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Program : **B.Tech**

Subject Name: **Project Management**

Subject Code: **CS-604**

Semester: **6th**

Department of Computer Science and Engineering
Subject Notes
CS-604 (B) Project Management
Unit -1

Topics to be covered

Evolution of software economics, improving software economics: reducing product size, software processes, team effectiveness, automation through software environments. Principles of modern software management.

1. **Evolution of software economics**

Most software cost models can be abstracted into a function of five basic parameters: size, process, personnel, environment, and required quality.

1. The size of the end product (in human-generated components), which is typically quantified in terms of the number of source instructions or the number of function points required to develop the required functionality
2. The process used to produce the end product, in particular the ability of the process to avoid non-value-adding activities (rework, bureaucratic delays, communications overhead)
3. The capabilities of software engineering personnel, and particularly their experience with the computer science issues and the applications domain issues of the project
4. The environment, which is made up of the tools and techniques available to support efficient software development and to automate the process
5. The required quality of the product, including its features, performance, reliability, and adaptability

The relationships among these parameters and the estimated cost can be written as follows:

Effort = (Personnel) (Environment) (Quality) $(Size)^{Process}$

Several parametric models have been developed to estimate software costs; all of them can be generally abstracted into this form. One important aspect of software economics (as represented within today's software cost models) is that the relationship between effort and size exhibits a diseconomy of scale. The diseconomy of scale of software development is a result of the process exponent being greater than 1.0. Contrary to most manufacturing processes, the more software you build, the more expensive it is per unit item.

Target objective: improved ROI

Environment/Tools: Off-the-shelf, integrated
Size: 70% component-based 30% custom
Process: Managed/measured

Improving Software Economics: Reducing Software product size, improving software processes, improving team effectiveness, improving automation, Achieving required quality, peer inspections.

The old way and the new: The principles of conventional software Engineering, principles of modern software management, transitioning to an iterative process.

2. Improving Software Economics

Five basic parameters of the software cost model are

1. Reducing the size or complexity of what needs to be developed
2. Improving the development process
3. Using more-skilled personnel and better teams (not necessarily the same thing)
4. Using better environments (tools to automate the process)
5. Trading off or backing off on quality thresholds

These parameters are given in priority order for most software domains. Table 3-1 lists some of the technology developments, process improvement efforts, and management approaches targeted at improving the economics of software development and integration.

Important trends in improving software economics

COST MODEL PARAMETERS	TRENDS
Size Abstraction and component-based development technologies	Higher order languages (C++, Ada 95, Java, Visual Basic, etc.) Object-oriented (ana lysis, design, programming) Reuse Commercial components
Environment Automation technologies and tools	Integrated tools (visual modeling, compiler, editor, debugger, change management, etc.) Open systems Hardware platform performance Automation of coding, documents, testing, analyses
Quality Performance, reliability, accuracy	Hardware platform performance Demonstration-based assessment Statistical quality control

3. Reducing Software Product Size

The most significant way to improve affordability and return on investment (ROI) is usually to produce a product that achieves the design goals with the minimum amount of human-generated source material. *Component-based development* is introduced here as the general term for reducing the "source" language size necessary to achieve a software solution. Reuse, object-oriented technology, automatic code production, and higher order programming languages are all focused on achieving a given system with fewer lines of human-specified source directives (statements). This size reduction is the primary motivation behind improvements in higher order languages (such as C++, Ada 95, Java, Visual Basic, and fourth-generation languages), automatic code generators (CASE tools, visual modeling tools, GUI builders), reuse of commercial components (operating systems, windowing environments, database management systems, middleware, networks), and object-oriented technologies (Unified Modeling Language, visual modeling tools, architecture

frameworks). The reduction is defined in terms of human-generated source material. In general, when size-reducing technologies are used, they reduce the number of human-generated source lines.

LANGUAGES

Universal function points (UFPs) are useful estimators for language-independent, early life-cycle estimates. The basic units of function points are external user inputs, external outputs, internal logical data groups, external data interfaces, and external inquiries. SLOC metrics are useful estimators for software after a candidate solution is formulated and an implementation language is known. Substantial data have been documented relating SLOC to function points . Some of these results are shown in Table 3-2.

Language Expressiveness

LANGUAGE	SLOC PER UFP
Assembly	320
C	128
FORTAN 77	105
COBOL 85	91
Ada 83	71
C++	56
Ada 95	55
Java	55
Visual Basics	35

OBJECT-ORIENTED METHODS AND VISUAL MODELING

There has been a widespread movement in the 1990s toward object-oriented technology. I spend very little time on this topic because object-oriented technology is not germane to most of the software management topics discussed here, and books on object-oriented technology abound. Some studies have concluded that object-oriented programming languages appear to benefit both software productivity and software quality. The fundamental impact of object-oriented technology is in reducing the overall size of what needs to be developed. These are interesting examples of the interrelationships among the dimensions of improving software economics.

1. An object-oriented model of the problem and its solution encourages a common vocabulary between the end users of a system and its developers, thus creating a shared understanding of the problem being solved.
2. The use of continuous integration creates opportunities to recognize risk early and make incremental corrections without destabilizing the entire development effort.
3. An object-oriented architecture provides a clear separation of concerns among disparate elements of a system, creating firewalls that prevent a change in one part of the system from rending the fabric of the entire architecture.

Booch also summarized five characteristics of a successful object-oriented project.

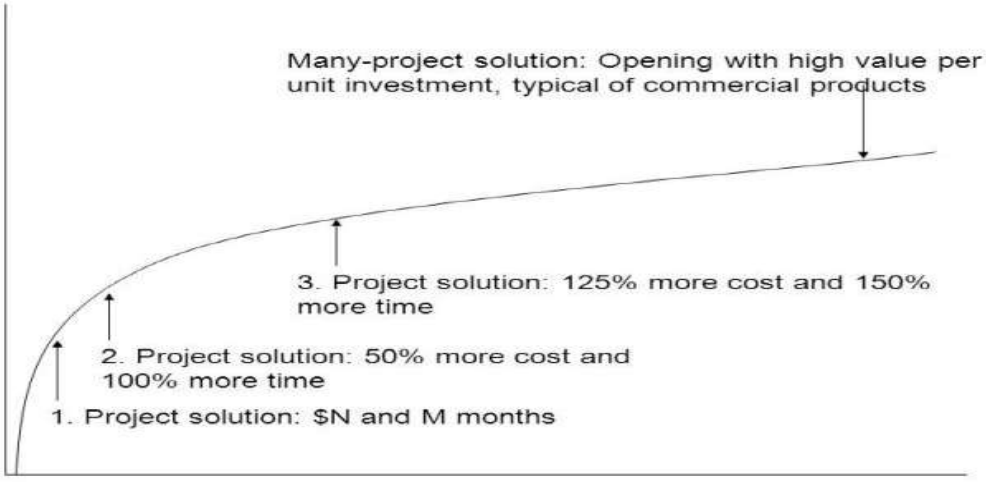
1. A ruthless focus on the development of a system that provides a well understood collection of essential minimal characteristics.
2. The existence of a culture that is centred on results, encourages communication, and yet is not afraid to fail.
3. The effective use of object-oriented modelling.
4. The existence of a strong architectural vision.
5. The application of a well-managed iterative and incremental development life cycle.

REUSE

Reusing existing components and building reusable components have been natural software engineering activities since the earliest improvements in programming languages. Software design methods have always dealt implicitly with reuse in order to minimize development costs while achieving all the other required attributes of performance, feature set, and quality. Try to treat reuse as a mundane part of achieving a return on investment.
Most truly reusable components of value are transitioned to commercial products supported by organizations with the following characteristics:

- They have an economic motivation for continued support.
- They take ownership of improving product quality, adding new features, and transitioning to new technologies.
- They have a sufficiently broad customer base to be profitable.

The cost of developing a reusable component is not trivial. Figure 3-1 examines the economic trade-offs. The steep initial curve illustrates the economic obstacle to developing reusable components.
Reuse is an important discipline that has an impact on the efficiency of all workflows and the quality of most artifacts



Cost and schedule investments necessary to achieve reusable components

COMMERCIAL COMPONENTS

A common approach being pursued today in many domains is to maximize integration of commercial components and off-the-shelf products. While the use of commercial components is certainly desirable as a means of reducing custom development, it has not proven to be straightforward in practice. Following Table identifies some of the advantages and disadvantages of using commercial components.

Advantages and Disadvantages of Commercial Components and Custom Software

APPROACH	ADVANTAGE	DISADVANTAGE
Commercial Components	Predictable license costs Broadly used mature technology Dedicated support	Frequent upgrades Up-front license fees Recurring maintenance fees Dependency on vendor

	organization Hardware/Software independence Rich in functionality	Run time efficiency sacrifices Functionality constraints Integration not always trivial No control over upgrades and maintenance Unnecessary features that consumes extra resources Often inadequate reliability and stability Multiple vendor incompatibilities
Custom development	Complete change freedom Smaller, often simpler implementations Often better performance Control of development and enhancement	Expensive, unpredictable development Unpredictable availability date Undefined maintenance model Often immature and fragile Drain on expert resources

4. Improving Software Process

Process is an overloaded term. For software-oriented organizations, there are many processes and sub processes. Three distinct process perspectives are.

Metaprocess: *A*n organization's policies, procedures, and practices for pursuing a software-intensive line of business. The focus of this process is on organizational economics, long-term strategies, and software ROI.

Macroprocess: A project's policies, procedures, and practices for producing a complete software product within certain cost, schedule, and quality constraints. The focus of the macro process is on creating an adequate instance of the Meta process for a specific set of constraints.

Microprocess: A project team's policies, procedures, and practices for achieving an artifact of the software process. The focus of the micro process is on achieving an intermediate product baseline with adequate quality and adequate functionality as economically and rapidly as practical.

Although these three levels of process overlap somewhat, they have different objectives, audiences, metrics, concerns, and time scales as shown in Table.

In a perfect software engineering world with an immaculate problem description, an obvious solution space, a development team of experienced geniuses, adequate resources, and stakeholders with common goals, we could execute a software development process in one iteration with almost no scrap and rework. Because we work in an imperfect world, however, we need to manage engineering activities so that scrap and rework profiles do not have an impact on the win conditions of any stakeholder. This should be the underlying premise for most process improvement

5. Improving Team Effectiveness

Teamwork is much more important than the sum of the individuals. With software teams, a project manager needs to configure a balance of solid talent with highly skilled people in the leverage positions. Some maxims of team management include the following:

- A well-managed project can succeed with a nominal engineering team.
- A mismanaged project will almost never succeed, even with an expert team of engineers.
- A well-architected system can be built by a nominal team of software builders.

- A poorly architected system will flounder even with an expert team of builders. **Boehm five staffing principles are**

1. The principle of top talent: Use better and fewer people
2. The principle of job matching: Fit the tasks to the skills and motivation of the people available.
3. The principle of career progression: An organization does best in the long run by helping its people to self-actualize.
4. The principle of team balance: Select people who will complement and harmonize with one another
5. The principle of phase-out: Keeping a misfit on the team doesn't benefit anyone

Software project managers need many leadership qualities in order to enhance team effectiveness. The following are some crucial attributes of successful software project managers that deserve much more attention:

- **Hiring skills**. Few decisions are as important as hiring decisions. Placing the right person in the right job seems obvious but is surprisingly hard to achieve.
- **Customer-interface skill**. Avoiding adversarial relationships among stakeholders is a prerequisite for success.
- **Decision-making skill.** The jillion books written about management have failed to provide a clear definition of this attribute. We all know a good leader when we run into one, and decision-making skill seems obvious despite its intangible definition.
- **Team-building skill.** Teamwork requires that a manager establish trust, motivate progress, exploit eccentric prima donnas, transition average people into top performers, eliminate misfits, and consolidate diverse opinions into a team direction.
- **Selling skill**. Successful project managers must sell all stakeholders (including themselves) on decisions and priorities, sell candidates on job positions, sell changes to the status quo in the face of resistance, and sell achievements against objectives. In practice, selling requires continuous negotiation, compromise, and empathy

6. Improving Automation through Software Environments

The tools and environment used in the software process generally have a linear effect on the productivity of the process. Planning tools, requirements management tools, visual modelling tools, compilers, editors, debuggers, quality assurance analysis tools, test tools, and user interfaces provide crucial automation support for evolving the software engineering artifacts. Above all, configuration management environments provide the foundation for executing and instrument the process. At first order, the isolated impact of tools and automation generally allows improvements of 20% to 40% in effort. However, tools and environments must be viewed as the primary delivery vehicle for process automation and improvement, so their impact can be much higher.

Automation of the design process provides payback in quality, the ability to estimate costs and schedules, and overall productivity using a smaller team. Integrated toolsets play an increasingly important role in incremental/iterative development by allowing the designers to traverse quickly among development artifacts and keep them up-to-date.

Round-trip engineering is a term used to describe the key capability of environments that support iterative development. As we have moved into maintaining different information repositories for the engineering artifacts, we need automation support to ensure efficient and error-free transition of data from one artifact to another. *Forward engineering* is the automation of one engineering artifact from another, more abstract

representation. For example, compilers and linkers have provided automated transition of source code into executable code. *Reverse engineering* is the generation or modification of a more abstract representation from an existing artifact (for example, creating a visual design model from a source code representation).

Economic improvements associated with tools and environments. It is common for tool vendors to make relatively accurate individual assessments of life-cycle activities to support claims about the potential economic impact of their tools. For example, it is easy to find statements such as the following from companies in a particular tool.

- Requirements analysis and evolution activities consume 40% of life-cycle costs.
- Software design activities have an impact on more than 50% of the resources.
- Coding and unit testing activities consume about 50% of software development effort and schedule.
- Test activities can consume as much as 50% of a project's resources.
- Configuration control and change management are critical activities that can consume as much as 25% of resources on a large-scale project.
- Documentation activities can consume more than 30% of project engineering resources.
- Project management, business administration, and progress assessment can consume as much as 30% of project budgets.

ACHIEVING REQUIRED QUALITY

Software best practices are derived from the development process and technologies. Table 3-5 summarizes some dimensions of quality improvement.

- Key practices that improve overall software quality include the following:
- Focusing on driving requirements and critical use cases early in the life cycle, focusing on requirements completeness and traceability late in the life cycle, and focusing throughout the life cycle on a balance between requirements evolution, design evolution, and plan evolution
- Using metrics and indicators to measure the progress and quality of an architecture as it evolves from a high-level prototype into a fully compliant product
- Providing integrated life-cycle environments that support early and continuous configuration control, change management, rigorous design methods, document automation, and regression test automation
- Using visual modelling and higher level languages that support architectural control, abstraction, reliable programming, reuse, and self-documentation
- Early and continuous insight into performance issues through demonstration-based evaluations

Conventional development processes stressed early sizing and timing estimates of computer program resource utilization. However, the typical chronology of events in performance assessment was as follows

- **Project inception.** The proposed design was asserted to be low risk with adequate performance margin.
- **Initial design review.** Optimistic assessments of adequate design margin were based mostly on paper analysis or rough simulation of the critical threads. In most cases, the actual application algorithms and database sizes were fairly well understood.
- **Mid-life-cycle design review.** The assessments started whittling away at the margin, as early benchmarks and initial tests began exposing the optimism inherent in earlier estimates.
- **Integration and test**. Serious performance problems were uncovered, necessitating fundamental changes in the architecture. The underlying infrastructure was usually the scapegoat, but the real culprit was immature use of the infrastructure, immature architectural solutions, or poorly understood early design trade-offs.

PEER INSPECTIONS: A PRAGMATIC VIEW

Peer inspections are frequently over hyped as the key aspect of a quality system. In my experience, peer reviews are valuable as secondary mechanisms, but they are rarely significant contributors to quality compared with the following primary quality mechanisms and indicators, which should be emphasized in the management process:

- Transitioning engineering information from one artifact set to another, thereby assessing the consistency, feasibility, understandability, and technology constraints inherent in the engineering artifacts
- Major milestone demonstrations that force the artifacts to be assessed against tangible criteria in the context of relevant use cases
- Environment tools (compilers, debuggers, analyzers, automated test suites) that ensure representation rigor, consistency, completeness, and change control
- Life-cycle testing for detailed insight into critical trade-offs, acceptance criteria, and requirements compliance
- Change management metrics for objective insight into multiple-perspective change trends and convergence or divergence from quality and progress goals

Inspections are also a good vehicle for holding authors accountable for quality products. All authors of software and documentation should have their products scrutinized as a natural by-product of the process. Therefore, the coverage of inspections should be across all authors rather than across all components.

THE PRINCIPLES OF CONVENTIONAL SOFTWARE ENGINEERING

1. **Make quality #1.** Quality must be quantified and mechanisms put into place to motivate its achievement
2. **High-quality software is possible**. Techniques that have been demonstrated to increase quality include involving the customer, prototyping, simplifying design, conducting inspections, and hiring the best people
3. **Give products to customers early**. No matter how hard you try to learn users' needs during the requirements phase, the most effective way to determine real needs is to give users a product and let them play with it
4. **Determine the problem before writing the requirements**. When faced with what they believe is a problem, most engineers rush to offer a solution. Before you try to solve a problem, be sure to explore all the alternatives and don't be blinded by the obvious solution
5. **Evaluate design alternatives**. After the requirements are agreed upon, you must examine a variety of architectures and algorithms. You certainly do not want to use “architecture” simply because it was used in the requirements specification.
6. **Use an appropriate process model**. Each project must select a process that makes ·the most sense for that project on the basis of corporate culture, willingness to take risks, application area, volatility of requirements, and the extent to which requirements are well understood.
7. **Use different languages for different phases**. Our industry's eternal thirst for simple solutions to complex problems has driven many to declare that the best development method is one that uses the same notation throughout the life cycle.
8. **Minimize intellectual distance**. To minimize intellectual distance, the software's structure should be as close as possible to the real-world structure

9. **Put techniques before tools**. An undisciplined software engineer with a tool becomes a dangerous, undisciplined software engineer
10. **Get it right before you make it faster**. It is far easier to make a working program run faster than it is to make a fast program work. Don't worry about optimization during initial coding
11. **Inspect code**. Inspecting the detailed design and code is a much better way to find errors than testing
12. **Good management is more important than good technology**. Good management motivates people to do their best, but there are no universal "right" styles of management.
13. **People are the key to success.** Highly skilled people with appropriate experience, talent, and training are key.
14. **Follow with care**. Just because everybody is doing something does not make it right for you. It may be right, but you must carefully assess its applicability to your environment.
15. **Take responsibility**. When a bridge collapses we ask, "What did the engineers do wrong?" Even when software fails, we rarely ask this. The fact is that in any engineering discipline, the best methods can be used to produce awful designs, and the most antiquated methods to produce elegant designs.
16. **Understand the customer's priorities**. It is possible the customer would tolerate 90% of the functionality delivered late if they could have 10% of it on time.
17. **The more they see, the more they need**. The more functionality (or performance) you provide a user, the more functionality (or performance) the user wants.
18. **Plan to throw one away**. One of the most important critical success factors is whether or not a product is entirely new. Such brand-new applications, architectures, interfaces, or algorithms rarely work the first time.
19. **Design for change**. The architectures, components, and specification techniques you use must accommodate change.
20. **Design without documentation is not design**. I have often heard software engineers say, "I have finished the design. All that is left is the documentation. "
21. **Use tools, but be realistic.** Software tools make their users more efficient.
22. **Avoid tricks**. Many programmers love to create programs with tricks constructs that perform a function correctly, but in an obscure way. Show the world how smart you are by avoiding tricky code
23. **Encapsulate.** Information-hiding is a simple, proven concept that results in software that is easier to test and much easier to maintain.
24. **Use coupling and cohesion**. Coupling and cohesion are the best ways to measure software's inherent maintainability and adaptability.
25. **Use the McCabe complexity measure**. Although there are many metrics available to report the inherent complexity of software, none is as intuitive and easy to use as Tom McCabe's.

7. Principles of Modern Software Management

Top 10 principles of modern software management are. (The first five, which are the main themes of my definition of an iterative process)

1. **Base the process on an *architecture-first approach.*** This requires that a demonstrable balance be achieved among the driving requirements, the architecturally significant design decisions, and the life-cycle plans before the resources are committed for full-scale development.

2. **Establish an *iterative life-cycle process* that confronts risk early**. With today's sophisticated software systems, it is not possible to define the entire problem, design the entire solution, build the software, then test the end product in sequence. Instead, an iterative process that refines the problem understanding, an effective solution, and an effective plan over several iterations encourages a balanced treatment of all stakeholder objectives. Major risks must be addressed early to increase predictability and avoid expensive downstream scrap and rework.
3. **Transition design methods to emphasize *component-based development.*** Moving from a line-of-code mentality to a component-based mentality is necessary to reduce the amount of human-generated source code and custom development.
4. **Establish a *change management environment.*** The dynamics of iterative development, including concurrent workflows by different teams working on shared artifacts, necessitates objectively controlled baselines.
5. **Enhance change freedom through tools that support *round-trip engineering*.** Round-trip engineering is the environment support necessary to automate and synchronize engineering information in different formats (such as requirements specifications, design models, source code, executable code, test cases).

    1. **Capture design artifacts in rigorous, *model-based notation.*** A model based approach (such as UML) supports the evolution of semantically rich graphical and textual design notations.

    2. **Instrument the process for *objective quality control* and progress assessment**. Life-cycle assessment of the progress and the quality of all intermediate products must be integrated into the process.

    3. **Use a *demonstration-based approach* to assess intermediate artifacts. Plan intermediate releases in groups of usage scenarios with *evolving levels* of *detail.*** It is essential that the software management process drive toward early and continuous demonstrations within the operational context of the system, namely its use cases.
6. **Establish a *configurable process* that is economically scalable.** No single process is suitable for all software developments.

TRANSITIONING TO AN ITERATIVE PROCESS

Modern software development processes have moved away from the conventional waterfall model, in which each stage of the development process is dependent on completion of the previous stage.

The economic benefits inherent in transitioning from the conventional waterfall model to an iterative development process are significant but difficult to quantify. As one benchmark of the expected economic impact of process improvement, consider the process exponent parameters of the COCOMO II model. (Appendix B provides more detail on the COCOMO model) This exponent can range from 1.01 (virtually no diseconomy of scale) to 1.26 (significant diseconomy of scale). The parameters that govern the value of the process exponent are application precedentedness, process flexibility, architecture risk resolution, team cohesion, and software process maturity.

The following paragraphs map the process exponent parameters of CO COMO II to my top 10 principles of a modern process.

- **Application precedentedness**. Domain experience is a critical factor in understanding how to plan and execute a software development project. For unprecedented systems, one of the key goals is to confront risks and establish early precedents, even if they are incomplete or experimental. This is one of the primary reasons that the software industry has moved to an ***iterative life-cycle process.*** Early

iterations in the life cycle establish precedents from which the product, the process, and the plans can be elaborated in ***evolving levels* of *detail.***

- **Process flexibility**. Development of modern software is characterized by such a broad solution space and so many interrelated concerns that there is a paramount need for continuous incorporation of changes. These changes may be inherent in the problem understanding, the solution space, or the plans. Project artifacts must be supported by efficient ***change management*** commensurate with project needs. A ***configurable process*** that allows a common framework to be adapted across a range of projects is necessary to achieve a software return on investment.
- **Architecture risk resolution**. ***Architecture-first*** development is a crucial theme underlying a successful iterative development process. A project team develops and stabilizes architecture before developing all the components that make up the entire suite of applications components. An ***architecture-first*** and ***component-based development approach*** forces the infrastructure, common mechanisms, and control mechanisms to be elaborated early in the life cycle and drives all component make/buy decisions into the architecture process.
- **Team cohesion**. Successful teams are cohesive, and cohesive teams are successful. Successful teams and cohesive teams share common objectives and priorities. Advances in technology (such as programming languages, UML, and visual modelling) have enabled more rigorous and understandable notations for communicating software engineering information, particularly in the requirements and design artifacts that previously were ad hoc and based completely on paper exchange. These ***model-based*** formats have also enabled the ***round-trip engineering*** support needed to establish change freedom sufficient for evolving design representations.
- **Software process maturity**. The Software Engineering Institute's Capability Maturity Model (CMM) is a well-accepted benchmark for software process assessment. One of key themes is that truly mature processes are enabled through an integrated environment that provides the appropriate level of automation to instrument the process for ***objective quality control.***

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