

# **IT2205: Programming I**

## **Section 1**

### **The history and evolution of Java (2 hrs)**



# 1.1 The History and Evolution of Java

- To fully understand Java, one must understand the reasons behind its creation, the forces that shaped it, and the legacy that it inherits.
- Like the successful computer languages that came before, Java is a blend of the best elements of its rich heritage combined with the innovative concepts required by its unique mission.
- Although Java has become inseparably linked with the online environment of the Internet, it is important to remember that Java is first and foremost a programming language.

# 1.1 The History and Evolution of Java

## Cont...

- Computer language innovation and development occurs for two fundamental reasons:
  - To adapt to changing environments and uses
  - To implement refinements and improvements in the art of programming
- The development of Java was driven by both elements in nearly equal measure.

# 1.1 Java's Lineage

- Java is related to C++, which is a direct descendant of C.
- Much of the character of Java is inherited from these two languages.
- From C, Java derives its syntax.
- Many of Java's object-oriented features were influenced by C++.

# 1.2 The Birth of Modern Programming: C

- The C language shook the computer world. Its impact should not be underestimated, because it fundamentally changed the way programming was approached and thought about.
- The creation of C was a direct result of the need for a structured, efficient, high-level language that could replace assembly code when creating systems programs.
- When a computer language is designed, trade-offs are often made, such as the following:
  - Ease-of-use versus power
  - Safety versus efficiency
  - Rigidity versus extensibility

# 1.2 The Birth of Modern Programming: C Cont...

- Prior to C, programmers usually had to choose between languages that optimized one set of traits or the other.
- For example, although FORTRAN could be used to write fairly efficient programs for scientific applications, it was not very good for system code.
- And while BASIC was easy to learn, it wasn't very powerful, and its lack of structure made its usefulness questionable for large programs.
- Assembly language can be used to produce highly efficient programs, but it is not easy to learn or use effectively. Further, debugging assembly code can be quite difficult.

# 1.2 The Birth of Modern Programming: C Cont...

- Another compounding problem was that early computer languages such as BASIC, COBOL, and FORTRAN were not designed around structured principles.
- Instead, they relied upon the GOTO as a primary means of program control.
- As a result, programs written using these languages tended to produce “spaghetti code”—a mass of tangled jumps and conditional branches that make a program virtually impossible to understand.

# 1.2 The Birth of Modern Programming: C Cont...

- While languages like Pascal are structured, they were not designed for efficiency, and failed to include certain features necessary to make them applicable to a wide range of programs.
- Just prior to the invention of C, no one language had reconciled the conflicting attributes that had dogged earlier efforts.
- Yet the need for such a language was pressing.
- By the early 1970s, the computer revolution was beginning to take hold, and the demand for software was rapidly outpacing programmers' ability to produce it.



# 1.2 The Birth of Modern Programming: C Cont...

- A great deal of effort was being expended in academic circles in an attempt to create a better computer language.
- But, and perhaps most importantly, a secondary force was beginning to be felt.
- Computer hardware was finally becoming common enough that a critical mass was being reached.
- No longer were computers kept behind locked doors.
- For the first time, programmers were gaining virtually unlimited access to their machines.

# 1.2 The Birth of Modern Programming: C Cont...

- This allowed the freedom to experiment.
- It also allowed programmers to begin to create their own tools.
- On the eve of C's creation, the stage was set for a quantum leap forward in computer languages.
- Invented and first implemented by Dennis Ritchie on a DEC PDP-11 running the UNIX operating system, C was the result of a development process that started with an older language called BCPL, developed by Martin Richards.

# 1.2 The Birth of Modern Programming: C Cont...

- BCPL influenced a language called B, invented by Ken Thompson, which led to the development of C in the 1970s.
- For many years, the de facto standard for C was the one supplied with the UNIX operating system and described in *The C Programming Language* by Brian Kernighan and Dennis Ritchie (Prentice-Hall, 1978).
- C was formally standardized in December 1989, when the American National Standards Institute (ANSI) standard for C was adopted.
- The creation of C is considered by many to have marked the beginning of the modern age of computer languages.

# 1.2 The Birth of Modern Programming: C Cont...

- It successfully synthesized the conflicting attributes that had so troubled earlier languages.
- The result was a powerful, efficient, structured language that was relatively easy to learn.
- It also included one other, nearly intangible aspect: it was a *programmer's* language.
- Prior to the invention of C, computer languages were generally designed either as academic exercises or by bureaucratic committees.

# 1.2 The Birth of Modern Programming: C Cont...

- C is different. It was designed, implemented, and developed by real, working programmers, reflecting the way that they approached the job of programming. Its features were honed, tested, thought about, and rethought by the people who actually used the language.
- The result was a language that programmers liked to use.
- Indeed, C quickly attracted many followers who had a near-religious zeal for it.
- As such, it found wide and rapid acceptance in the programmer community.
- In short, C is a language designed by and for programmers.
- Java inherited this legacy.

# 1.3 C++: The Next Step

- During the late 1970s and early 1980s, C became the dominant computer programming language, and it is still widely used today.
- Since C is a successful and useful language, one might ask why a need for something else existed. The answer is *complexity*.
- Throughout the history of programming, the increasing complexity of programs has driven the need for better ways to manage that complexity.
- C++ is a response to that need.
- To better understand why managing program complexity is fundamental to the creation of C++, consider the following.

# 1.3 C++: The Next Step Cont...

- Approaches to programming have changed dramatically since the invention of the computer.
- For example, when computers were first invented, programming was done by manually toggling in the binary machine instructions by use of the front panel.
- As long as programs were just a few hundred instructions long, this approach worked.
- As programs grew, assembly language was invented so that a programmer could deal with larger, increasingly complex programs by using symbolic representations of the machine instructions.

# 1.3 C++: The Next Step Cont...

- As programs continued to grow, high-level languages were introduced that gave the programmer more tools with which to handle complexity.
- The first widespread language was, of course, FORTRAN. While FORTRAN was an impressive first step, it is hardly a language that encourages clear and easy-to-understand programs.
- The 1960s gave birth to *structured programming*. This is the method of programming championed by languages such as C.
- The use of structured languages enabled programmers to write, for the first time, moderately complex programs fairly easily.



# 1.3 C++: The Next Step Cont...

- However, even with structured programming methods, once a project reaches a certain size, its complexity exceeds what a programmer can manage.
- By the early 1980s, many projects were pushing the structured approach past its limits.
- To solve this problem, a new way to program was invented, called *object-oriented programming (OOP)*.
- A brief definition: OOP is a programming methodology that helps organize complex programs through the use of inheritance, encapsulation, and polymorphism.

# 1.3 C++: The Next Step Cont...

- In the final analysis, although C is one of the world's great programming languages, there is a limit to its ability to handle complexity.
- Once the size of a program exceeds a certain point, it becomes so complex that it is difficult to grasp as a totality.
- While the precise size at which this occurs differs, depending upon both the nature of the program and the programmer, there is always a threshold at which a program becomes unmanageable.
- C++ added features that enabled this threshold to be broken, allowing programmers to comprehend and manage larger programs.

# 1.3 C++: The Next Step Cont...

- C++ was invented by Bjarne Stroustrup in 1979, while he was working at Bell Laboratories in Murray Hill, New Jersey.
- Stroustrup initially called the new language "C with Classes."
- However, in 1983, the name was changed to C++.
- C++ extends C by adding object-oriented features.
- Because C++ is built on the foundation of C, it includes all of C's features, attributes, and benefits.

# 1.3 C++: The Next Step Cont...

- This is a crucial reason for the success of C++ as a language.
- The invention of C++ was not an attempt to create a completely new programming language.
- **Instead, it was an enhancement to an already highly successful one.**

# The Stage Is Set for Java

- By the end of the 1980s and the early 1990s, object-oriented programming using C++ took hold.
- Indeed, for a brief moment it seemed as if programmers had finally found the perfect language.
- Because C++ blended the high efficiency and stylistic elements of C with the object-oriented paradigm, it was a language that could be used to create a wide range of programs.

# The Stage Is Set for Java Cont...

- However, just as in the past, forces were brewing that would, once again, drive computer language evolution forward.
- Within a few years, the World Wide Web and the Internet would reach critical mass.
- This event would precipitate another revolution in programming.

# The Creation of Java

- Java was conceived by James Gosling, Patrick Naughton, Chris Warth, Ed Frank, and Mike Sheridan at Sun Microsystems, Inc. in 1991.
- It took 18 months to develop the first working version. This language was initially called “Oak,” but was renamed “Java” in 1995.
- Between the initial implementation of Oak in the fall of 1992 and the public announcement of Java in the spring of 1995, many more people contributed to the design and evolution of the language. Bill Joy, Arthur van Hoff, Jonathan Payne, Frank Yellin, and Tim Lindholm were key contributors to the maturing of the original prototype.

# The Creation of Java Cont...

- Somewhat surprisingly, the original impetus for Java was not the Internet! Instead, the primary motivation was the need for a platform-independent (that is, architecture-neutral) language that could be used to create software to be embedded in various consumer electronic devices, such as microwave ovens and remote controls.
- As one can probably guess, many different types of CPUs are used as controllers.
- The trouble with C and C++ (and most other languages) is that they are designed to be compiled for a specific target.



# The Creation of Java Cont...

- Although it is possible to compile a C++ program for just about any type of CPU, to do so requires a full C++ compiler targeted for that CPU.
- The problem is that compilers are expensive and time-consuming to create.
- An easier—and more cost-efficient—solution was needed.
- In an attempt to find such a solution, Gosling and others began work on a portable, platform-independent language that could be used to produce code that would run on a variety of CPUs under differing environments.
- This effort ultimately led to the creation of Java.

# The Creation of Java Cont...

- About the time that the details of Java were being worked out, a second, and ultimately more important, factor was emerging that would play a crucial role in the future of Java.
- This second force was, of course, the World Wide Web.
- Had the Web not taken shape at about the same time that Java was being implemented, Java might have remained a useful but obscure language for programming consumer electronics.
- However, with the emergence of the World Wide Web, Java was propelled to the forefront of computer language design, because the Web, too, demanded portable programs.

# The Creation of Java Cont...

- Most programmers learn early in their careers that portable programs are as elusive as they are desirable.
- While the quest for a way to create efficient, portable (platform-independent) programs is nearly as old as the discipline of programming itself, it had taken a back seat to other, more pressing problems.
- Further, because (at that time) much of the computer world had divided itself into the three competing camps of Intel, Macintosh, and UNIX, most programmers stayed within their fortified boundaries, and the urgent need for portable code was reduced.

# The Creation of Java Cont...

- However, with the advent of the Internet and the Web, the old problem of portability returned with a vengeance.
- After all, the Internet consists of a diverse, distributed universe populated with various types of computers, operating systems, and CPUs.
- Even though many kinds of platforms are attached to the Internet, users would like them all to be able to run the same program.
- What was once an irritating but low-priority problem had become a high-profile necessity.

# The Creation of Java Cont...

- By 1993, it became obvious to members of the Java design team that the problems of portability frequently encountered when creating code for embedded controllers are also found when attempting to create code for the Internet.
- In fact, the same problem that Java was initially designed to solve on a small scale could also be applied to the Internet on a large scale.
- This realization caused the focus of Java to switch from consumer electronics to Internet programming.
- So, while the desire for an architecture-neutral programming language provided the initial spark, the Internet ultimately led to Java's large-scale success.

# The Creation of Java Cont...

- The Java designers knew that using the familiar syntax of C and echoing the object-oriented features of C++ would make their language appealing to the legions of experienced C/C++ programmers.
- In addition to the surface similarities, Java shares some of the other attributes that helped make C and C++ successful.
- First, Java was designed, tested, and refined by real, working programmers.
- It is a language grounded in the needs and experiences of the people who devised it.

# The Creation of Java Cont...

- Thus, Java is a programmer's language. Second, Java is cohesive and logically consistent. Third, except for those constraints imposed by the Internet environment, Java gives the programmer, full control. If you program well, your programs reflect it.
- If you program poorly, your programs reflect that, too. Put differently, Java is not a language with training wheels. It is a language for professional programmers.
- Because of the similarities between Java and C++, it is tempting to think of Java as simply the "Internet version of C++." However, to do so would be a large mistake.
- Java has significant practical and philosophical differences.

# The Creation of Java Cont...

- While it is true that Java was influenced by C++, it is not an enhanced version of C++. For example, Java is neither upwardly nor downwardly compatible with C++.
- Of course, the similarities with C++ are significant, and if you are a C++ programmer, then you will feel right at home with Java.
- One other point: Java was not designed to replace C++. Java was designed to solve a certain set of problems. C++ was designed to solve a different set of problems. Both will coexist for many years to come.



# The Creation of Java Cont...

- Computer languages evolve for two reasons: to adapt to changes in environment and to implement advances in the art of programming.
- The environmental change that prompted Java was the need for platform-independent programs destined for distribution on the Internet.
- However, Java also embodies changes in the way that people approach the writing of programs. For example, Java enhanced and refined the object-oriented paradigm used by C++, added integrated support for multithreading, and provided a library that simplified Internet access.

# The Creation of Java Cont...

- In the final analysis, though, it was not the individual features of Java that made it so remarkable. Rather, it was the language as a whole.
- Java was the perfect response to the demands of the then newly emerging, highly distributed computing universe.
- Java was to Internet programming what C was to system programming: a revolutionary force that changed the world.

# The C# Connection

- The power of Java continues to be felt in the world of computer language development.
- Many of its innovative features, constructs, and concepts have become part of the baseline for any new language.
- The success of Java is simply too important to ignore.
- Perhaps the most important example of Java's influence is C#. Created by Microsoft to support the .NET Framework, C# is closely related to Java.
- For example, both share the same general syntax, support distributed programming, and utilize the same object model.

# The C# Connection Cont...

- There are, of course, differences between Java and C#, but the overall “look and feel” of these languages is very similar. This “cross-pollination” from Java to C# is the strongest testimonial to date that Java redefined the way we think about and use a computer language.

# 1.4 Java and the Internet

- The Internet helped catapult Java to the forefront of programming, and Java, in turn, had a profound effect on the Internet.
- In addition to simplifying web programming in general, Java innovated a new type of networked program called the applet that changed the way the online world thought about content.
- Java also addressed some of the thorniest issues associated with the Internet: portability and security. Let's look more closely at each of these.

# 1.4.1 Java Applets

- An *applet* is a special kind of Java program that is designed to be transmitted over the Internet and automatically executed by a Java-compatible web browser.
- Furthermore, an applet is downloaded on demand, without further interaction with the user.
- If the user clicks a link that contains an applet, the applet will be automatically downloaded and run in the browser.
- Applets are intended to be small programs.

# 1.4.1 Java Applets Cont...

- They are typically used to display data provided by the server, handle user input, or provide simple functions, such as a loan calculator, that execute locally, rather than on the server. In essence, the applet allows some functionality to be moved from the server to the client.
- The creation of the applet changed Internet programming because it expanded the universe of objects that can move about freely in cyberspace.
- In general, there are two very broad categories of objects that are transmitted between the server and the client: passive information and dynamic, active programs.

# 1.4.1 Java Applets Cont...

- For example, when you read your e-mail, you are viewing passive data. Even when you download a program, the program's code is still only passive data until you execute it.
- By contrast, the applet is a dynamic, self-executing program. Such a program is an active agent on the client computer, yet it is initiated by the server.
- As desirable as dynamic, networked programs are, they also present serious problems in the area of security and portability.
- Obviously, a program that downloads and executes automatically on the client computer must be prevented from doing harm.
- It must also be able to run in a variety of different environments and under different operating systems.



## 1.4.2 Security

- Every time a “normal” program is downloaded, one is taking a risk, because the code you are downloading might contain a virus, Trojan horse, or other harmful code.
- At the core of the problem is the fact that malicious code can cause its damage because it has gained unauthorized access to system resources.
- For example, a virus program might gather private information, such as credit card numbers, bank account balances, and passwords, by searching the contents of a computer’s local file system.

## 1.4.2 Security Cont...

- In order for Java to enable applets to be downloaded and executed on the client computer safely, it was necessary to prevent an applet from launching such an attack.
- Java achieved this protection by confining an applet to the Java execution environment and not allowing it access to other parts of the computer.
- The ability to download applets with confidence that no harm will be done and that no security will be breached is considered by many to be the single most innovative aspect of Java.

# 1.4.3 Portability

- Portability is a major aspect of the Internet because there are many different types of computers and operating systems connected to it.
- If a Java program were to be run on virtually any computer connected to the Internet, there needed to be some way to enable that program to execute on different systems.
- For example, in the case of an applet, the same applet must be able to be downloaded and executed by the wide variety of CPUs, operating systems, and browsers connected to the Internet.
- It is not practical to have different versions of the applet for different computers.
- The *same* code must work on *all* computers. Therefore, some means of generating portable executable code was needed.

# 1.5 The Bytecode

- The key that allows Java to solve both the security and the portability problems just described is that the output of a Java compiler is not executable code. Rather, it is bytecode.
- *Bytecode* is a highly optimized set of instructions designed to be executed by the Java run-time system, which is called the *Java Virtual Machine (JVM)*.
- In essence, the original JVM was designed as an *interpreter for bytecode*.
- This may come as a bit of a surprise since many modern languages are designed to be compiled into executable code because of performance concerns. However, the fact that a Java program is executed by the JVM helps solve the major problems associated with web-based programs.

# 1.5 The Bytecode Cont...

- Translating a Java program into bytecode makes it much easier to run a program in a wide variety of environments because only the JVM needs to be implemented for each platform.
- Once the run-time package exists for a given system, any Java program can run on it.
- Remember, although the details of the JVM will differ from platform to platform, all understand the same Java bytecode.
- If a Java program were compiled to native code, then different versions of the same program would have to exist for each type of CPU connected to the Internet.
- This is, of course, not a feasible solution. Thus, the execution of bytecode by the JVM is the easiest way to create truly portable programs.

# 1.5 The Bytecode Cont...

- The fact that a Java program is executed by the JVM also helps to make it secure.
- Because the JVM is in control, it can contain the program and prevent it from generating side effects outside of the system.
- As you will see, safety is also enhanced by certain restrictions that exist in the Java language.
- In general, when a program is compiled to an intermediate form and then interpreted by a virtual machine, it runs slower than it would run if compiled to executable code.
- However, with Java, the differential between the two is not so great.

# 1.5 The Bytecode Cont...

- Because bytecode has been highly optimized, the use of bytecode enables the JVM to execute programs much faster than you might expect.
- Although Java was designed as an interpreted language, there is nothing about Java that prevents on-the-fly compilation of bytecode into native code in order to boost performance.
- For this reason, the HotSpot technology was introduced not long after Java's initial release.
- HotSpot provides a Just-In-Time (JIT) compiler for bytecode. When a JIT compiler is part of the JVM, selected portions of bytecode are compiled into executable code in real time, on a piece-by-piece, demand basis.

# 1.5 The Bytecode Cont...

- It is important to understand that it is not practical to compile an entire Java program into executable code all at once, because Java performs various run-time checks that can be done only at run time.
- Instead, a JIT compiler compiles code as it is needed, during execution.
- Furthermore, not all sequences of bytecode are compiled—only those that will benefit from compilation.
- The remaining code is simply interpreted. However, the just-in-time approach still yields a significant performance boost.
- Even when dynamic compilation is applied to bytecode, the portability and safety features still apply, because the JVM is still in charge of the execution environment.



# 1.6 Servlets: Java on the Server Side

- As useful as applets can be, they are just one half of the client/server equation.
- Not long after the initial release of Java, it became obvious that Java would also be useful on the server side.
- The result was the *servlet*. A servlet is a small program that executes on the server.
- Just as applets dynamically extend the functionality of a web browser, servlets dynamically extend the functionality of a web server.
- Thus, with the advent of the servlet, Java spanned both sides of the client/server connection.

# 1.6 Servlets: Java on the Server Side

## Cont...

- Servlets are used to create dynamically generated content that is then served to the client.
- For example, an online store might use a servlet to look up the price for an item in a database.
- The price information is then used to dynamically generate a web page that is sent to the browser.
- Although dynamically generated content is available through mechanisms such as CGI (Common Gateway Interface), the servlet offers several advantages, including increased performance.

# 1.6 Servlets: Java on the Server Side

## Cont...

- Because servlets (like all Java programs) are compiled into bytecode and executed by the JVM, they are highly portable.
- Thus, the same servlet can be used in a variety of different server environments.
- The only requirements are that the server support the JVM and a servlet container.

# 1.7 Features of Java

- Although the fundamental forces that necessitated the invention of Java are portability and security, other factors also played an important role in molding the final form of the language.

# 1.7 Features of Java Cont...

- Simple
- Secure
- Portable
- Object-oriented
- Robust
- Multithreaded
- Architecture-neutral
- Interpreted
- High performance
- Distributed
- Dynamic

# 1.7 Features of Java Cont...

## Simple

- Java was designed to be easy for the professional programmer to learn and use effectively.
- Assuming that you have some programming experience, you will not find Java hard to master.
- If you already understand the basic concepts of object-oriented programming, learning Java will be even easier. Best of all, if you are an experienced C++ programmer, moving to Java will require very little effort.
- Because Java inherits the C/C++ syntax and many of the object-oriented features of C++, most programmers have little trouble learning Java.

# 1.7 Features of Java Cont...

## Object-Oriented

- Although influenced by its predecessors, Java was not designed to be source-code compatible with any other language.
- This allowed the Java team the freedom to design with a blank slate.
- One outcome of this was a clean, usable, pragmatic approach to objects.
- Borrowing liberally from many seminal object-software environments of the last few decades, Java manages to strike a balance between the purist's "everything is an object" paradigm and the pragmatist's "stay out of my way" model.
- The object model in Java is simple and easy to extend, while primitive types, such as integers, are kept as high-performance nonobjects.

# 1.7 Features of Java Cont...

## Robust

- The multiplatformed environment of the Web places extraordinary demands on a program, because the program must execute reliably in a variety of systems. Thus, the ability to create robust programs was given a high priority in the design of Java.
- To gain reliability, Java restricts you in a few key areas to force you to find your mistakes early in program development.
- At the same time, Java frees you from having to worry about many of the most common causes of programming errors.
- Because Java is a strictly typed language, it checks your code at compile time.



# 1.7 Features of Java Cont...

## Robust cont...

- However, it also checks your code at run time.
- Many hard-to-track-down bugs that often turn up in hard-to-reproduce run-time situations are simply impossible to create in Java.
- Knowing that what you have written will behave in a predictable way under diverse conditions is a key feature of Java.
- To better understand how Java is robust, consider two of the main reasons for program failure: memory management mistakes and mishandled exceptional conditions (that is, run-time errors).

# 1.7 Features of Java Cont...

## Robust cont...

- Memory management can be a difficult, tedious task in traditional programming environments. For example, in C/C++, the programmer must manually allocate and free all dynamic memory.
- This sometimes leads to problems, because programmers will either forget to free memory that has been previously allocated or, worse, try to free some memory that another part of their code is still using.

# 1.7 Features of Java Cont...

## Robust Cont...

- Java virtually eliminates these problems by managing memory allocation and deallocation for you. (In fact, deallocation is completely automatic, because Java provides garbage collection for unused objects.) Exceptional conditions in traditional environments often arise in situations such as division by zero or “file not found,” and they must be managed with clumsy and hard-to-read constructs.
- Java helps in this area by providing object-oriented exception handling. In a well-written Java program, all run-time errors can—and should—be managed by your program.

# 1.7 Features of Java Cont...

## Multithreaded

- Java was designed to meet the real-world requirement of creating interactive, networked programs.
- To accomplish this, Java supports multithreaded programming, which allows you to write programs that do many things simultaneously.
- The Java run-time system comes with an elegant yet sophisticated solution for multiprocess synchronization that enables you to construct smoothly running interactive systems.
- Java's easy-to-use approach to multithreading allows you to think about the specific behavior of your program, not the multitasking subsystem.

# 1.7 Features of Java Cont...

## Architecture-Neutral

- A central issue for the Java designers was that of code longevity and portability.
- At the time of Java's creation, one of the main problems facing programmers was that no guarantee existed that if you wrote a program today, it would run tomorrow—even on the same machine.
- Operating system upgrades, processor upgrades, and changes in core system resources can all combine to make a program malfunction. The Java designers made several hard decisions in the Java language and the Java Virtual Machine in an attempt to alter this situation.
- Their goal was “write once; run anywhere, any time, forever.”
- To a great extent, this goal was accomplished.

# 1.7 Features of Java Cont...

## Interpreted and High Performance

- As described earlier, Java enables the creation of cross-platform programs by compiling into an intermediate representation called Java bytecode.
- This code can be executed on any system that implements the Java Virtual Machine.
- Most previous attempts at cross-platform solutions have done so at the expense of performance.
- As explained earlier, the Java bytecode was carefully designed so that it would be easy to translate directly into native machine code for very high performance by using a just-in-time compiler.
- Java run-time systems that provide this feature lose none of the benefits of the platform-independent code.

# 1.7 Features of Java Cont...

## Distributed

- Java is designed for the distributed environment of the Internet because it handles TCP/IP protocols.
- In fact, accessing a resource using a URL is not much different from accessing a file.
- Java also supports *Remote Method Invocation (RMI)*. This feature enables a program to invoke methods across a network.

# 1.7 Features of Java Cont...

## Dynamic

- Java programs carry with them substantial amounts of run-time type information that is used to verify and resolve accesses to objects at run time.
- This makes it possible to dynamically link code in a safe and expedient manner.
- This is crucial to the robustness of the Java environment, in which small fragments of bytecode may be dynamically updated on a running system.



# 1.8 The Evolution of Java

- The initial release of Java was nothing short of revolutionary, but it did not mark the end of Java's era of rapid innovation.
- Unlike most other software systems that usually settle into a pattern of small, incremental improvements, Java continued to evolve at an explosive pace.
- Soon after the release of Java 1.0, the designers of Java had already created Java 1.1. The features added by Java 1.1 were more significant and substantial than the increase in the minor revision number would have you think.
- Java 1.1 added many new library elements, redefined the way events are handled, and reconfigured many features of the 1.0 library.

# 1.8 The Evolution of Java Cont...

- It also deprecated (rendered obsolete) several features originally defined by Java 1.0.
- Thus, Java 1.1 both added to and subtracted from attributes of its original specification.
- The next major release of Java was Java 2, where the “2” indicates “second generation.”
- The creation of Java 2 was a watershed event, marking the beginning of Java’s “modern age.”
- The first release of Java 2 carried the version number 1.2.
- It may seem odd that the first release of Java 2 used the 1.2 version number.

# 1.8 The Evolution of Java Cont...

- The reason is that it originally referred to the internal version number of the Java libraries, but then was generalized to refer to the entire release.
- With Java 2, Sun repackaged the Java product as J2SE (Java 2 Platform Standard Edition), and the version numbers began to be applied to that product.
- Java 2 added support for a number of new features, such as Swing and the Collections Framework, and it enhanced the Java Virtual Machine and various programming tools.
- Java 2 also contained a few deprecations.
- The most important affected the **Thread** class in which the methods **suspend()**, **resume()**, and **stop()** were deprecated.

# 1.8 The Evolution of Java Cont...

- J2SE 1.3 was the first major upgrade to the original Java 2 release.
- For the most part, it added to existing functionality and “tightened up” the development environment.
- In general, programs written for version 1.2 and those written for version 1.3 are source-code compatible.
- Although version 1.3 contained a smaller set of changes than the preceding three major releases, it was nevertheless important.
- The release of J2SE 1.4 further enhanced Java.
- This release contained several important upgrades, enhancements, and additions.

# 1.8 The Evolution of Java Cont...

- For example, it added the new keyword **assert**, chained exceptions, and a channel-based I/O subsystem.
- It also made changes to the Collections Framework and the networking classes.
- In addition, numerous small changes were made throughout.
- Despite the significant number of new features, version 1.4 maintained nearly 100 percent source-code compatibility with prior versions.
- The next release of Java was J2SE 5, and it was revolutionary.
- Unlike most of the previous Java upgrades, which offered important, but measured improvements, J2SE 5 fundamentally expanded the scope, power, and range of the language.

# 1.8 The Evolution of Java Cont...

- To grasp the magnitude of the changes that J2SE 5 made to Java, consider the following list of its major new features:
  - Generics
  - Annotations
  - Autoboxing and auto-unboxing
  - Enumerations
  - Enhanced, for-each style **for** loop
  - Variable-length arguments (varargs)
  - Static import
  - Formatted I/O
  - Concurrency utilities

# 1.8 The Evolution of Java Cont...

- This is not a list of minor tweaks or incremental upgrades.
- Each item in the list represented a significant addition to the Java language.
- Some, such as generics, the enhanced **for**, and varargs, introduced new syntax elements.
- Others, such as autoboxing and auto-unboxing, altered the semantics of the language.
- Annotations added an entirely new dimension to programming.
- In all cases, the impact of these additions went beyond their direct effects.

# 1.8 The Evolution of Java Cont...

- They changed the very character of Java itself.
- The importance of these new features is reflected in the use of the version number "5."
- The next version number for Java would normally have been 1.5.
- However, the new features were so significant that a shift from 1.4 to 1.5 just didn't seem to express the magnitude of the change.
- Instead, Sun elected to increase the version number to 5 as a way of emphasizing that a major event was taking place.
- Thus, it was named J2SE 5, and the Developer's Kit was called JDK 5.



# 1.8 The Evolution of Java Cont...

- However, in order to maintain consistency, Sun decided to use 1.5 as its internal version number, which is also referred to as the *developer version* number.
- The “5” in J2SE 5 is called the *product version* number.
- The next release of Java was called Java SE 6. Sun once again decided to change the name of the Java platform.
- First, notice that the “2” was dropped.
- Thus, the platform was now named *Java SE*, and the official product name was *Java Platform, Standard Edition 6*.
- The Java Developer’s Kit was called JDK 6.

# 1.8 The Evolution of Java Cont...

- As with J2SE 5, the 6 in Java SE 6 is the product version number.
- The internal, developer version number is 1.6.
- Java SE 6 built on the base of J2SE 5, adding incremental improvements.
- Java SE 6 added no major features to the Java language proper, but it did enhance the API libraries, added several new packages, and offered improvements to the runtime.
- It also went through several updates during its (in Java terms) long life cycle, with several upgrades added along the way.

# 1.8 The Evolution of Java Cont...

- In general, Java SE 6 served to further solidify the advances made by J2SE 5.
- Java SE 7
- The newest release of Java is called Java SE 7, with the Java Developer's Kit being called JDK 7, and an internal version number of 1.7.
- Java SE 7 is the first major release of Java since Sun Microsystems was acquired by Oracle (a process that began in April 2009 and that was completed in January 2010).
- Java SE 7 contains many new features, including significant additions to the language and the API libraries.

# 1.8 The Evolution of Java Cont...

- Upgrades to the Java run-time system that support non-Java languages are also included, but it is the language and library additions that are of most interest to Java programmers.
- The new language features were developed as part of *Project Coin*.
- The purpose of Project Coin was to identify a number of small changes to the Java language that would be incorporated into JDK7.
- Although these new features are collectively referred to as “small,” the effects of these changes are quite large in terms of the code they impact. In fact, for many programmers, these changes may well be the most important new features in Java SE 7.

# 1.8 The Evolution of Java Cont...

- Here is a list of the new language features:
- A **String** can now control a **switch** statement.
  - Binary integer literals.
  - Underscores in numeric literals.
  - An expanded **try** statement, called *try-with-resources*, that supports automatic resource management. (For example, streams can now be closed automatically when they are no longer needed.)
  - Type inference (via the *diamond* operator) when constructing a generic instance.
  - Enhanced exception handling in which two or more exceptions can be caught by a single **catch** (multi-catch) and better type checking for exceptions that are rethrown.
  - Although not a syntax change, the compiler warnings associated with some types of varargs methods have been improved, and have more control over the warnings.

# 1.8 The Evolution of Java Cont...

- As one can see, even though the Project Coin features were considered small changes to the language, their benefits will be much larger than the qualifier “small” would suggest.
- In particular, the **try-with-resources** statement will profoundly affect the way that stream-based code is written.
- Also, the ability to now use a **String** to control a **switch** statement is a long-desired improvement that will simplify coding in many situations.
- Java SE 7 makes several additions to the Java API library.
- Two of the most important are the enhancements to the NIO Framework and the addition of the Fork/Join Framework.

# 1.8 The Evolution of Java Cont...

- NIO (which originally stood for *New I/O*) was added to Java in version 1.4. However, the changes proposed for Java SE 7 fundamentally expand its capabilities. So significant are the changes, that the term *NIO.2* is often used.
- The Fork/Join Framework provides important support for *parallel programming*.
- Parallel programming is the name commonly given to the techniques that make effective use of computers that contain more than one processor, including multicore systems.
- The advantage that multicore environments offer is the prospect of significantly increased program performance.

# 1.8 The Evolution of Java Cont...

- The Fork/Join Framework addresses parallel programming by
  - Simplifying the creation and use of tasks that can execute concurrently
  - Automatically making use of multiple processors
- Therefore, by using the Fork/Join Framework, you can easily create scaleable applications that automatically take advantage of the processors available in the execution environment.
- Of course, not all algorithms lend themselves to parallelization, but for those that do, a significant improvement in execution speed can be obtained.



# 1.9 Understanding of the Java innovations

- Since the beginning, Java has been at the center of a culture of innovation.
- Its original release redefined programming for the Internet.
- The Java Virtual Machine (JVM) and bytecode changed the way we think about security and portability.
- The applet (and then the servlet) made the Web come alive.
- The Java Community Process (JCP) redefined the way that new ideas are assimilated into the language.

# 1.9 Understanding of the Java innovations Cont...

- Because Java is used for Android programming, Java is part of the smartphone revolution. The world of Java has never stood still for very long. Java SE 7 is the latest release in Java's ongoing, dynamic history.

# The End of Section 01

