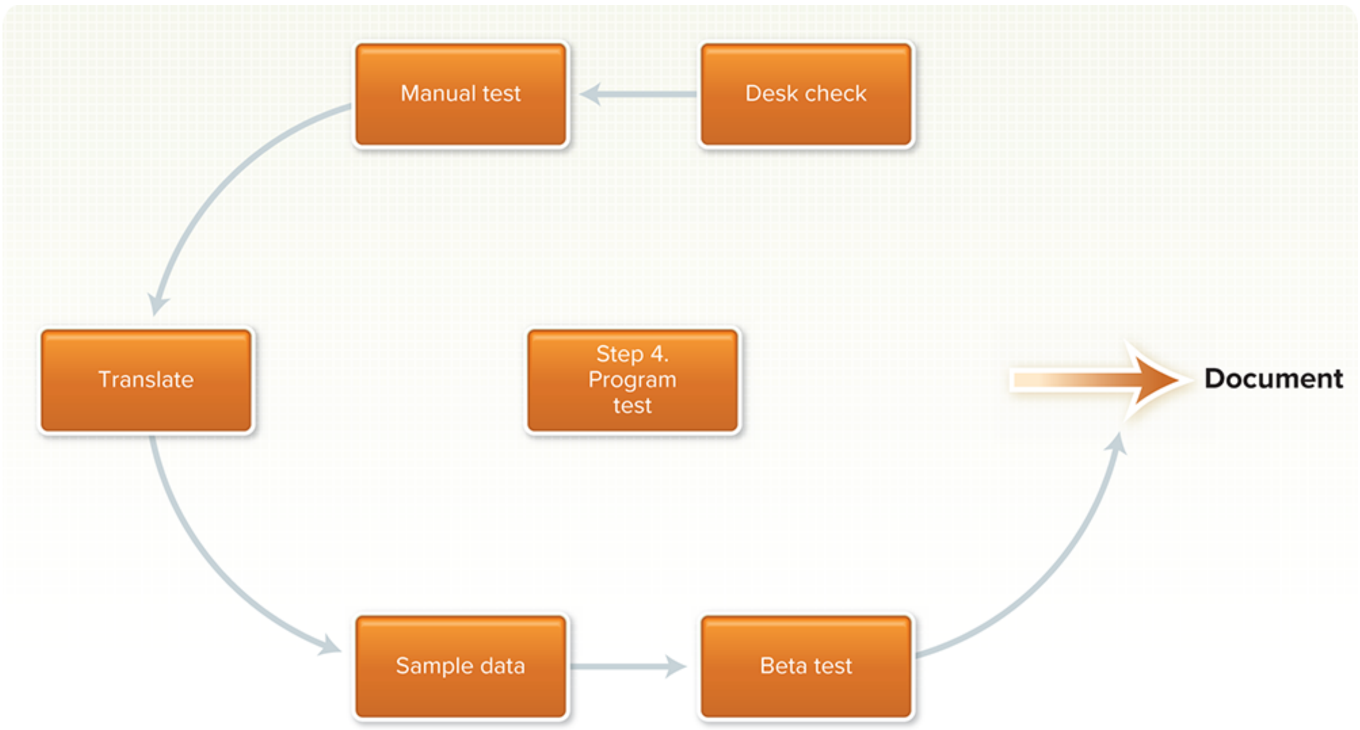
Testing and Debugging

- Once the program has been coded, the next step is testing or debugging the program.

Conclusion

- In this section, we learned that coding is the process of writing a program using the logic developed in the program design step.
- A good program should be reliable, catch obvious and common input errors, and produce correct output.
- Programming languages use a collection of symbols, words, and phrases to instruct a computer to perform specific operations.
- Testing and debugging the program is the next step after coding.

Step 4: Program Test



Debugging

- Refers to the process of testing and then eliminating errors ("getting the bugs out").
- Programming errors are of two types:
  - **Syntax errors**
  - **Logic errors**

Syntax Errors

- Violation of the rules of the programming language.
- *Example: In* `C++`*, each statement must end with a semicolon (;). If the semicolon is omitted, then the program will not run or execute due to a syntax error.*
- Testing of the compute time module in which a syntax error was identified.

Logic Errors

- Occurs when the programmer uses an incorrect calculation or leaves out a programming procedure.

- *Example: A payroll program that did not compute overtime hours would have a logic error.*

Testing Process

Several methods have been devised for finding and removing both types of errors:

1. **Desk checking** or **code review**
   - A programmer sitting at a desk checks (proofreads) a printout of the program for syntax and logic errors.
2. **Manually testing with sample data**
   - A programmer follows each program statement and performs every calculation using sample data. The programmer compares the manually calculated values to those calculated by the program to look for programming logic errors.
3. **Attempt at translation**
   - The program is run through a computer, using a translator program. The translator attempts to translate the written program from the programming language (such as `C++`) into the machine language. Before the program will run, it must be free of syntax errors. Such errors will be identified by the translating program.
4. **Testing sample data on the computer**
   - After all syntax errors have been corrected, the program is tested for logic errors. Sample data is used to test the correct execution of each program statement.
5. **Testing by a select group of potential users (beta testing)**
   - It is usually the final step in testing a program. Potential users try out the program and provide feedback.

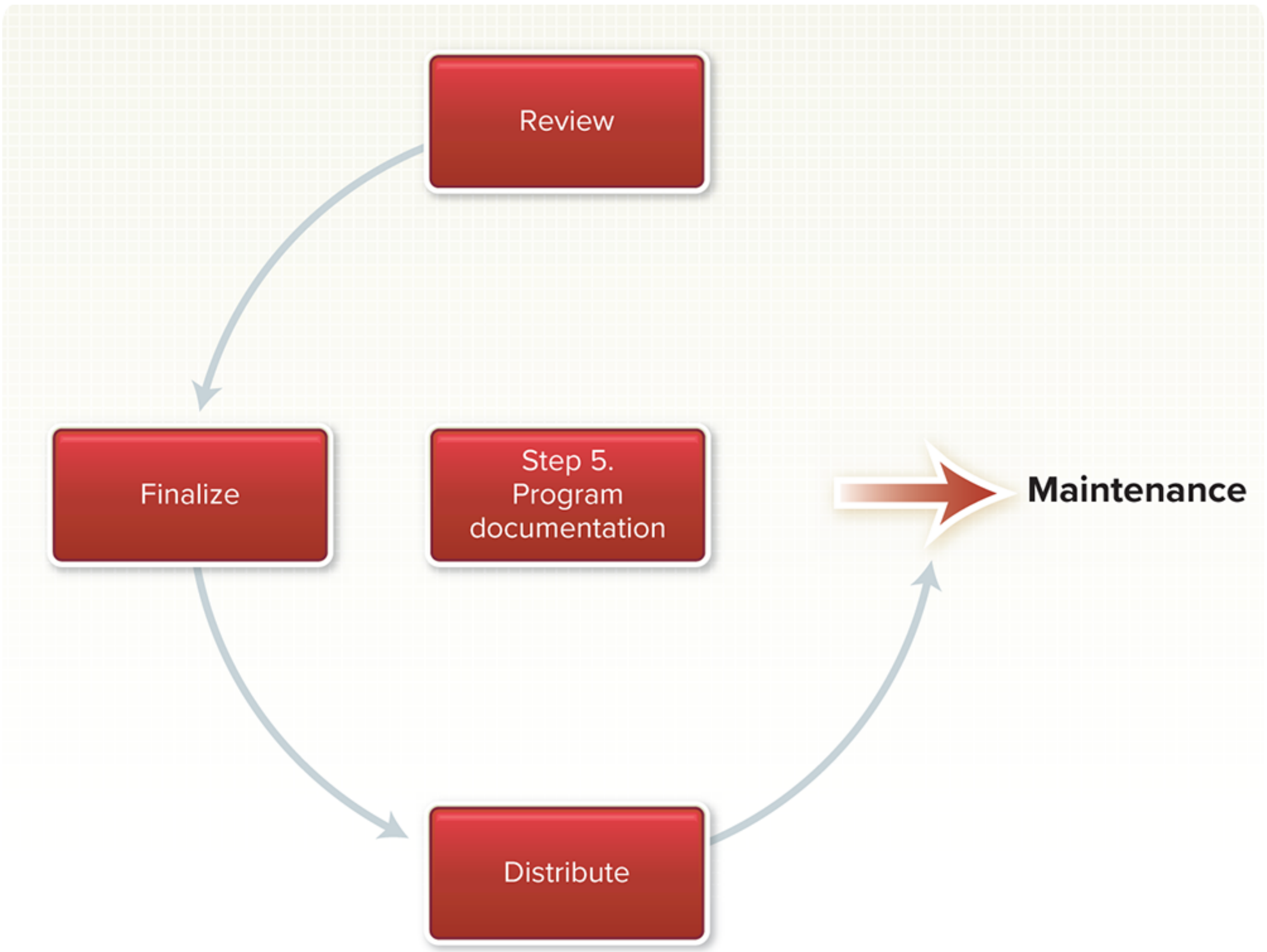
Testing Process Summary

Task	Description
1	Desk check for syntax and logic errors
2	Manually test with sample data
3	Translate program to identify syntax errors
4	Run program with sample data
5	Beta test with potential users

Conclusion

- Debugging is the process of testing and then eliminating errors in a program.
- Syntax errors are violations of the rules of the programming language, while logic errors occur when the programmer uses an incorrect calculation or leaves out a programming procedure.
- The testing process includes desk checking, manually testing with sample data, attempting at translation, testing sample data on the computer, and beta testing with potential users.

Step 5: Program Documentation



Definition and Purpose of Documentation

- Documentation refers to written descriptions and procedures about a program and how to use it.
- It is not something done just at the end of the programming process, but rather carried on throughout all the programming steps.
- Documentation is important for people who may be involved with the program in the future, such as:
    - **Users**
    - **Operators**
    - **Programmers**

Users and User Documentation

- Users need to know how to use the software.

- Printed manuals and the help option within most applications are two examples of user documentation.
- Some organizations may offer training courses to guide users through the program.

Operators and Operator Documentation

- Documentation must be provided for computer operators.
- Operators need to know how to respond to error messages, for instance.

Programmers and Programmer Documentation

- Other programmers wishing to update and modify the program may find themselves frustrated without adequate documentation.
- Programmer documentation should include text and program flowcharts, program listings, and sample output.
- It also might include system flowcharts to show how the particular program relates to other programs within an information system.

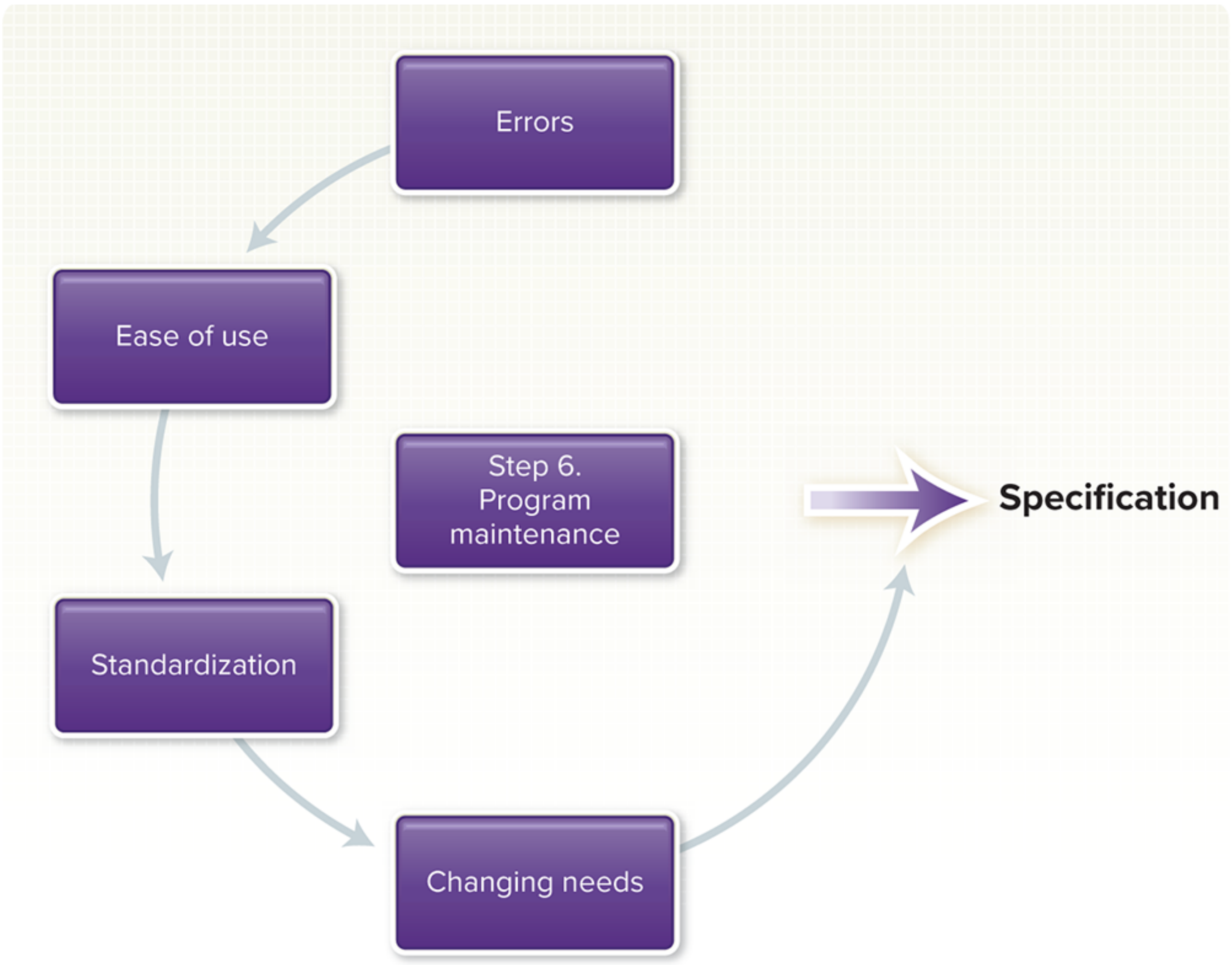
Additional Information:

- Documentation is an essential aspect of software development that can help users, operators, and programmers to better understand and use the software.
- Program documentation occurs throughout all programming steps and not just at the end of the programming process.

Conclusion

Program documentation is an essential aspect of software development that ensures that people who may be involved with the program in the future can easily understand and use it. The documentation should be written throughout all the programming steps, including text and program flowcharts, program listings, and sample output. Adequate documentation can help users, operators, and programmers to better understand and use the software, while poor documentation can lead to frustration and confusion.

Step 6: Program Maintenance



Purpose of Program Maintenance

- The purpose of program maintenance is to ensure that current programs are operating error-free, efficiently, and effectively.
- Maintenance is responsible for locating and correcting operational errors, making programs easier to use, and standardizing software using structured programming techniques.
- Activities in this area fall into two categories:
    - **Operations**
    - **Changing needs**
- As much as 75 percent of the total lifetime cost for an application program is for maintenance.
    - This activity is so commonplace that a special job title, **maintenance programmer**, exists.

Operations Activities

- Operations activities concern locating and correcting operational errors, making programs easier to use, and standardizing software using structured programming techniques.
- For properly designed programs, these activities should be minimal.
- Programming modifications or corrections are often referred to as **patches**.
    - If the patches are significant, they are known as **software updates**.
- For software that is acquired, it is common for the software manufacturer to periodically send patches or updates for its software.

Changing Needs

- Programs need to be adjusted for a variety of reasons, including new tax laws, new information needs, and new company policies.
- Significant revisions may require that the entire programming process begin again with program specification.
- All organizations change over time, and their programs must change with them.

Programming Process

- Ideally, a software project sequentially follows the six steps of software development.
- The six steps are **program specification**, **program design**, **program code**, **program test**, **program documentation**, and **program maintenance**.
- Some projects start before all requirements are known, in which case the SDLC becomes a more cyclical process, repeated several times throughout the development of the software.
- **Agile development**, a popular development methodology, starts by getting core functionality of a program working, and then expands on it until the customer is satisfied with the results.
- All six steps are repeated over and over as quickly as possible to create incrementally more functional versions of the application.

Summarizing The Six Steps of The Programming Process

Step	Primary Activity
1. Program specification	Determine program objectives, desired output, required input, and processing requirements.
2. Program design	Use structured programming techniques.
3. Program code	Select programming language; write the program.
4. Program test	Perform desk check (code review) and manual checks; attempt translation; test using sample data; beta test with potential users.
5. Program documentation	Write procedure for users, operators, and programmers.
6. Program maintenance	Adjust for errors, inefficient or ineffective operations, nonstandard code, and changes over time.

Conclusion

Program maintenance is an essential step in the software development process, accounting for a significant portion of the total lifetime cost of an application program. It involves two main categories of activities: operations and changing needs. Operations activities focus on locating and correcting operational errors, making programs easier to use, and standardizing software using structured programming techniques. Changing needs refer to the need to adjust programs for various reasons, including new company policies and tax laws. The software development process typically follows the six steps outlined in Figure 13-21, but it may become a more cyclical process if all requirements are not known at the outset. Agile development, a popular methodology, emphasizes quick iterations and core functionality.

CASE and OOP

CASE Tools

- **Computer-aided software engineering (CASE)** tools provide automation and assistance in program design, coding, and testing.
- CASE tools help in making professional programmers work easier, faster, and more reliable.
- Examples of CASE tools are Enterprise Architect from Sparx Systems and Smartdraw Software, LLC.

Object-Oriented Software Development

- Traditional systems development focuses on the procedures needed to complete a certain objective.
- Object-oriented software development focuses on defining the relationships between previously defined procedures or "objects".
- Object-oriented programming (OOP) is a process by which a program is organized into objects.
- Each object contains both the data and processing operations necessary to perform a task.
- Programs built with objects are reusable, self-contained components, making the development process faster and easier.

Object-Oriented Programming Example

- Object-oriented programming is like building a car from prefabricated parts instead of building it from scratch.
- Object-oriented programs assume that certain functions are the same and use reusable objects to accomplish them.
- For example, many programs have an instruction that will sort lists of names in alphabetical order. A programmer might use this object for alphabetizing in many other programs.

Concept Check

- CASE tools are computer-aided software engineering tools that provide automation and assistance in program design, coding, and testing.
- Object-oriented software development is a development approach that focuses on defining relationships between previously defined procedures or "objects".
- Object-oriented programming is a process by which a program is organized into objects, each containing both data and processing operations necessary to perform a task.

Conclusion

- CASE tools and object-oriented programming are two resources that help in making professional programmers work more efficient and reliable.
- While CASE tools assist in automation and program design, coding, and testing, object-oriented programming allows for faster development with reusable, self-contained components.

Generations of Programming Languages

Overview

- Computer professionals use levels or generations to classify programming languages.
- Programming languages are called lower level if they are closer to the language the computer uses and higher level if they are closer to the language humans use.
- There are five generations of programming languages:
  - Machine languages
  - Assembly languages
  - Procedural languages
  - Task-oriented languages
  - Problem and constraint languages

Machine Languages: The First Generation

- Data in bits that consist of **1s** and **0s** is written in machine language.
- Example coding schemes developed from this two-state system are **EBCDIC**, **ASCII**, and **Unicode**.
- Machine languages are difficult to understand and vary according to the make of computer.

```
111100100111001111010010000100000111000000101011
```

Assembly Languages: The Second Generation

- Assembly languages use abbreviations or mnemonics such as `ADD` that are automatically converted to machine language.
- Assembly languages are easier for humans to understand than machine languages.
- Assembly languages are also considered low level.

```
ADD 210(8, 13), 02 B(4, 7)
```

High-Level Procedural Languages: The Third Generation

- High-level languages are considered **portable languages**.
- Procedural languages are also known as **3GLs (third-generation languages)**.
- Procedural languages are more English-like programming languages.
- Procedural languages are designed to express the logic that can solve general problems.
- Procedural languages must be translated into machine language so that the computer can process them.
- The translation is performed by either a compiler or an interpreter.
- `C++` is a procedural language widely used by today’s programmers.

```
if (score > = 90) grade = ‘A’;
```

Like assembly languages, procedural languages must be translated into machine language so that the computer processes them. Depending on the language, this translation is performed by either a *compiler* or an *interpreter.*

- A **compiler** converts the programmer's procedural language program, called the **source code**, into a machine language code, called the **object code**.
    - This object code can then be saved and run later.
    - The standard version of `C++` is a procedural language that uses a compiler.
- An **interpreter** converts the procedural language one statement at a time into machine code just before it is to be executed.
    - No object code is saved.
    - An example of a procedural language using an interpreter is the standard version of **BASIC**.

Difference between Compiler and Interpreter

The following table summarizes the differences between a Compiler and an Interpreter.

Criteria	Compiler	Interpreter
Conversion process	Converts entire source code to object code	Converts one line of code to machine code
Execution process	Runs object code	Executes the converted code and repeats the process for each line of code
Program execution	Faster execution once object code is obtained	Slower execution compared to compiled programs
Program size	More efficient for large programs	Not as efficient for large programs
Development	Programs are generally harder to develop	Programs are easier to develop
Debugging	Debugging is generally harder	Debugging is easier

Steps

- **Compiler**

   1. Converts entire source code to object code
   2. Runs object code

- **Interpreter**

   1. Converts one line of code to machine code
   2. Executes the converted code
   3. Repeats the above steps for every line of code in the program

Task-Oriented Languages: The Fourth Generation

Overview

- Task-oriented languages are also known as 4GLs (fourth-generation languages).
- They require little special training on the part of the user.
- 4GLs are designed to solve specific problems.

Comparison with 3GLs

- 3GLs require training in programming.
- 4GLs are nonprocedural and focus on specifying the specific tasks the program is to accomplish.
- 4GLs are more English-like and easier to program.

Query Languages

- Query languages enable nonprogrammers to use certain easily understood commands to search and generate reports from a database.
- One of the most widely used query languages is SQL (Structured Query Language).
- Example SQL command to create a list of clients who incurred overtime charges:

  ```
  SELECT client FROM dailyLog WHERE serviceEnd >17
  ```

- Microsoft Access can generate SQL commands using its Query wizard.

Application Generators

- Also known as a **program coder**
- An application generator provides modules of prewritten code.
- It greatly reduces the time to create an application.
- Access has a report generation application and a Report wizard for creating a variety of different types of reports using database information.

Conclusion

- Task-oriented languages or 4GLs are useful because they require little special training on the part of the user.
- Query languages and application generators are examples of 4GLs that make it easy for nonprogrammers to search and generate reports from a database or quickly create a program by referencing prewritten code modules.

Problem and Constraint Languages: The Fifth Generation

- The fifth-generation language (5GL) incorporates the concepts of artificial intelligence to allow a person to provide a system with a problem and some constraints and then request a solution.
- These languages enable a computer to learn and to apply new information as people do.
- Researchers are actively working on the development of 5GL languages.

```
Get patientDiagnosis from patientSymptoms “sneezing”,“coughing”, “aching”
```

Summary of Generations of Programming Languages

Generation	Sample Statement
First: Machine	`111100100111001111010010000100000111000000101011`
Second: Assembly	ADD 210(8,13),02B(4,7)
Third: Procedural	`if (score >= 90) grade = 'A';`
Fourth: Task	SELECT client FROM dailyLog WHERE serviceEnd > 17
Fifth: Problems and Constraints	`Get patientDiagnosis from patientSymptoms "sneezing", "coughing", "aching"`

Concept Check

- A lower-level language is closer to the language the computer uses, while a higher-level language is closer to the language humans use.
- Machine languages are written in 1s and 0s and are difficult to understand, while assembly languages use abbreviations that are automatically converted to machine language and are easier for humans to understand.
- Procedural languages express the logic that can solve general problems, while task-oriented languages are designed to solve specific problems.
- Problem and constraint languages are fifth-generation languages that incorporate the concepts of artificial intelligence to allow a person to provide a system with a problem and some constraints and then request a solution.

Conclusion

The generations of programming languages reflect the evolution of programming from the use of low-level machine languages to more human-readable high-level languages that allow for the creation of complex software applications. Each generation of languages has its unique features and advantages, and programmers should choose the language that best suits their project's requirements.

Careers in IT

Overview

- Computer programmers create, test, and troubleshoot computer programs.
- They may work on a project basis as consultants, employed by companies or other businesses.
- Demand for computer programmers with specializations in advanced programs continues to exist.
- The field requires at least a bachelor's degree in computer science or information systems, but a two-year degree could also lead to a position in the field.
- Employers looking for programmers usually prioritize previous experience.
- Necessary qualities for computer programmers are patience, logical thinking, attention to detail, and the ability to communicate technical information to non-technical people.
- The average annual salary for computer programmers is between $65,760 to$112,120.
- Talented programmers have advancement opportunities such as a lead programmer position or supervisory positions.
- Programmers with specializations and experience also may have an opportunity to consult.

A Look to the Future: Your Own Programmable Robot

Overview

- The field of robotics is continually advancing and making better programming tools.
- Several companies are already mass-producing programmable robots for individuals and educational institutions.
- A future where robots can understand human instructions instead of complex programming languages is possible.
- The hardware components needed to make robots are becoming cheaper.
- Developers will use sophisticated programming to give the robot the artificial intelligence necessary to understand natural language.

- Speech recognition continues to improve, but many improvements are necessary before a humanoid robot will be able to converse with humans.

Examples

- The Roomba from iRobot was one of the earliest robots available to consumers and is essentially an automated, intelligent vacuum cleaner.
- Aldebaran Robotics created small, humanoid robots called Nao, which the end-user can program.
- Using a GUI, students can create programs that the robot will follow.
- The Nao robots are being mass-produced and are being marketed toward schools and research institutions.
- Developers will use sophisticated programming to give the robot the artificial intelligence necessary to understand natural language, which will be embedded in a chip within the robot.

Useful tips and tricks

- Programming skills may be necessary to program robots in the future.
- Technology is making better programming tools that will make programming robots easier.
- Speech recognition continues to improve, but many improvements are necessary before a humanoid robot will be able to converse with humans.

Conclusion

The field of computer programming requires patience, logical thinking, attention to detail, and the ability to communicate technical information to non-technical people. Programmers can expect to earn an annual salary in the range of $65, 760 to$112,120, and there are advancement opportunities for talented programmers.
In the future, owning a programmable humanoid robot that understands natural language is possible. However, many improvements are necessary in speech recognition technology to achieve this goal.