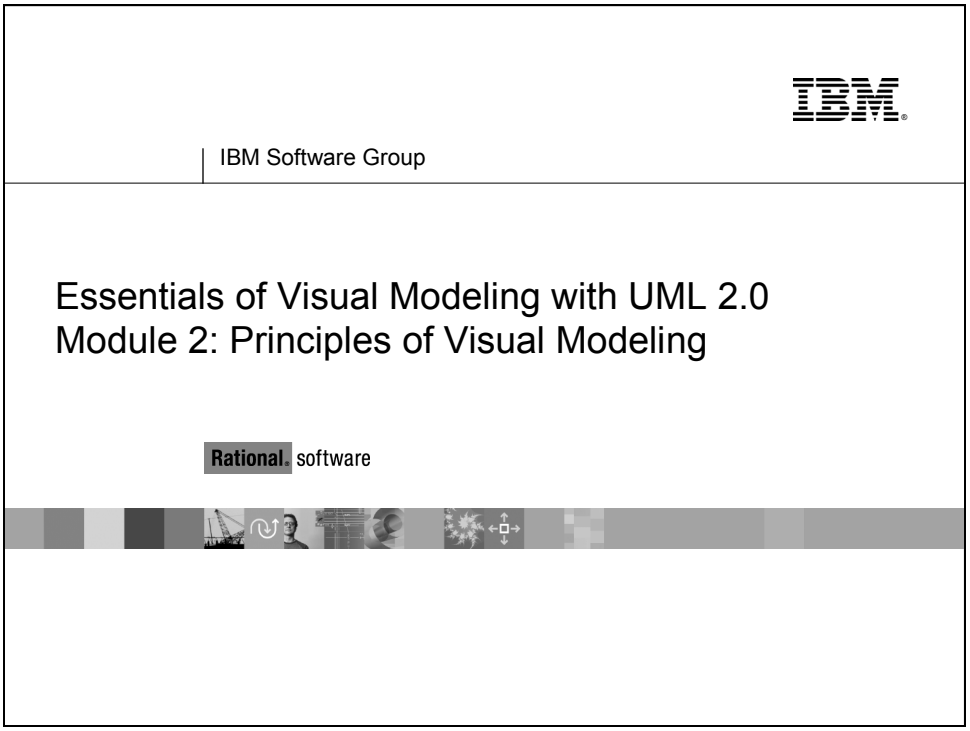
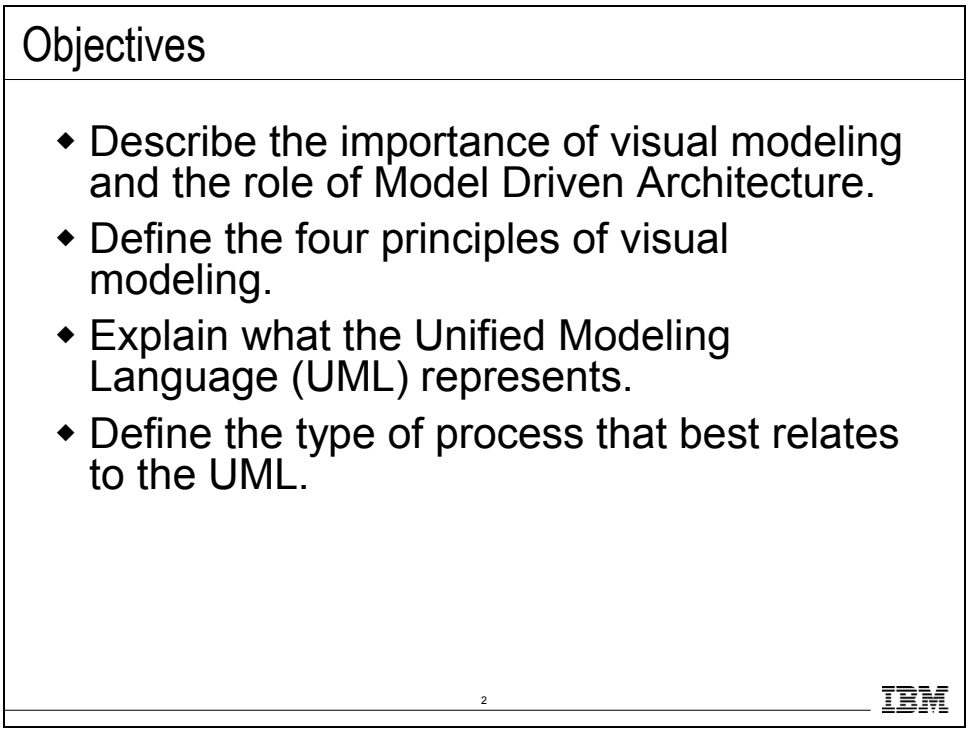
▸ ▸ ▸ Module 2
Principles of Visual Modeling



Topics

Objectives



Where Are We?

Where Are We?

- ☆ What is modeling?
- Four principles of visual modeling
- The UML
- Process and visual modeling

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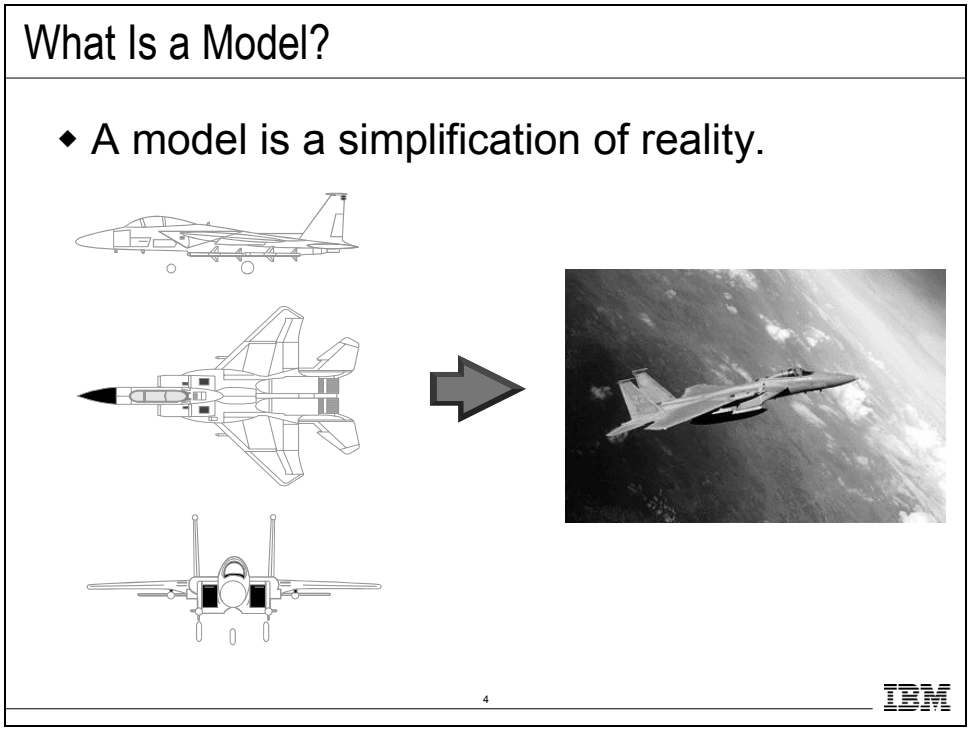
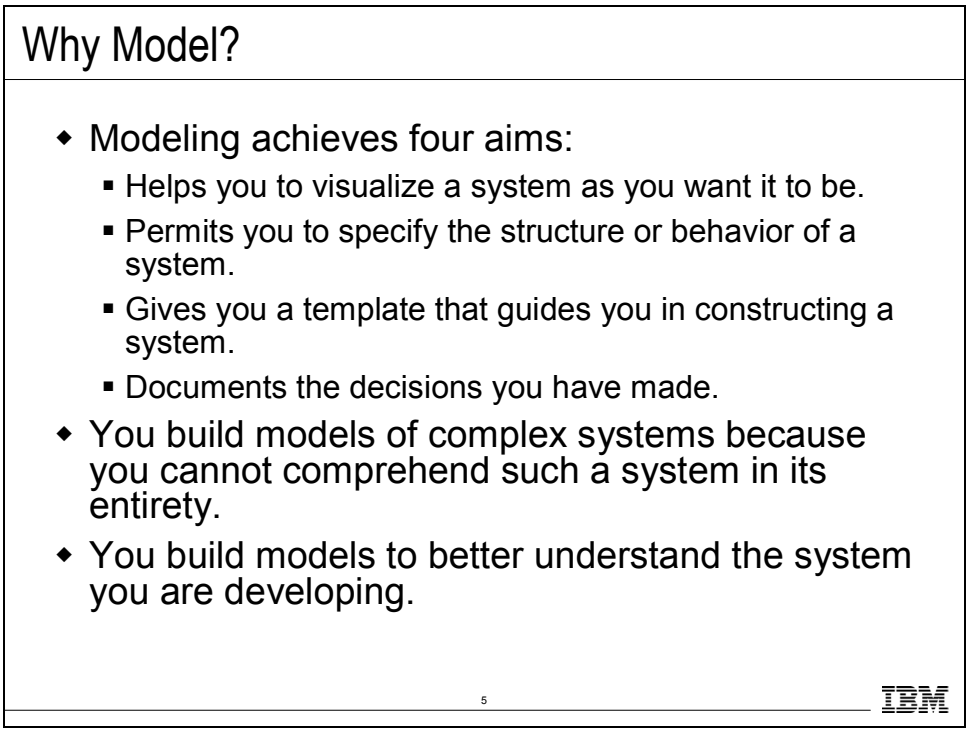
What Is a Model?



According to Grady Booch, IBM Fellow, a model provides the blueprints of a system. Models may encompass detailed plans, as well as more general plans that give a 30,000-foot view of the system under construction. A good model includes those elements that are not relevant to the given level of abstraction. Every system may be described from different aspects using different models, and each model is therefore a semantically closed abstraction of the system. A model may be structural, emphasizing the organization of the system, or it may be behavioral, emphasizing the dynamics of the system.

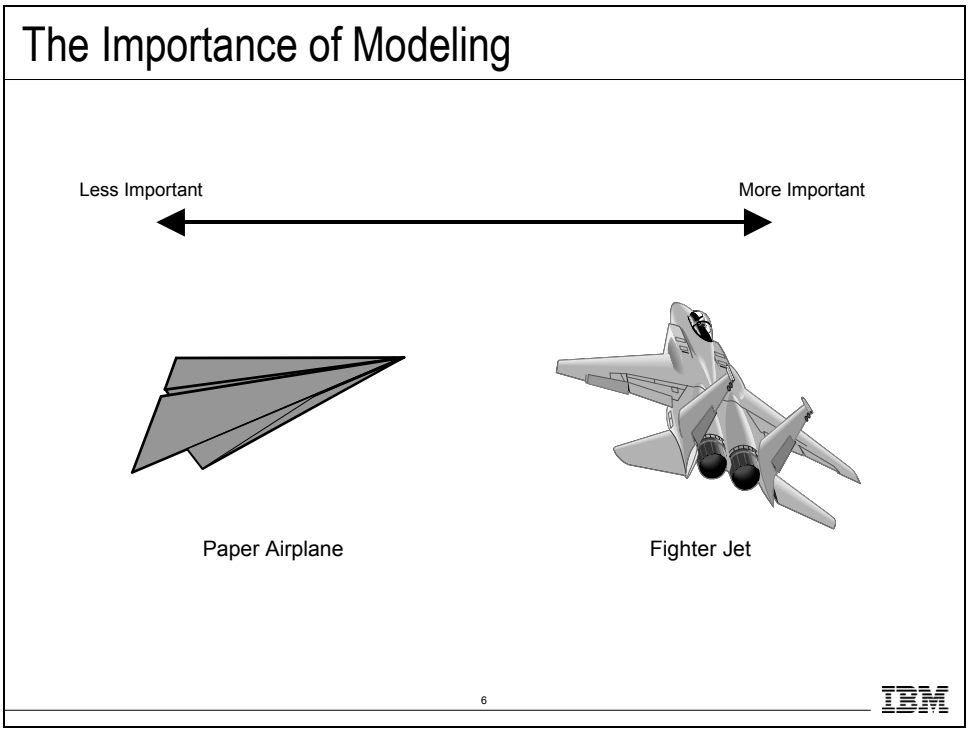
Why Model?



According to Booch in *The Unified Modeling Language User Guide*, modeling achieves four aims:

1. Models help you to **visualize** a system, as you want it to be. A model helps the software team communicate the vision for the system being developed. It is difficult for a software team to have a unified vision of a system that is described only in specification and requirement documents. Models bring about understanding of the system.
2. Models permit you to **specify** the structure of behavior of a system. A model allows how to document system behavior and structure before coding the system.
3. Models give a template that guide you in **constructing** a system. A model is an invaluable tool during construction. It serves as a road map for a developer. Have you experienced a situation where a developer coded incorrect behavior because he or she was confused over the wording in a requirements document? Modeling helps alleviate that situation.
4. Models **document** the decisions you've made. Models are valuable tools in the long term because they give "hard" information on design decisions. You don't need to rely on someone's memory.

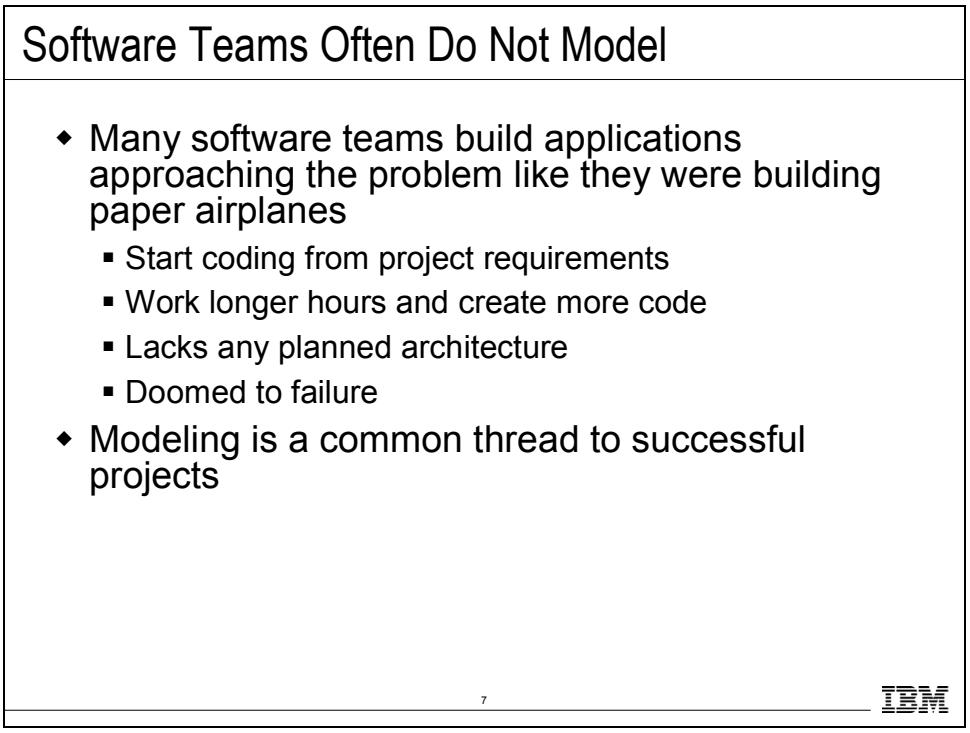
The Importance of Modeling



You can take a piece of paper and a paper clip, and, in a few minutes, have a paper airplane that entertains your kids. If it isn't built just right, you can always start over and build another airplane.

Would it be smart for you to build a fighter jet in the same way? That is, start with some steel, nuts, bolts, and wiring and go right to work. Of course not. You're building an airplane that costs millions of dollars, and the cost of failure is high. You're also be part of a much larger team, needing blueprints and models to effectively communicate with one another. (*The Unified Modeling Language User Guide*, Booch, 1999.)

Software Teams Often Do Not Model

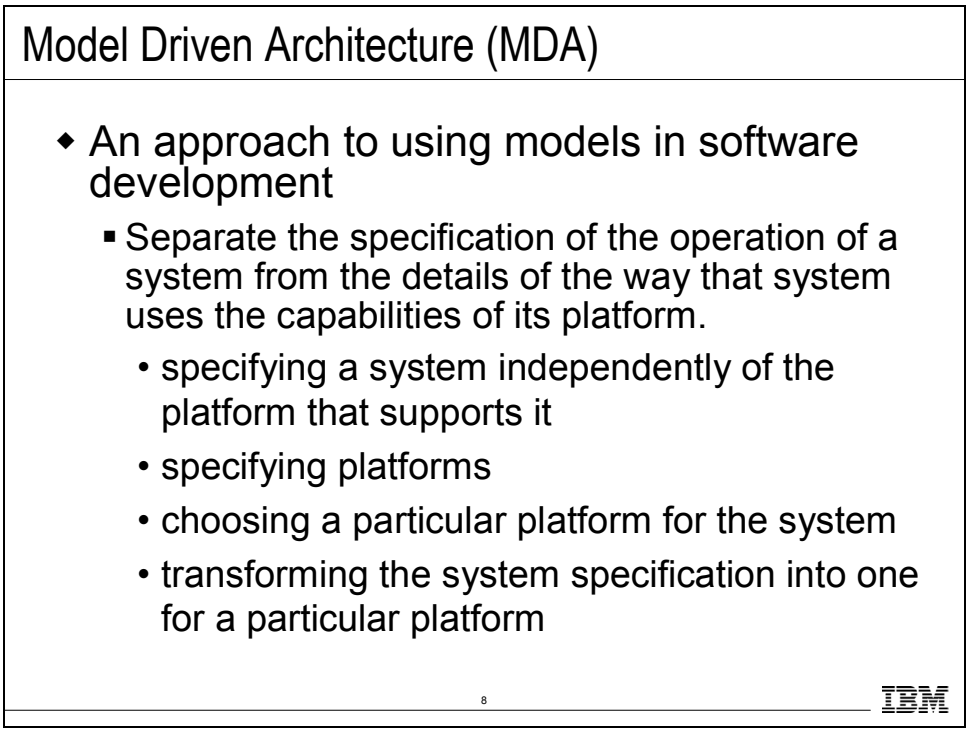


If defense contractors want to build fighter jets for the government, they need to achieve a certain balance between the desires of the military with the realities of aerospace engineering. They also want to treat their employees professionally, never placing them at risk or driving them so hard that they burn out.

Curiously, many software development organizations begin wanting to build complex software systems, but approach the problem as though they were building a paper airplane.

With the increasing demand to build more complex software in shorter time, development teams often retreat to the only thing they know how to do well - pound out lines of code. Developers start working longer hours and frequently produce code with a requirements document as their only source of input. However, there eventually comes a time when the application collapses due to the lack of a well thought-out architecture. Consequently, many of these software projects result in failure.

Model Driven Architecture (MDA)

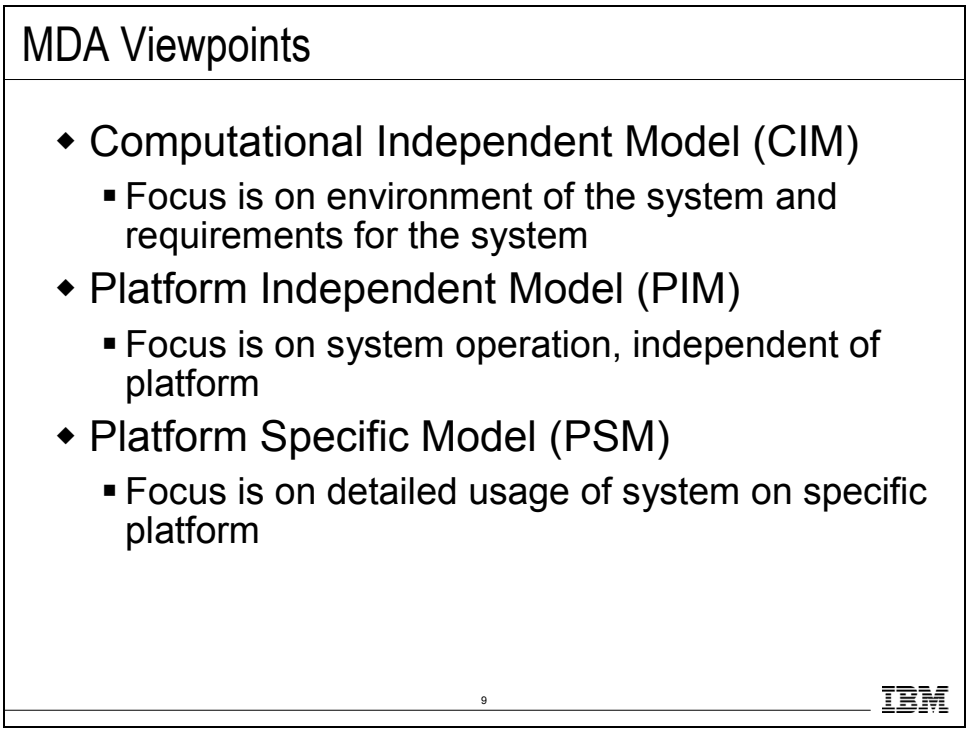


The Model-Driven Architecture prescribes certain kinds of models to be used, how those models may be prepared, and the relationships of these different models.

It's termed *model-driven* because this provides a means for using models to guide the understanding, design, construction, deployment, operation, maintenance and modification.

The *architecture* of a system is the specification of the parts and connectors of the system and the rules for the interactions of the parts using the connectors.

MDA Viewpoints



A *viewpoint* on a system is the process of suppressing selected detail to establish a simplified model, in order to focus on particular concerns within that system.

A CIM does not show details of the structure of systems and is sometimes called a domain model. The vocabulary used in its specification is familiar to the practitioners of the domain in question. The CIM plays an important role in bridging the gap between those that are experts in the domain and its requirements, and those that are experts in the design and construction of the artifacts that together satisfy the requirements.

A PIM exhibits a specified degree of platform independence so as to be suitable for use with a number of different platforms. A very common technique for achieving this independence is to target a system model for a technology-neutral virtual machine. A virtual machine is defined as a set of parts and services (communications, scheduling, naming, etc.), which are defined independently of any specific platform and which are realized in platform-specific ways on different platforms.

A PSM combines the specifications in the PIM with the details that specify how that system uses a particular type of platform.

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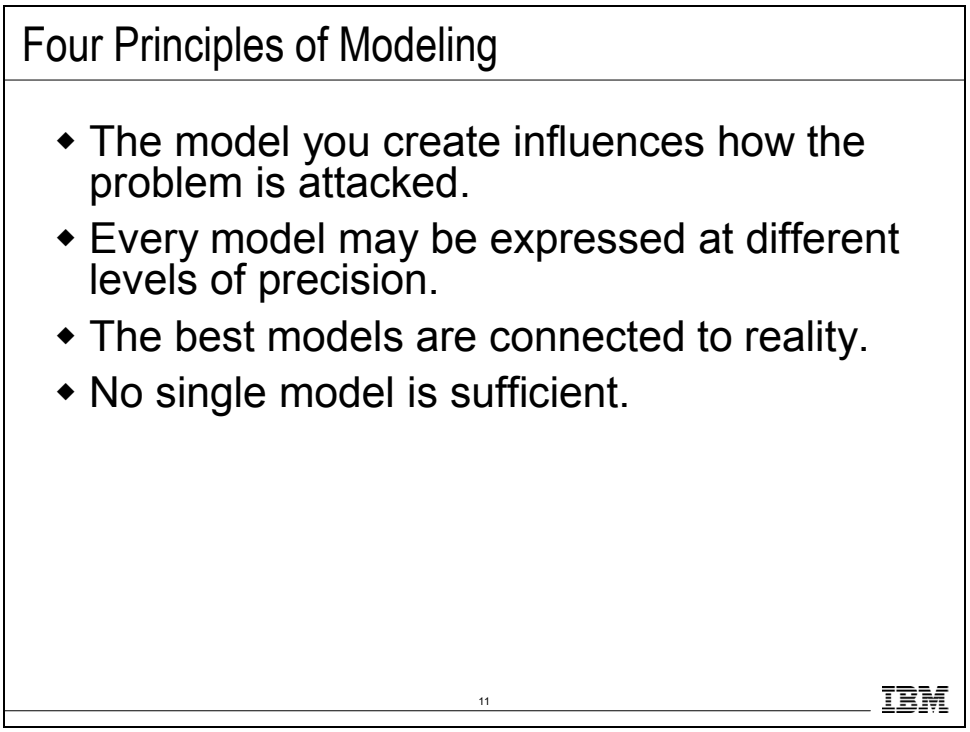
Four Principles of Modeling

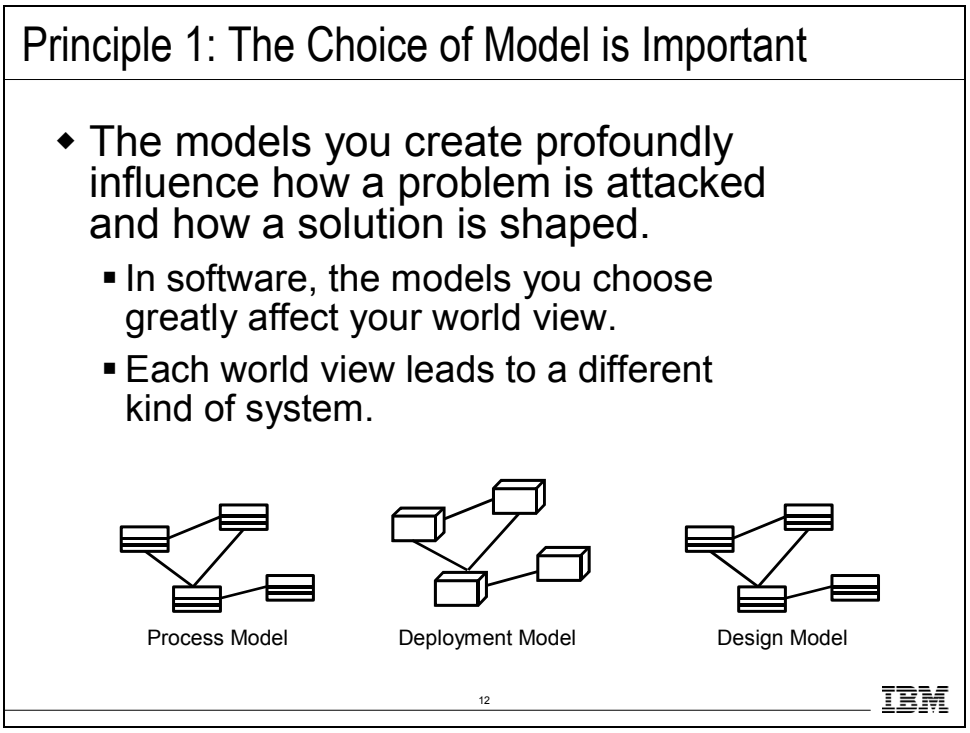


Modeling has a rich history in all the engineering disciplines.

The four basic principles of modeling are derived from this history.

1. The models you create profoundly influence how a problem is attacked and how a solution is shaped.
2. Every model may be expressed at different levels of precision.
3. The best models are connected to reality.
4. No single model is sufficient. Every non-trivial system is best approached through a small set of nearly independent models.

Principle 1: The Choice of Model is Important



The right models illuminate the most difficult development problems, offering insight that you could not gain otherwise. The wrong models mislead you, causing you to focus on irrelevant issues.

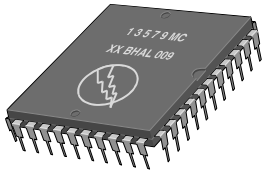
In software, the models you choose can greatly affect your world view. If you build a system through the eyes of a database developer, you'll likely end up with entity-relationship models that push behavior into stored procedures and triggers. If you build a system through the eyes of an object-oriented developer, you'll end up with a system that has its architecture centered around many classes and patterns of interaction that direct how those classes work together.

Each world view leads to a different kind of system with different costs and benefits. (*The Unified Modeling Language User Guide*, Booch, 1999.)

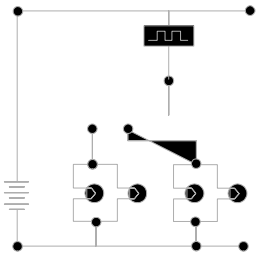
Principle 2: Levels of Precision May Differ

Principle 2: Levels of Precision May Differ

- Every model may be expressed at different levels of precision.
  - The best kinds of models let you choose your degree of detail, depending on:
    - Who is viewing the model.
    - Why they need to view it.



View for Customers



View for Designers

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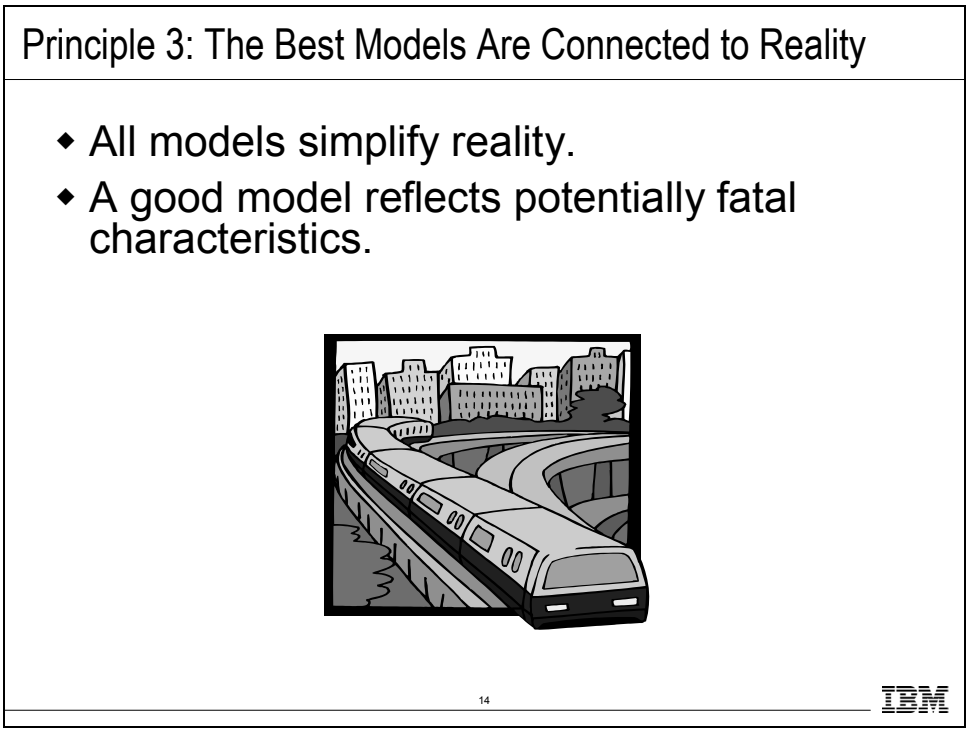
If you are building computer chips, sometimes you need a 30,000-foot view. For example, you need your investors to visualize the end product. Other times, you need to get down to the level of the circuits.

When developing a GUI system, a quick and dirty executable model of the user interface may be all you need to communicate your intentions. Other times, when you are dealing with cross-system interfaces of network bottlenecks, you need to model down to the bit level. In either case, the best models are those that let you choose your degree of detail, depending on who is doing the viewing and why they need to view it. (*The Unified Modeling Language User Guide*, Booch, 1999.)

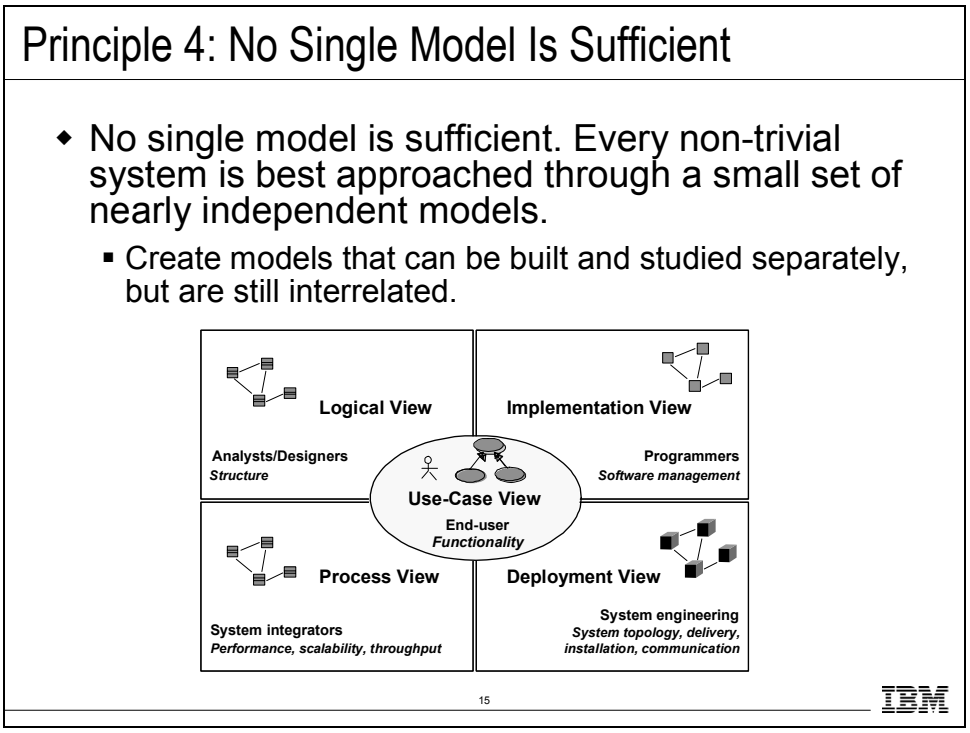
Principle 3: The Best Models Are Connected to Reality



A physical model of a building that doesn't respond the same way as the real materials has limited value. It's best to have models that have a clear connection to reality. Where that connection is weak, you need to know exactly how those models are divorced from the real world.

All models simplify reality. The trick is to be sure that your simplifications don't mask any important details. A good model reveals any potentially fatal flaws in design. (*The Unified Modeling Language User Guide*, Booch, 1999.)

Principle 4: No Single Model Is Sufficient



The key phrase is "nearly independent," meaning that models can be built and studied separately, but are still interrelated.

To understand the architecture of object-oriented systems, you need several complementary and interlocking views. An architectural view can be defined as a simplified description (an abstraction) of a system from a particular perspective or vantage point, covering particular concerns, and omitting entities that are not relevant to this perspective. Views are "slices" of models.

Each of the views below may have structural and behavioral aspects. Together, they represent the blueprints of a software system.

- **Use-case view** exposing the requirements of the system
- **Logical view** capturing the vocabulary of the problem space and the solution space
- **Process view** modeling the distribution of the system's processes and threads
- **Implementation view** addressing the physical realization of the system
- **Deployment view** focusing on system engineering issues

To address these different needs, Rational has defined the "4+1 view" architecture model.

Remember that not all systems require all views. The number of views is dependent on the system you're building. For example, a single processor does not require a deployment view or a small program does not require an implementation view and so on.

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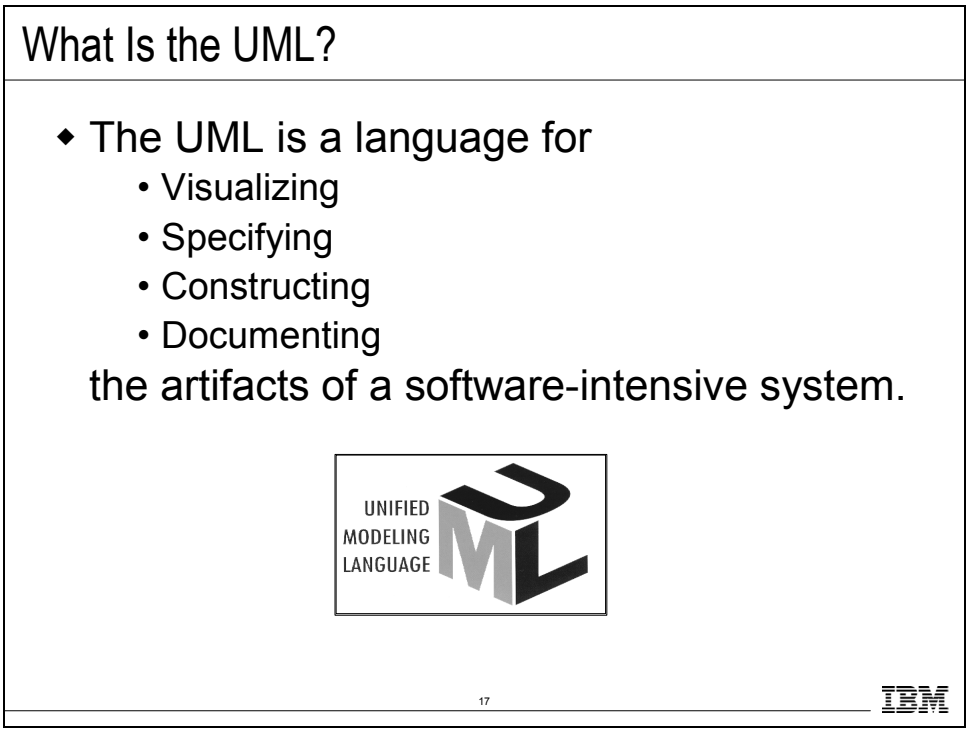
What Is the UML?



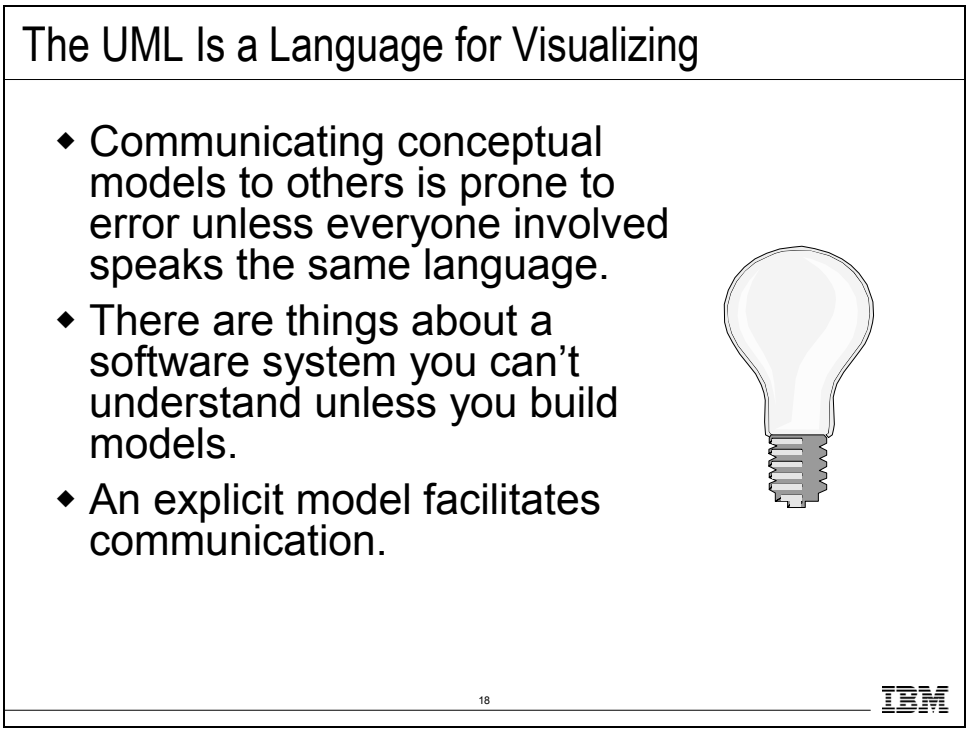
The software systems that you develop today are more complex than the human mind can comprehend. This is why you model systems. Your model selection profoundly influences how you attack the problem and shape the solution.

No single model is sufficient. Every complex system is best approached through a small set of nearly independent models.

Therefore, to increase comprehension, a common language like the Unified Modeling Language (UML) is used to express models.

A modeling language is a language whose vocabulary and rules focus on the conceptual and physical representation of a system. A modeling language like the UML is a standard language for software blueprints.

The UML Is a Language for Visualizing



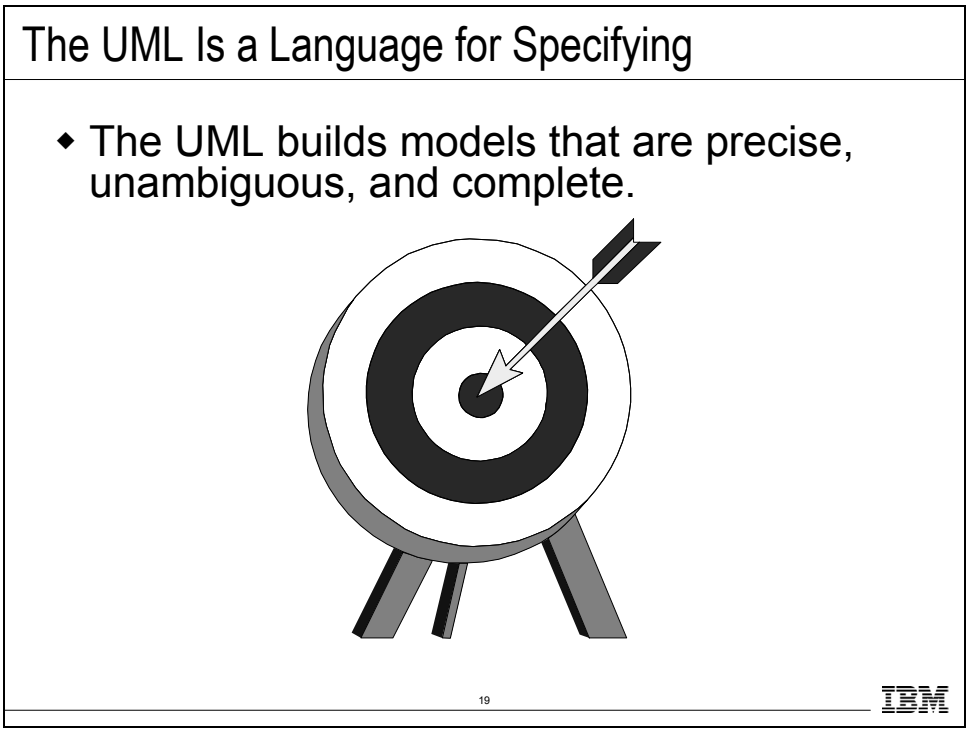
Typically, projects and organizations develop their own language for modeling systems, making it difficult for outsiders and new team members to understand what is going on.

Communicating these conceptual models to others is prone to error unless everyone involved speaks the same language. The UML offers a set of symbols that represents well-defined semantics. One developer can write a model in the UML, and another developer can interpret that model unambiguously.

There are things about a software system you can't understand unless you build models that transcend the textual programming language. For example, the meaning of a class hierarchy can be inferred, but not directly grasped, by staring at the code for all the classes in the hierarchy. The UML is a graphical language that addresses this problem.

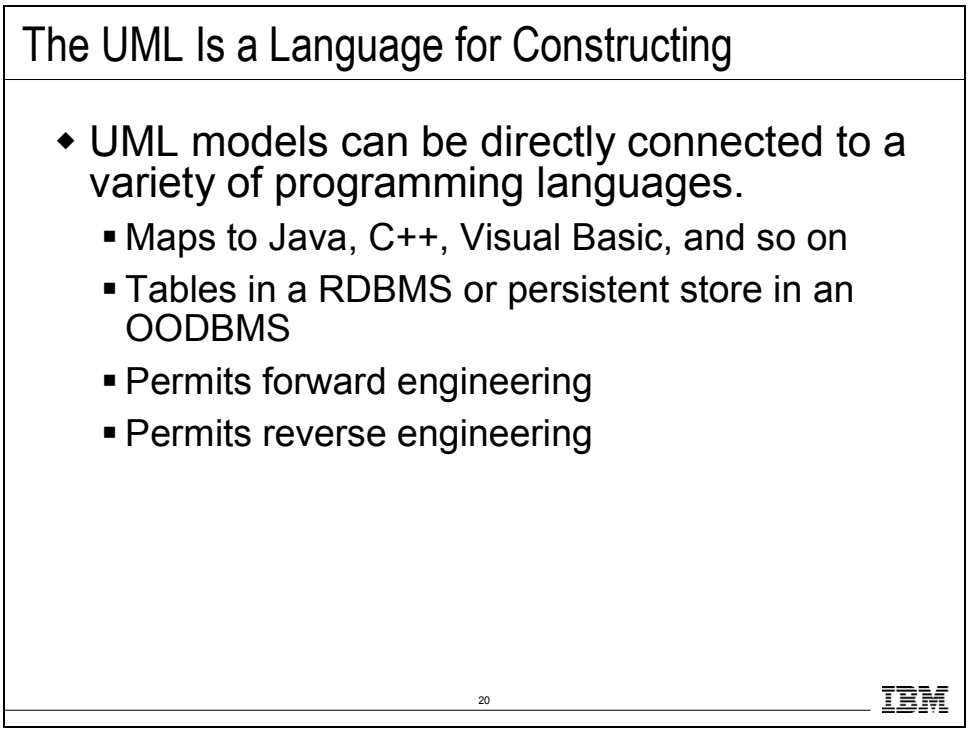
If the developer who cut the code never wrote down the models, the information would be lost forever. At best, the information would only be partially recoverable from the implementation after the developer has moved on. Writing models in the UML addresses this issue. An explicit model facilitates communication. (*The Unified Modeling Language User Guide*, Booch, 1999.)

The UML Is a Language for Specifying



In this context, **specifying** means to build models that are precise, unambiguous, and complete. In particular, the UML addresses the specification of all the important analysis, design, and implementation decisions that must be made to develop and deploy software-intensive systems. (*The Unified Modeling Language User Guide*, Booch, 1999.)

The UML Is a Language for Constructing



The UML is not a visual programming language. However, models using the UML can be directly connected to a variety of programming languages, making it possible to map from a model in the UML to a programming language or even to a database.

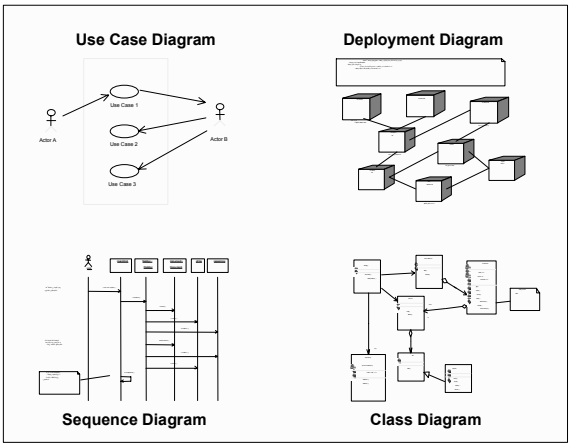
If it is best expressed graphically, it is done graphically in the UML. If it is best expressed textually, it is done in the programming language.

This mapping permits **forward engineering**: the generation of code from a UML model to a programming language. **Reverse engineering** is also possible: the reconstruction of a model from implementation back into the UML.

The UML Is a Language for Documenting

The UML Is a Language for Documenting

- The UML addresses documentation of system architecture, requirements, tests, project planning, and release management.



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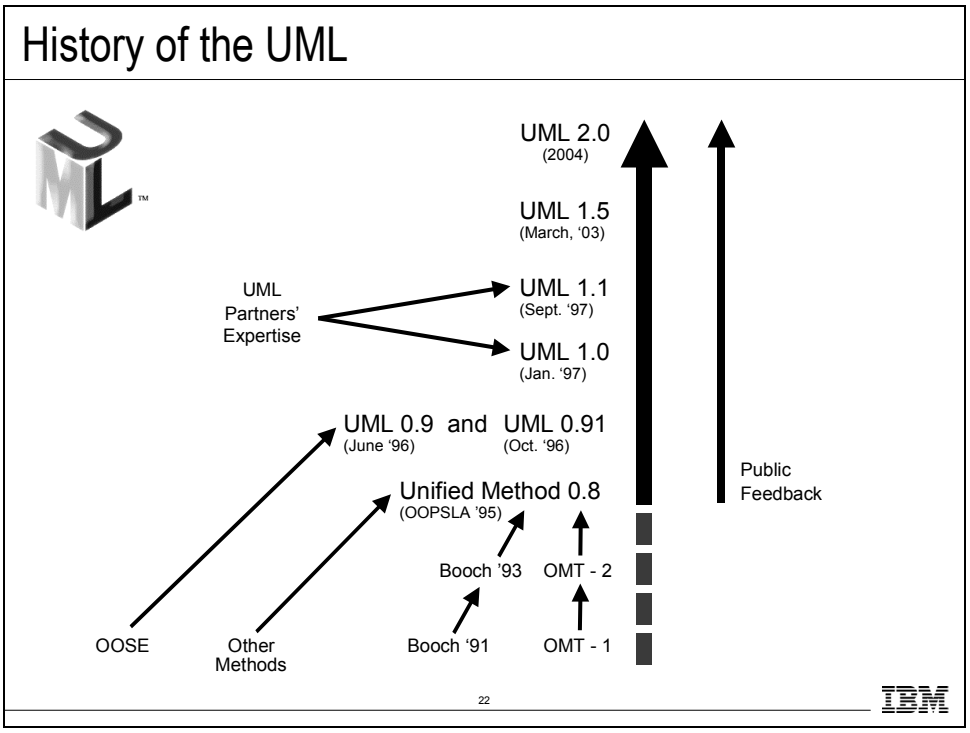
Project artifacts are critical in controlling, measuring, and communicating about a system during its development and after its deployment.

The UML addresses the documentation of a system's architecture and all of its details. The UML also provides a language for expressing requirements and for tests. Finally, the UML provides a language for modeling the activities of project planning and release management. (*The Unified Modeling Language User Guide*, Booch, 1999.)

This slide does not represent all the diagrams defined in the UML specification. For example, there is no graphic presented here for a composite structure diagram or a timing diagram. Composite structure is a more advanced modeling concept that is not covered in this course. The timing diagram is new to UML2 and will be introduced in a later module.

History of the UML



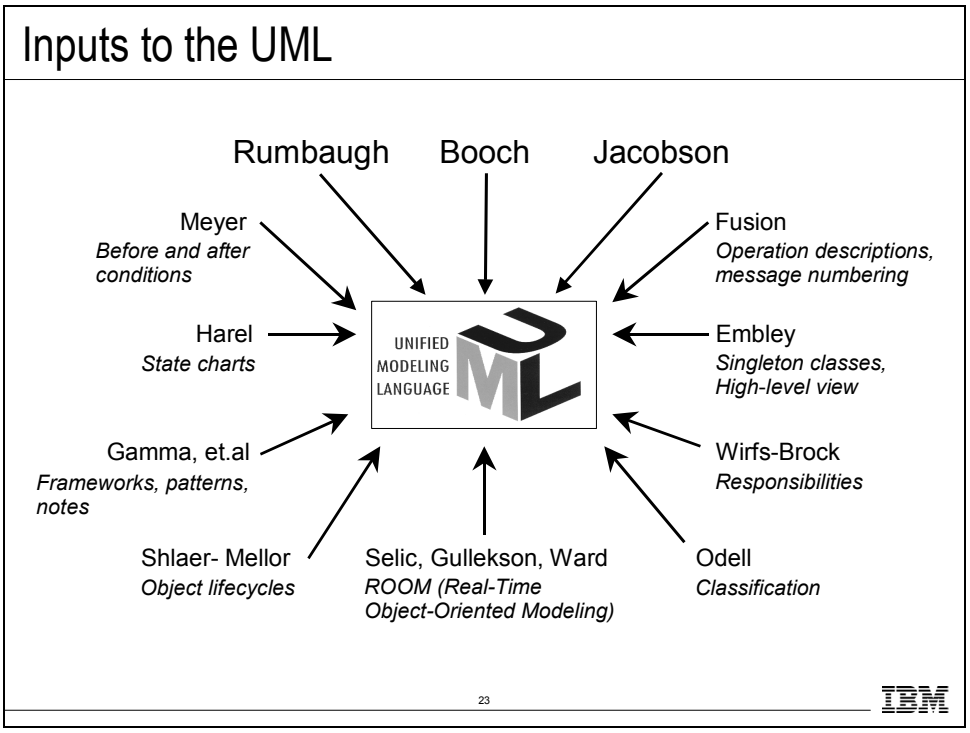
The UML 2.0 is defined by two complementary specifications, the *Infrastructure* and the *Superstructure*. The UML infrastructure defines foundational concepts that can be used in part or entirely by other specifications. The UML superstructure defines the complete UML. The superstructure specification is self contained and you won't have to read the infrastructure specification unless you are concerned about configuring other specifications in parallel to UML.

The UML metamodel (a description of a model) is divided into two main packages, structure and behavior with two supporting packages, auxiliary elements and profiles.

- The structure package defines the static structure of the UML.
- The behavior package defines the dynamic structure of the UML.

Each package is described by a chapter in the superstructure specification document.

Inputs to the UML



UML development included incorporating ideas from numerous other methodologists. The main challenge was to construct an approach that was simple, yet allowed the modeling of a broad range of systems. The conceptual framework was established quickly, but the notational semantics took more time.

Active collaboration with other industry leaders has brought unique expertise and experience into the UML effort. The UML effort was supported by a cross-section of the industry. Partners in the UML effort included HP, ICON Computing, IBM, I-Logix, Intellicorp, MCI Systemhouse, Microsoft, ObjecTime, Oracle, Platinum Technology, Ptech, Reich Technologies, Softeam, Sterling Software, Taskon, and Unisys. These partners provided contributors, reviewers, and advocates for the standardization efforts.

In the end, a modeling language was created that has already withstood the test of widespread use in the industry and the scrutiny of international standardization efforts.

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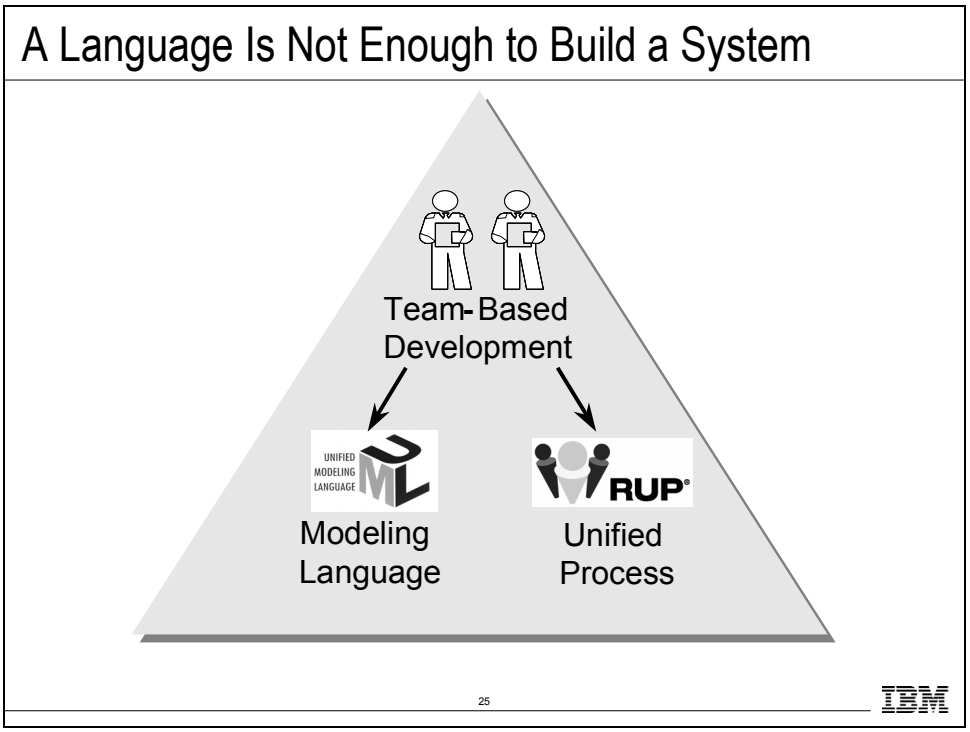
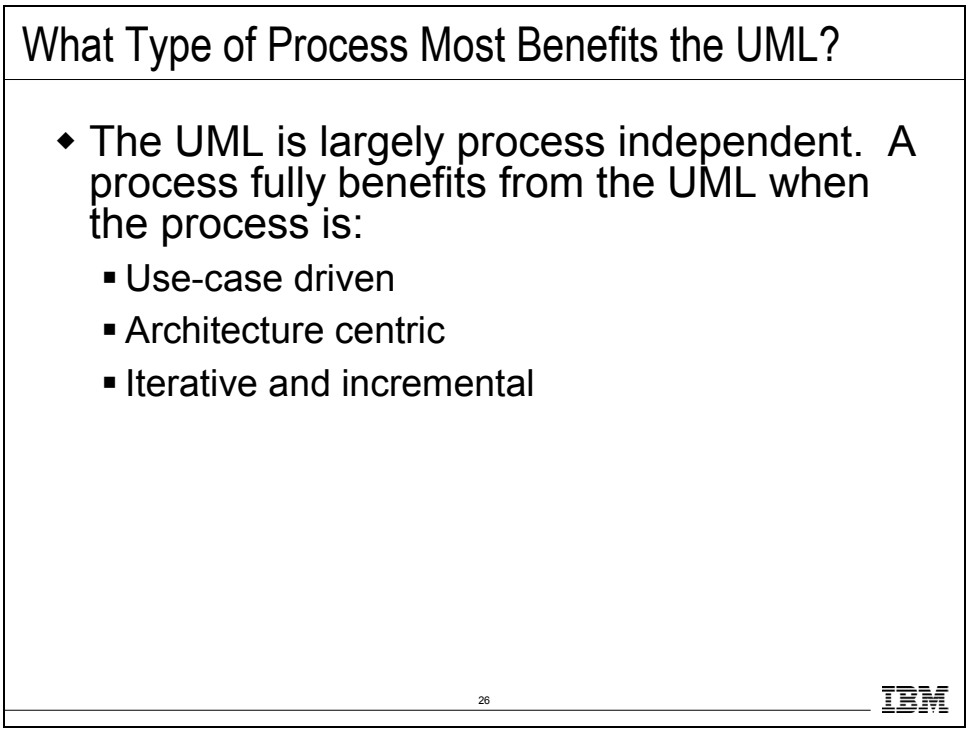
A Language Is Not Enough to Build a System



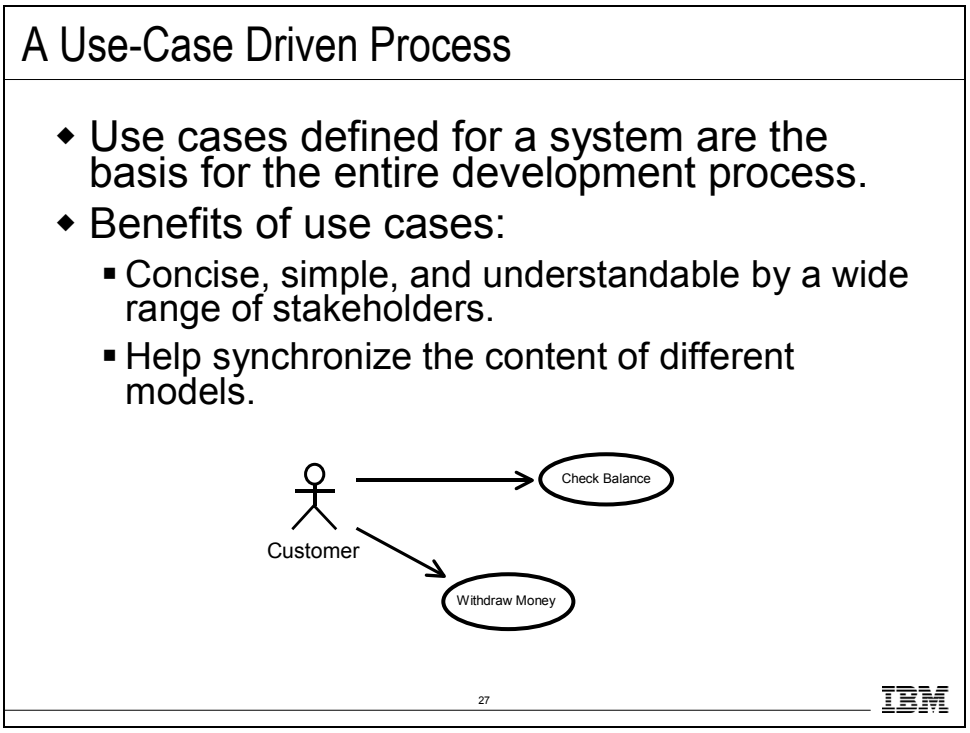
The UML provides a standard for the artifacts of development (semantic models, syntactic notation, and diagrams) that must be controlled and exchanged. But the UML is not a standard for the development process.

Despite all its value, you cannot achieve successful development of today's complex systems solely by using the UML. Successful development also requires employing an equally robust development process.

What Type of Process Most Benefits the UML?



A Use-Case Driven Process

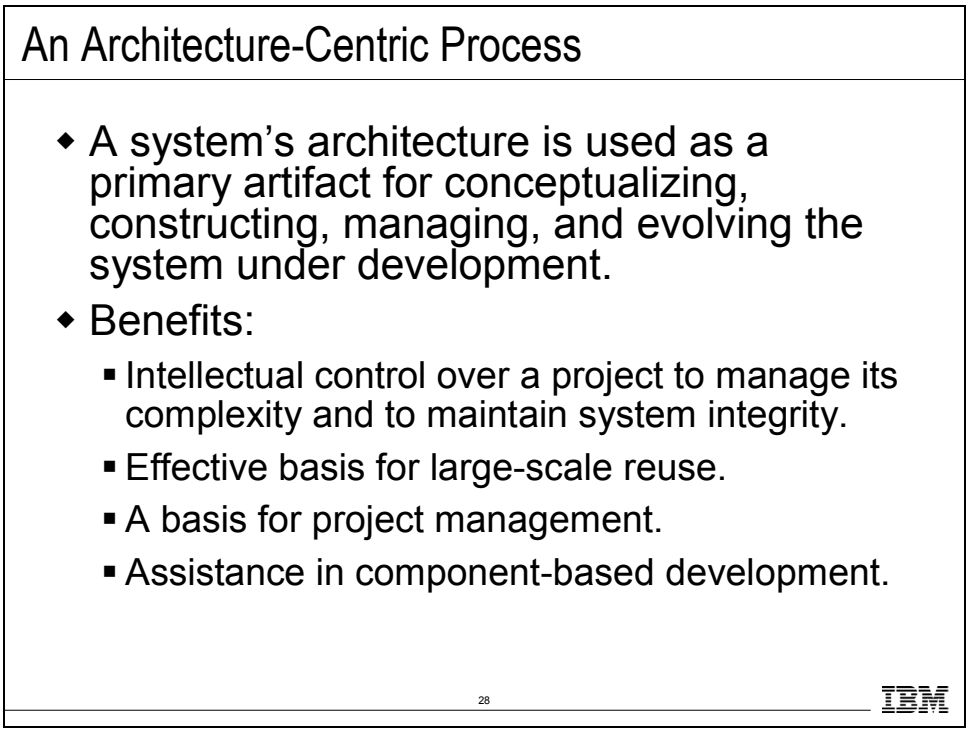


Use cases are one recommended method for organizing your requirements. Instead of a bulleted list of requirements, you organize them in a way that shows how someone can use the system. By doing so, a requirement is more complete and consistent. You can also better understand the importance of a requirement from a user perspective.

It's often difficult to tell how a system does what it is supposed to do from a traditional object-oriented system model. This stems from the lack of a "thread" through the system when it performs certain tasks. Use cases are that thread because they define the behavior performed by a system.

Use cases are not part of "traditional" object orientation, but their importance has become more and more apparent, further emphasized that use cases are part of the UML.

An Architecture-Centric Process

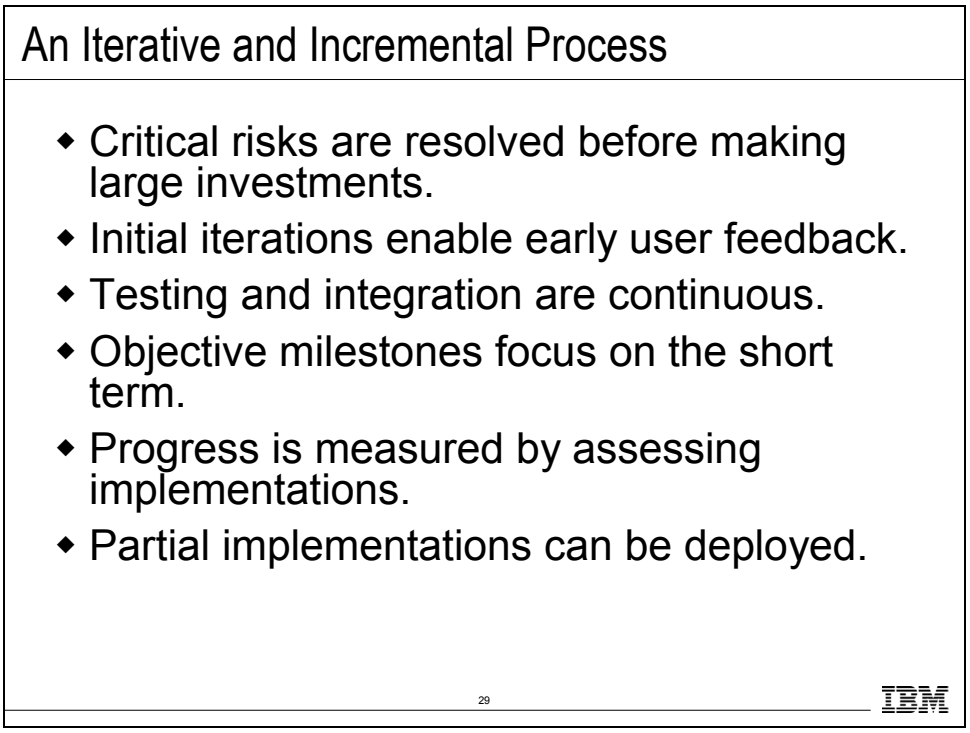


Use cases drive the process end-to-end over the entire lifecycle. The design activities are centered around architecture-centric architecture, or for software-intensive systems, software architecture. The main focus of the early iterations of a architecture-centric process is to produce and validate a software architecture, which in the initial development cycle takes the form of an executable architectural prototype that gradually evolves to become the final system in later iterations.

A complex system is more than the sum of its parts, more than a succession of small independent tactical decisions. It must have some unifying, coherent structure to organize those parts systematically, and provide precise rules on how to grow the system without having its complexity "explode" beyond human understanding. Architecture provides this structure and these rules.

By clearly articulating the major components and the critical interfaces among them, architecture lets you reason about reuse, both internal reuse (the identification of common parts), and external reuse (the incorporation of ready-made, off-the-shelf components). Architecture can also help reuse on a larger scale. That is, the reuse of the architecture itself in the context of a product line that addresses different functionality in a common domain.

An Iterative and Incremental Process



An iterative approach allows users to be involved in a meaningful way throughout the project life cycle. Since each iteration produces an executable release, users can observe the partially executing system and provide meaningful feedback to their level of satisfaction. This ensures that the final system delivered to users is acceptable.

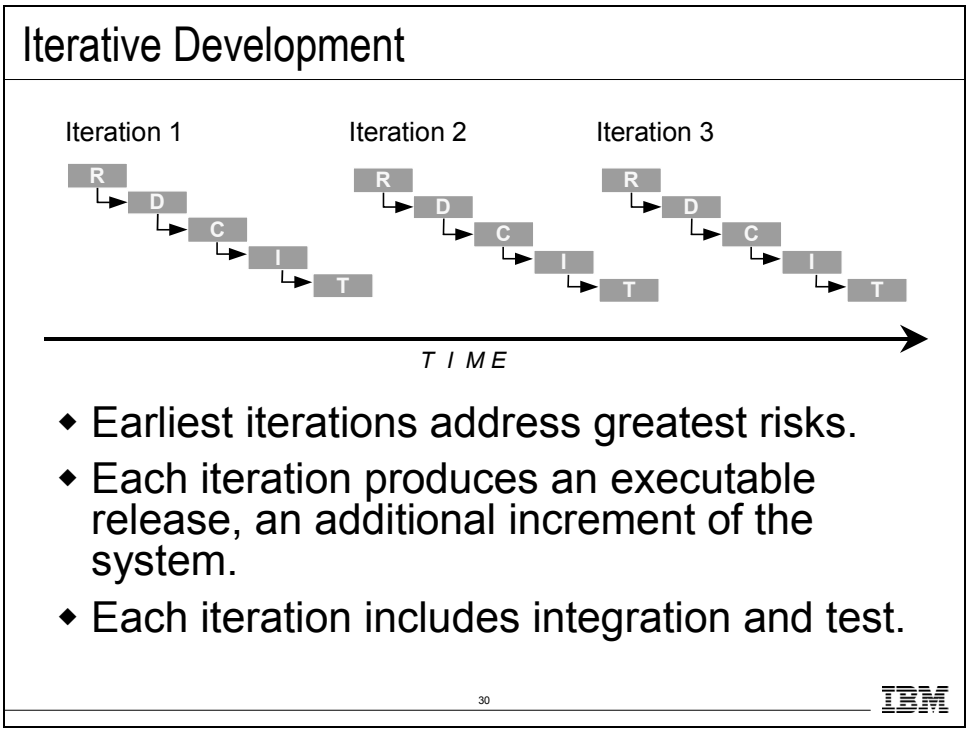
Continuous testing and integration ensures that, at every iteration, the pieces all fit together and that the system-level requirements (for example, performance and capacity) are being met.

The **short-term focus of an iteration** is an objective measure of "doneness." Either a class is included in the build or it's not. It can't be 90 percent done. Either a test is executed successfully or it's not. There is very little room for subjective estimates.

In spite of the best efforts of the development team, not all system features may be complete on the original delivery date. With a waterfall approach, this would usually mean that nothing was ready to be delivered (everything is 90 percent done).

With an iterative approach, most of the system is already fully tested and operational. In many cases, there is value in delivering the partial system on the promised date with the remaining features incorporated at a later time. This can be important when a user has a critical need for some of the new functionality provided by the system or it may help the training and installation process to proceed on schedule. An iterative approach can avoid inconvenient re-planning and re-assignment of resources.

Iterative Development



In the diagram above, the following abbreviations are used.

- **R** Requirements analysis
- **D** Design
- **C** Coding, unit testing
- **I** Implementation
- **T** Subsystem and system test

Iterative processes were developed in response to these waterfall characteristics. With an iterative process, apply the waterfall steps **iteratively**. Instead of developing the whole system at once, select and develop an increment (a subset of system functionality), then another increment, and so on.

Develop the first increment based on risk, with the highest priority risks to be developed first.

To address the selected risk(s), choose a subset of use cases.

Develop the smallest number of use cases that allow objective verification (like a set of executable tests) of the risks that you've chosen.

Select the next increment to address the next highest risk, and so on. Thus, you apply the waterfall within each iteration and the system evolves incrementally.

Review

Review

- What is a model?
- What are the viewpoints of MDA? Describe each one.
- What are the four principles of modeling? Describe each one.
- What is the UML? Describe each of its four benefits.
- What process characteristics best fit the UML? Describe each characteristic.
- What is an iteration?

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