Spring 2025

CS350:
Introduction to Software Engineering

Lecture #19

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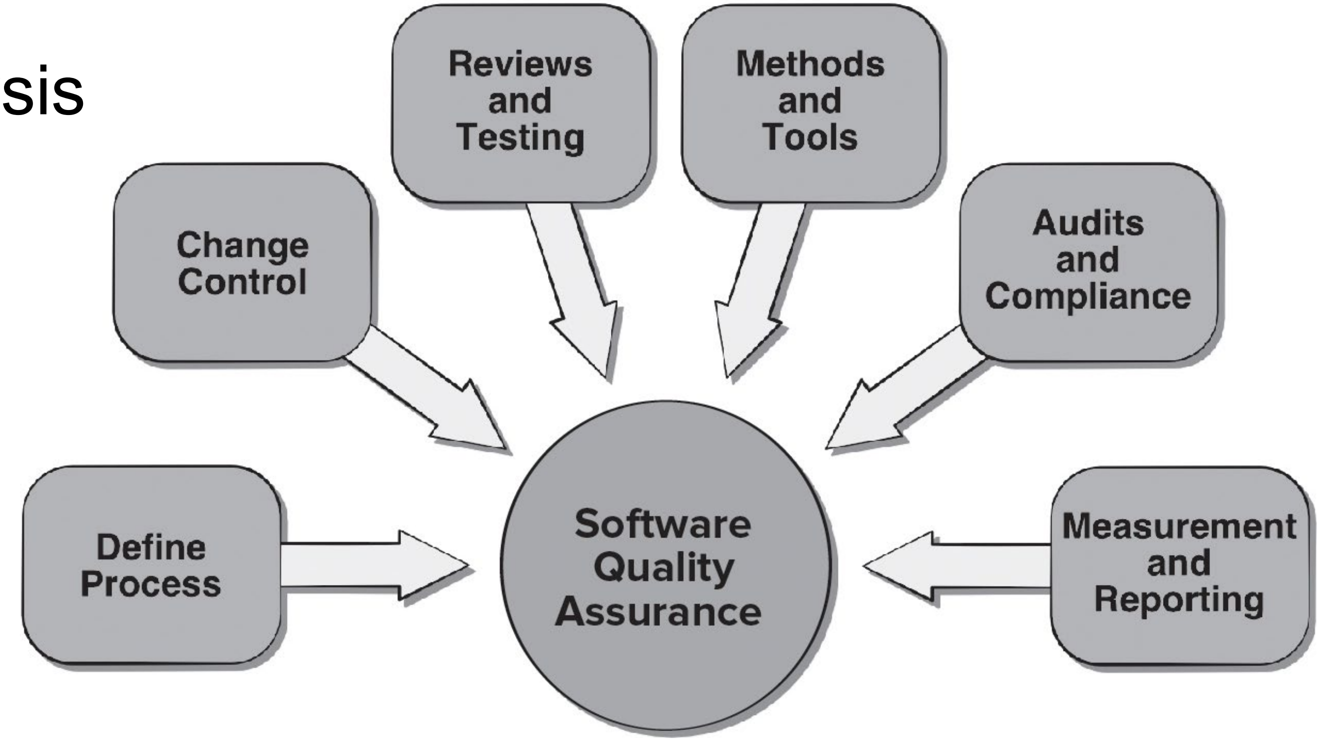
SOFTWARE QUALITY ASSURANCE

Software Quality Assurance (SQA)

Elements of SQA

- Standards
- Reviews and Audits
- Testing
- Error/defect collection and analysis
- Change management
- Education
- Vendor management
- Security management
- Safety
- Risk management



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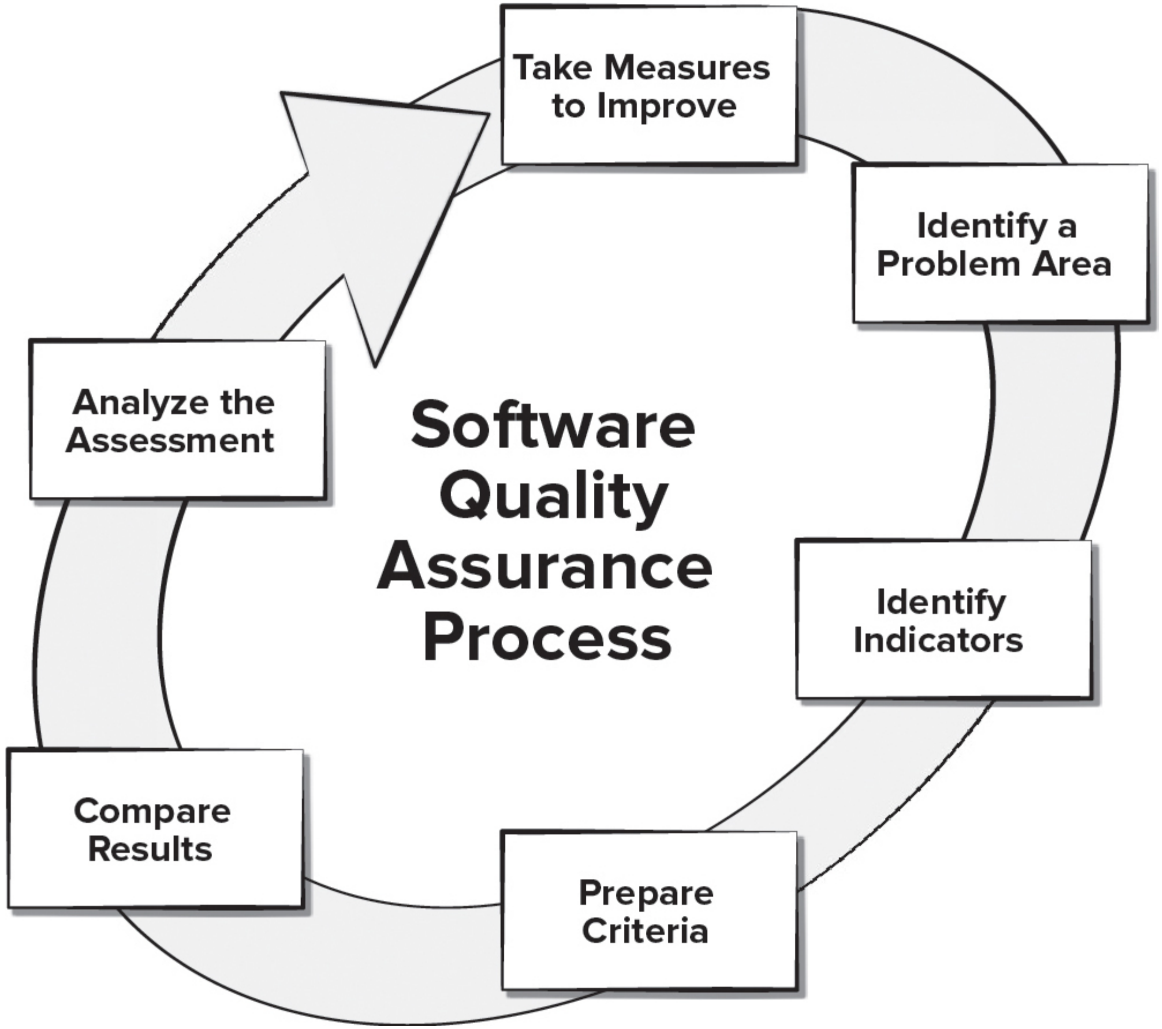
Data Driven SQA

- Modern SQA is often data driven
- Stakeholders define goals and quality measures
- Identifying problem areas → measuring indicators → making change decision
- SQA tasks are performed by an independent SQA group



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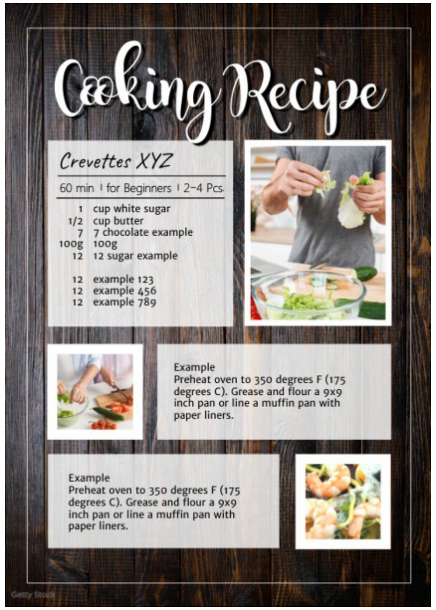
SQA Tasks (1/2)

- Prepares an **SQA plan** for a project which identifies:
  - Evaluations to be performed
  - Audits and reviews to be performed
  - Standards that are applicable to the project
  - Procedures for error reporting and tracking
  - Documents to be produced by the SQA group
  - Amount of feedback provided to the software project team
- Participates in the development of the project's software process description
  - Reviews the process description for compliance with organizational policy, internal software standards, externally imposed standards (e.g., ISO-9001), and other parts of the software project plan

https://www.tangylife.com/blog/best-baking-measuring-tools/



1	cup white sugar
1/2	cup butter
7	7 chocolate example
100g	100g
12	12 sugar example
12	example 123
12	example 456
12	example 789

Example
Preheat oven to 350 degrees F (175 degrees C). Grease and flour a 9x9 inch pan or line a muffin pan with paper liners.

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https://www.postermywall.com/index.php/posterbuilder/copy/60eaad5688764f4ce14f3e157127bd02

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SQA Tasks (2/2)

https://www.koreatimes.co.kr/www/nation/2018/06/617_202747.html

- Reviews software engineering activities to verify compliance with the defined software process
  - Identifies, documents, and tracks deviations from the process and verifies that corrections have been made
- Audits designated software work products to verify compliance with those defined as part of the software process
  - Reviews selected work products; identifies, documents, and tracks deviations; verifies that corrections have been made
  - Periodically reports the results of its work to the project manager
- Ensures that deviations in software work and work products are documented and handled according to a documented procedure
- Records any noncompliance and reports to senior management
  - Noncompliance items are tracked until they are resolved

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SQA Goals

- **Requirements quality**. The correctness, completeness, and consistency of the requirements model will have a strong influence on the quality of all work products
- **Design quality**. To ensure that it exhibits high quality and that the design itself conforms to requirements
- **Code quality**. Source code and related work products must conform to local coding standards and exhibit characteristics that will facilitate maintainability
- **Quality control effectiveness**. A software team should apply limited resources in a way that has the highest likelihood of achieving a high quality result

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Formal SQA

- Assumes that a rigorous syntax and semantics can be defined for every programming language
- Allows the use of a rigorous approach to the specification of software requirements
- Applies mathematical proof of correctness techniques to demonstrate that a program conforms to its specification

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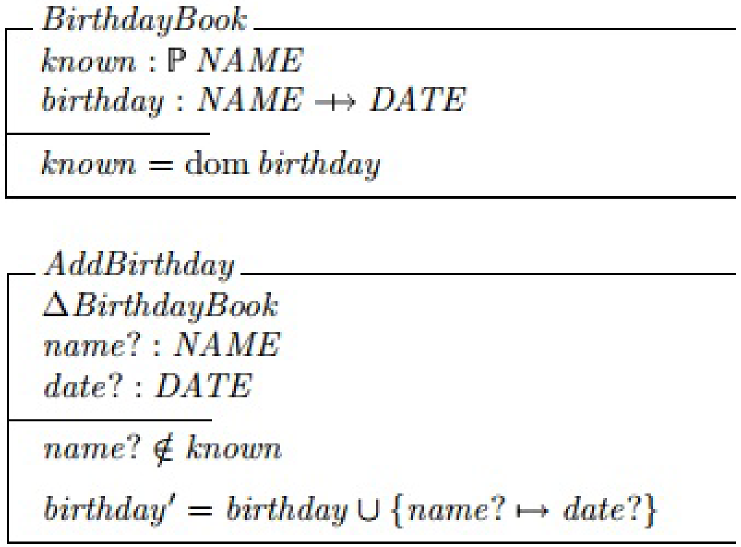


BirthdayBook

$known : \mathbb{P}\ NAME$

$birthday : NAME \nrightarrow DATE$

$known = \mathrm{dom}\ birthday$

AddBirthday

$\Delta BirthdayBook$

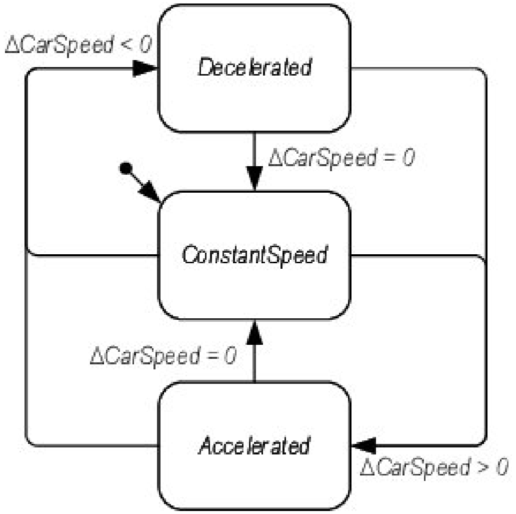
$name? : NAME$

$date? : DATE$

$name? \notin known$

$birthday' = birthday \cup \{name? \mapsto date?\}$

https://www.neverletdown.net/2009/01/thoughts-on-formal-methods-in-software.html



https://www.researchgate.net/publication/265628720_Using_Task_Analytic_Behavior_Modeling_Erroneous_Human_Behavior_Generation_and_Formal_Methods_to_Evaluate_the_Role_of_Human-automation_Interaction_in_System_Failure/figures?lo=1

Statistical SQA

1. Collect and categorize information about software errors and defects
2. Trace each error and defect to its underlying cause (e.g., design error, violation of standards, non-conformance to specifications, poor communication with the customer)
3. Using the Pareto principle (80 percent of the defects can be traced to 20 percent of all possible causes), isolate the 20 percent (the vital few)
4. Correct the problems that caused the errors and defects

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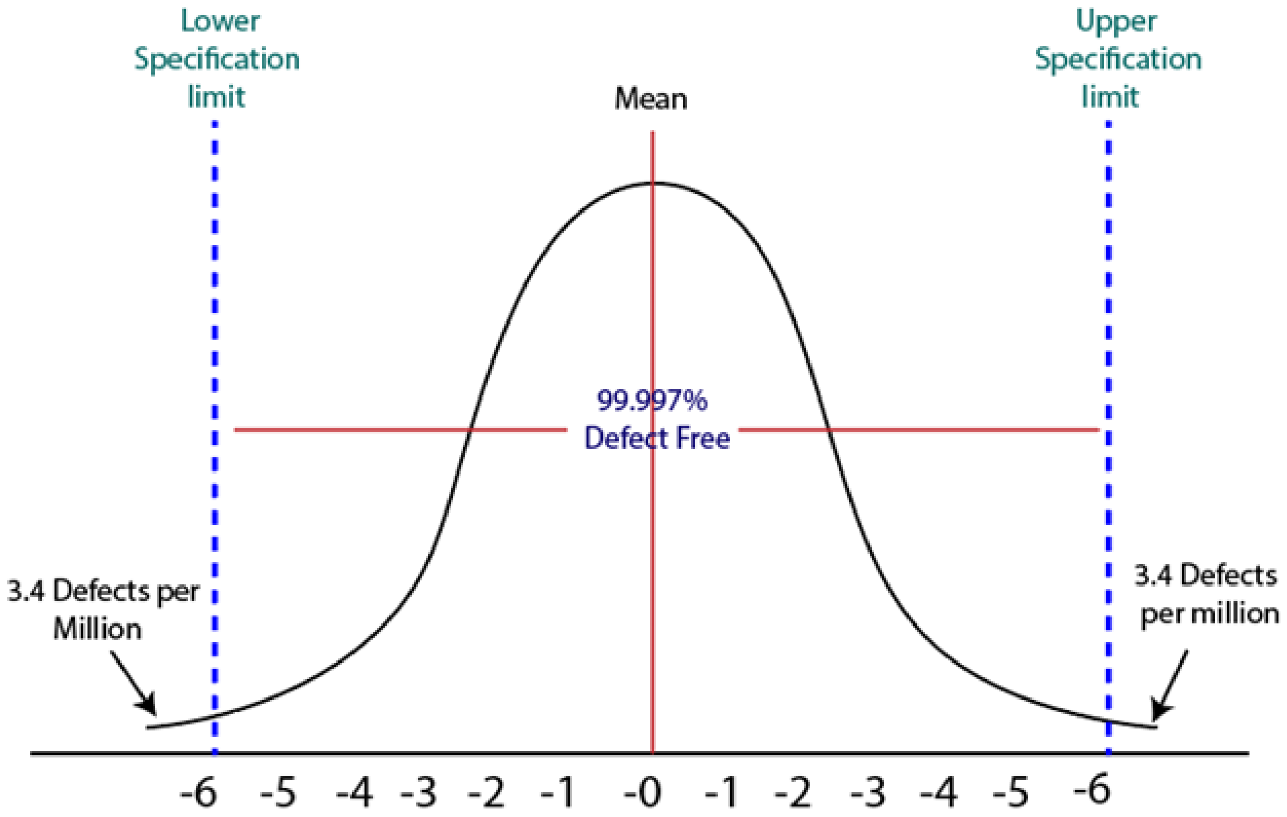
Six Sigma for Software Engineering (1/3)

- The term “six sigma” is derived from six standard deviations from the mean – 3.4 instances (defects) per million occurrences - implying an extremely high quality standard



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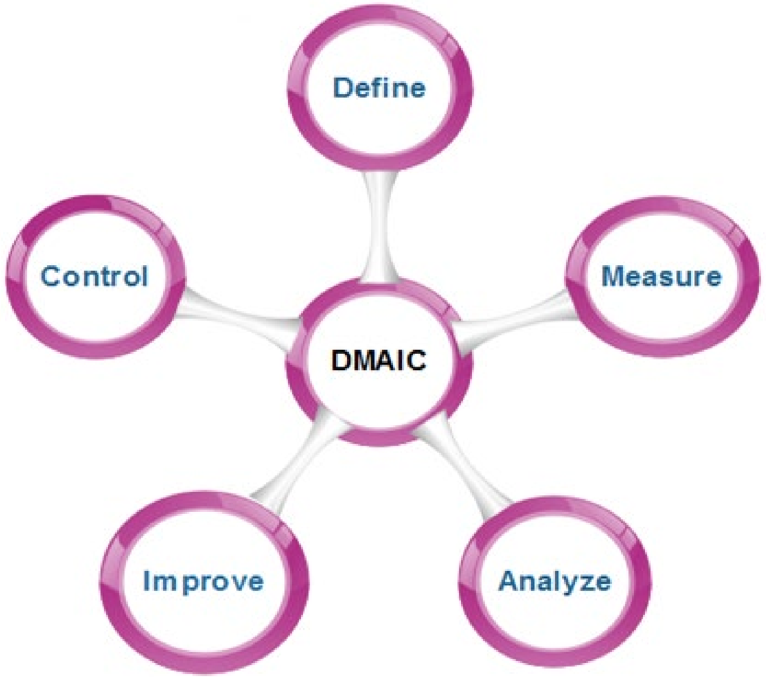
https://www.javatpoint.com/software-engineering-six-sigma

Six Sigma for Software Engineering (2/3)

- The three cores steps:
  - Define customer requirements and deliverables and project goals via well-defined methods of customer communication
  - Measure the existing process and its output to determine current quality performance (collect defect metrics)
  - Analyze defect metrics and determine the vital few causes



https://www.javatpoint.com/software-engineering-six-sigma

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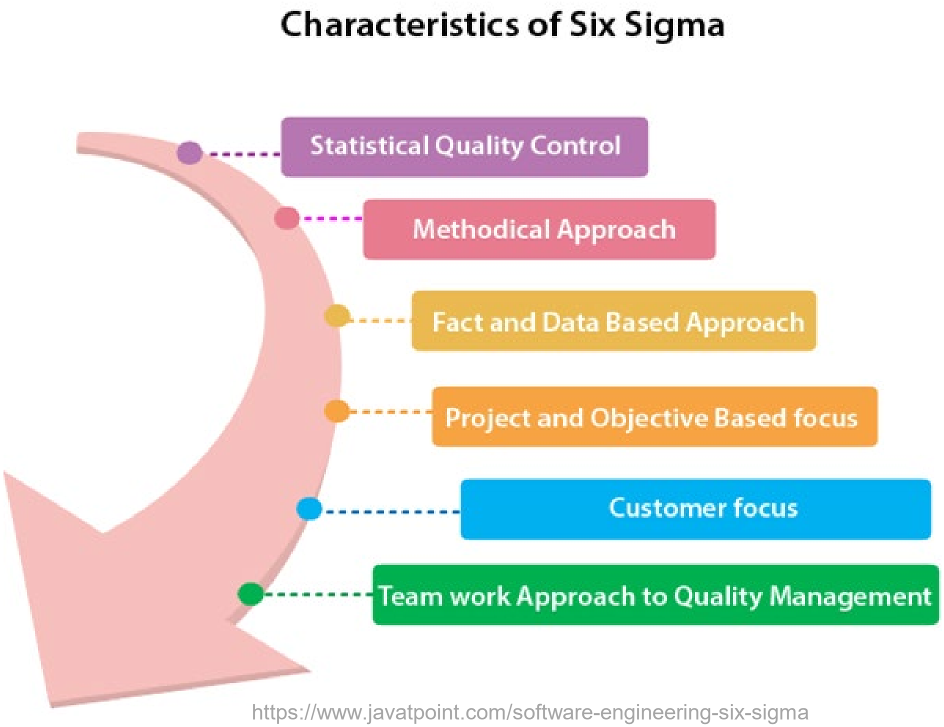
Six Sigma for Software Engineering (2/2)

- For an existing process the needs improvement:
  - Improve the process by eliminating the root causes of defects
  - Control the process to ensure that future work does not reintroduce the causes of defects
- For a new process being developed:
  - Design the process to: (1) avoid the root causes of defects and (2) to meet customer requirements
  - Verify that the process model will, in fact, avoid defects and meet customer requirements


Characteristics of Six Sigma
Statistical Quality Control
Methodical Approach
Fact and Data Based Approach
Project and Objective Based focus
Customer focus
Team work Approach to Quality Management

https://www.javatpoint.com/software-engineering-six-sigma

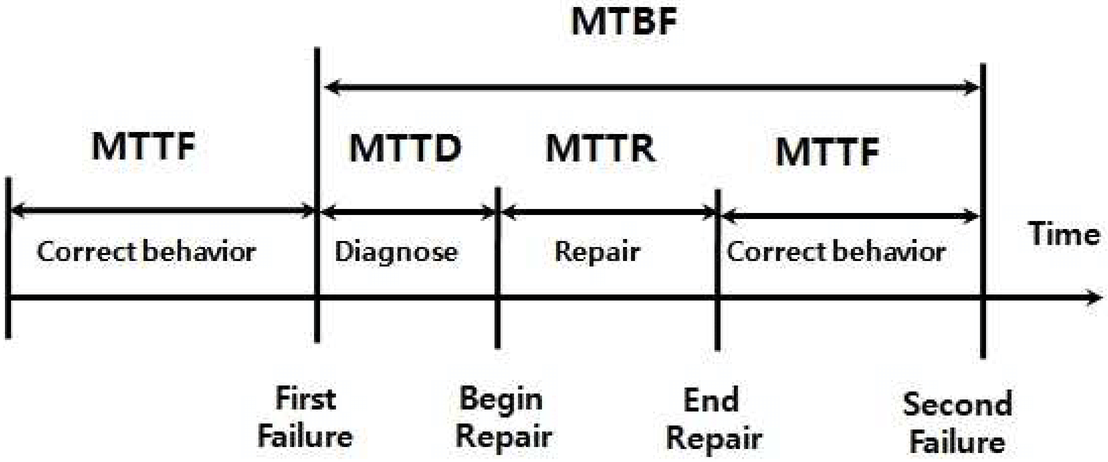
[PrMa20]

Software Reliability and Availability

- A simple measure of reliability is *mean-time-between-failure* (MTBF):

MTBF = MTTF + MTTR

  - MTTF: *mean-time-to-failure*
  - MTTR: *mean-time-to-repair*



Woo, Seongwoo. (2020). Modern Definitions in Reliability Engineering. 10.1007/978-981-13-7236-0_3.

- *Software availability* is the probability that a program is operating according to requirements at a given point in time and is defined as

Availability = (MTTF / MTBF) × 100%

[PrMa20]

AI and Reliability Models

- Software reliability is the probability of failure-free software operation for a specified time period in a specified environment
- Bayesian inference can be used to estimate probabilistic quantities using historic data even when some of the information is missing
- Predictive data analytics tools such as a regression model can be used to estimate where and what types of defects might occur in future prototypes
- Genetic algorithms can be used to grow reliability models by discovering relationships using historic system data to predict future software component failures

[PrMa20]

Software Safety

- Software safety is a SQA activity that focuses on the identification and assessment of potential hazards that may affect software negatively and cause an entire system to fail
- If hazards can be identified early in the software process, software design features can be specified that will either eliminate or control potential hazards

[PrMa20]

ISO 9001:2015 Standard

- ISO 9001:2015 is the quality assurance standard that applies to software engineering
- The requirements delineated by ISO 9001:
  - Management responsibility, quality system, contract review, design control, document and data control, product identification and traceability, process control, inspection and testing, corrective and preventive action, control of quality records, internal quality audits, training, servicing, and statistical techniques
- For an organization to become registered to ISO 9001, it must establish procedures to address each of the requirements listed and able to demonstrate these policies and being followed

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IEEE Std 730 – Software Quality Assurance Plans (SQAP)

https://ieeexplore.ieee.org/document/1040117

1) Purpose
2) Reference documents
3) Management
4) Documentation
5) Standards, practices, conventions, and metrics
6) Software reviews
7) Test
8) Problem reporting and corrective action
9) Tools, techniques, and methodologies
10) Media control
11) Supplier control
12) Records collection, maintenance, and retention
13) Training
14) Risk management
15) Glossary
16) SQAP change procedure and history

QUESTIONS?