

# Software, Performance, or Engineering?

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## Some Definitions

(according to CMU's SEI)

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  - Systematic application of scientific knowledge in creating and building cost-effective solutions to practical problems in the service of mankind.

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# What is (or should be) SE?

Systematic application of principles of computer science and mathematics to the design, maintenance, and evolution of software systems in such a way that all of its requirements---functional and non-functional---are met.

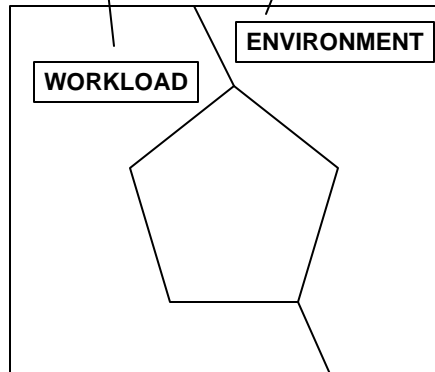
## A bit of history ...

- Software Engineering (SE): around for more than 35 years (1968 NATO conference)
  - Success in developing methods for programming in the small and in the large.
  - Methods for taming the complexity of software development
  - Methods and tools to develop and manage designs, requirements, test cases, configurations, versions, and evolution.

# Conventional Engineering

Sixty 3-ton vehicles  
at 60 mph.

35 mph horizontal winds.



Systems are designed with the workload and environment in mind

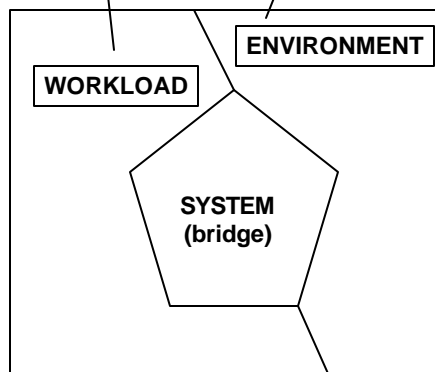
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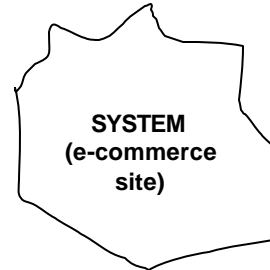
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Perfect fit.

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# Software Engineering

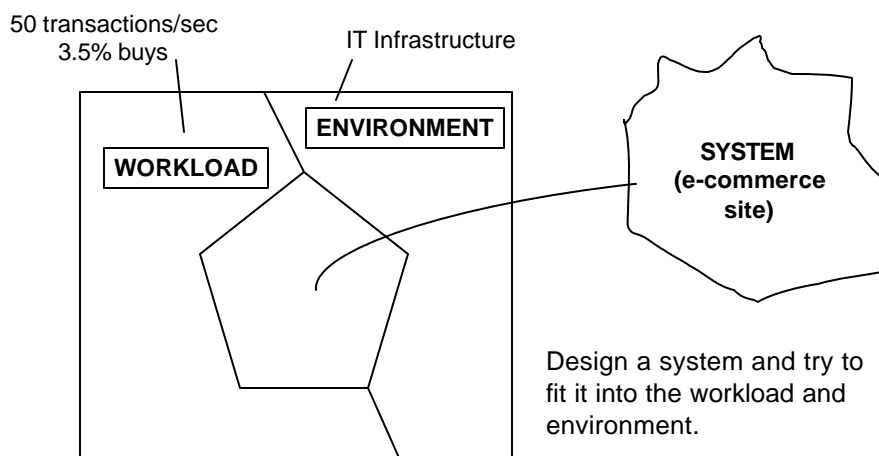


Design a system and try to fit it into the workload and environment.

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# Software Engineering



Design a system and try to fit it into the workload and environment.

Does not always fit!

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How can a software system work properly if some of its requirements (e.g., performance requirements) are not met?

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How can a software system work properly if some of its requirements (e.g., performance requirements) are not met?

All requirements should be called functional!  
Otherwise, they should not be requirements.

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## More history ...

- 21 years ago Connie Smith coined the term Software Performance Engineering (SPE) (CMG'81 paper).
- Claims:
  - “fix-it” later attitude when it came to performance.
  - performance was never a design consideration.

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- Is the term “Performance” in “Software Performance Engineering” redundant?
  - If SE is Engineering, then it should produce efficient systems by definition.
- Does it make sense to talk about “Efficient Mechanical Engineering?”
  - No. Mechanical engineers (and all other CEs) strive to design efficient mechanisms.

## The reality is ...

- Performance in SPE is not yet redundant!
- The SPE concepts introduced by Connie Smith over 20 years ago have not yet been incorporated into mainstream software engineering.

## Where is the P in SE?

1. Lack of scientific principles and models.
2. Education and curricula issues.
3. IT workforce problems.
4. Single-user mindset.
5. Small database mindset.

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- CEs need to rely on principles and models from mathematics, physics, and computational sciences to design their systems.
- SEs do not need to rely on formal and quantitative models to design and build their systems.

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## Where is the P in SE?

1. Lack of scientific principles and models.
  - SE: many advances in terms of formal models to support the software development life cycle: development, maintenance, and evolution. No universally agreed upon formalisms and quantitative models to support the core of SE.
  - SE: Most of the energy devoted to formalisms and methods that support “functional” requirements (over 80% of IEEE TSE papers since 1989).

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## Where is the P in SE?

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  - PE: mostly addresses issues of system performance from a resource demand point of view.
  - PE: most models do not model the application directly, only the demands it places on the physical resources (e.g., QN models).
  - PE: layered QN-type models represent the application explicitly. These models are not as widely-known and -adopted as conventional QN models.

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Exceptions: minimal performance-related hours in OS and networking courses.
- Joint IEEE CS/ACM Task Force on the “Model Curricula for Computing” draft CS curriculum: performance is overlooked!

## Joint IEEE CS/ACM Task Force on the “Model Curricula for Computing”

- CS divided into 14 areas:
  1. Discrete Structures (DS)
  2. Programming Fundamentals (PF)
  3. Algorithms and Complexity (AL)
  4. Programming Languages (PL)
  5. Architecture and Organization (AR)
  6. Operating Systems (OS)
  7. Net-Centric Computing (NC)
  8. Human-Computer Interaction (HC)
  9. Graphics and Visual Computing (GV)
  10. Intelligent Systems (IS)
  11. Information Management (IM)
  - 12. Software Engineering (SE)**
  13. Social and Professional Issues (SP)
  14. Computational Science and Numerical Methods (CN)

## Joint IEEE CS/ACM Task Force on the “Model Curricula for Computing”

- SE is divided into 12 areas:
  - SE1. Software design [core]
  - SE2. Using APIs [core]
  - SE3. Software tools and environments [core]
  - SE4. Software processes [core]
  - SE5. Software requirements and specifications [core]
  - SE6. Software validation [core]
  - SE7. Software evolution [core]
  - SE8. Software project management [core]
  - SE9. Component-based computing [elective]
  - SE10. Formal methods [elective]
  - SE11. Software reliability [elective]
  - SE12. Specialized systems development [elective]

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  3. Faculty resistance to change.
  4. Limits on total number of hours in the curriculum.

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- How do students view the importance of software issues in the performance of computer systems?
  - 5-question test answered by 59 grad and undergrad students:
    - ✓ 19 seniors in the BS in CS program.
    - ✓ 39 graduates in MS in CS and MS in SE programs.

# Test Questions

1. Define response time (RTDef)
2. What units are used to indicate response time? (RTU)
3. Define throughput. (XDef)
4. What units are used to indicate throughput? (XU)
5. Identify possible factors that contribute to the time taken by a Web search engine to return a reply to a browser. (RTFactors)

Level	No. Students	% took system courses	% took SE courses	Percent Answered Correctly					
				RTDef	RTU	Xdef	XU	RTFactors	Software Factors
Senior in BS	19	100	84	100	74	58	63	84	21
Graduate	39	95	44	87	82	74	54	87	5

Most students did well on basic performance questions.

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**Most students did well on basic performance questions.**

**A very high percentage of students was able to correctly identify factors that impact response time.**

**A very low percentage included software issues as factors that impact response time.**

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- IT workforce needs to grow by 175,000 a year (source: US Bureau of Labor and Statistics).
- 42,000 bachelor degrees in CS and engineering awarded in 2000 in the US and Canada.

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### 3. IT Workforce Issues.

- Computer scientists, computer engineers, system analysts, and programmers in 1998\*:
  - 67% held a BS or higher degree.
  - 33% (mostly programmers) had a 2-yr college degree or HS diploma.
  - < 50% had a bachelors or other degree with a major or minor in CS or CS-related discipline!

Many individuals without formal training are employed in IT and learn on the job!

\* source: US BLS

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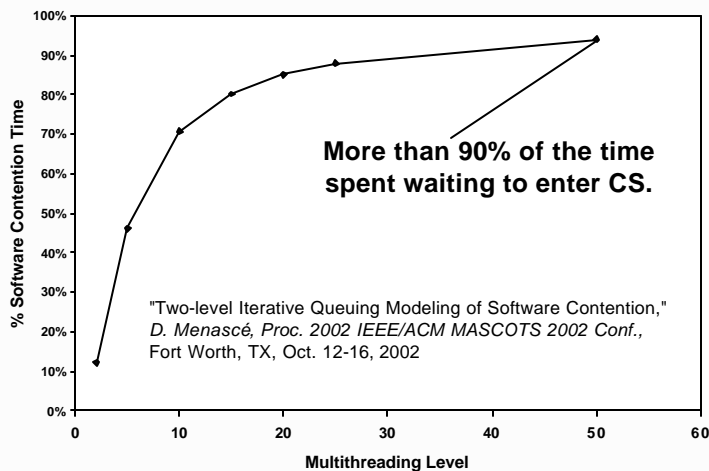
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## 4. Single-user mindset.

- Concurrency overlooked by people who write code.
  - Concurrency for physical resources.
  - Concurrency for software resources (database locks, critical sections, and software threads)

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## Where is the P in SE?

5. Small database mindset.
  - Most programmers write database access code without taking into account the size of the database.
  - Most tests are done in small development databases used to test functionality.
  - The performance of an SQL call on a DB with 1,000 rows may be significantly different than that on a DB with one million rows.

# What Can We Do?

- In education and training
  - Seamless integration of performance concepts into software engineering courses and degree programs at all levels.
- In research
  - Development of universal models and methods that can be easily used by software developers.
  - Development of QoS-aware software architectures and components.
- In industry
  - Development and adoption of integrated tools that facilitate integration of performance management and instrumentation in the software development life cycle.

# More on Research Issues

- At software design time:
  - Seamless integration of performance modeling with architecture and software design methods (e.g., performance annotation of UML designs)
    - OMG's Response to the OMG RFP for Schedulability, Performance, and Time, June'01.
    - OMG's RFP: UML Profile for Modeling QoS and Fault Tolerance Characteristics and Mechanisms, February'02.
  - Automatic generation of performance models from design specifications.

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How general? How easy to use? Is it universal?  
How do you get the parameters?