Statistical Process Control for Software

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Topics

• Introduction
• Statistical Thinking and Process Thinking
• Understanding Variation
• Control Charts
• Software Example
• 10 Steps to Get Started and FAQs
Process Thinking

Focus on the processes to improve quality and productivity

Managers must focus on fixing processes, not blaming people

Management action uses data from the process to guide decisions

Recognize that variation is present in all processes and that it is an opportunity for improvement
Statistical Thinking

• Fundamental axioms

  – all work is a series of interconnected processes

  – all processes are variable

  – understanding variation is the basis for management by fact and systematic improvement

Separation of signal from noise requires rigorous analysis procedures. This allows inferences to be drawn to guide decisions and actions.
Understanding Variation

• “While every process displays variation, some processes display controlled variation, while others display uncontrolled variation.”
  - Walter Shewhart

• Common cause or “controlled” variation - due to normal or inherent activities among the process components

• Assignable cause or “uncontrolled” variation - due to anomalies in the process

• \textit{total variation} = \textit{common cause variation} + \textit{assignable cause variation}
Process Behavior—Variation and Stability

Variation = process noise + process anomalies

Stable process = Controlled process
Stability

• *Is the process that we are managing behaving predictably?*

• Stable process = process in statistical control

  = sources of variability
due to common causes
The Concept of Controlled Variation

Frequency of Measured Values

Variation in Measured Values

time

Source: Adapted from Understanding Statistical Process Control, Wheeler & Chambers
The Concept of Uncontrolled Variation

Source: Adapted from Understanding Statistical Process Control, Wheeler & Chambers
A phenomenon will be said to be controlled when, through the use of past experience, we can predict, at least within limits, how the phenomenon may be expected to vary in the future.

Walter A. Shewhart, 1931
Why SPC for Software Development?

• To understand the “reliability” of human processes

• To establish bounds on management expectations

• To understand patterns and causes of variations

• To validate metric analysis used to forecast and plan

Control Charts - 1

- Upper Control Limit (UCL)
- Lower Control Limit (LCL)

Specification Limits

Limits

Control Limits → Determined by Process Performance Measurements (Voice of the process)

Specification Limits → Set by customer, engineer, etc. (Voice of the customer)
Control Charts - 2

Inspection Process Performance

Defects Per KLOC

UCL

Voice of the Process

LCL

Time
Why Control Charts?

• Control charts let you know what your processes can do, so that you can set achievable goals.

• They represent the “voice of the process.”

• Control charts provide the evidence of stability that justifies predicting process performance.
Detecting Instabilities and Out-of-Control Situations - 1

- To test for instabilities in processes, we examine control charts for instances and patterns that signal nonrandom behavior.

- Values falling outside the control limits and unusual patterns within the running record suggest that assignable causes exist.
Detecting Instabilities and Out-of-Control Situations - 2

• Test 1: A single point falls outside the 3-sigma control limits.

• Test 2: At least two of three successive values fall on the same side of, and more than two sigma units away from, the center line.

• Test 3: At least four out of five successive values fall on the same side of, and more than one sigma unit away from, the center line.

• Test 4: At least eight successive values fall on the same side of the center line.

Source: Western Electric Handbook
Detecting Instabilities and Out-of-Control Situations - 3

Test 1: Single point outside of zone C

Test 2: 2 out of three beyond zone B

Test 3: 4 out of 5 signals in zone B

Test 4: 8 successive points on same side of centerline
An Example Process in Statistical Control

Source: Adapted from *Understanding Statistical Process Control*, Wheeler & Chambers
X-Bar and Range Charts for a Process that Is In Control

Source: Adapted from Understanding Statistical Process Control, Wheeler & Chambers
An Example Out-of-Control Process

Source: Adapted from *Understanding Statistical Process Control*, Wheeler & Chambers
X-Bar and Range Charts for a Process that Is Out of Control

Source: Adapted from *Understanding Statistical Process Control*, Wheeler & Chambers
Example: Summary of Defect Types Found During Component Inspections

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Xm R Charts for the Total Number of Defects Found in Component Inspections

Control Charts for Individual Defect Types

Revised Control Charts for Each of the Defect Types
Improved Process-Reduction in Defect Insertion

Evaluating Process Performance

1. Clarify business goals and strategy
2. Identify and prioritize issues
3. Select and define measures
4. Measure process performance
   - Is process stable?
     - Yes
     - Is process capable?
       - Yes
       - Continual improvement
       - Change process
       - Remove assignable causes
     - No
   - No
5. New issues?
   - Yes
   - New goals, strategy?
     - Yes
     - New measures?
       - Yes
       - Continual improvement
       - Change process
       - Remove assignable causes
     - No
   - New measures?
     - Yes
     - New goals, strategy?
       - Yes
       - New measures?
         - Yes
         - Continual improvement
         - Change process
         - Remove assignable causes
       - No
       - New measures?
         - Yes
         - New goals, strategy?
           - Yes
           - New measures?
             - Yes
             - Continual improvement
             - Change process
             - Remove assignable causes
           - No
           - New measures?
             - Yes
             - New goals, strategy?
               - Yes
               - New measures?
                 - Yes
                 - Continual improvement
                 - Change process
                 - Remove assignable causes
               - No
               - New measures?
                 - Yes
                 - New goals, strategy?
                   - Yes
                   - New measures?
                     - Yes
                     - Continual improvement
                     - Change process
                     - Remove assignable causes
                   - No
                   - New measures?
                     - Yes
                     - New goals, strategy?
                       - Yes
                       - New measures?
                         - Yes
                         - Continual improvement
                         - Change process
                         - Remove assignable causes
                       - No
                       - New measures?
                         - Yes
                         - New goals, strategy?
                           - Yes
                           - New measures?
                             - Yes
                             - Continual improvement
                             - Change process
                             - Remove assignable causes
                           - No
                           - New measures?
                             - Yes
                             - New goals, strategy?
                               - Yes
                               - New measures?
                                 - Yes
                                 - Continual improvement
                                 - Change process
                                 - Remove assignable causes
                               - No
                               - New measures?
10 Steps to Get Started - 1

1. Get familiar with SPC techniques; refer to the SEI measurement guidebook and related books and papers on SPC.
2. Obtain a SPC tool.
3. Identify process issues.
4. Identify process performance attributes.
5. Select and define measures.
6. Collect data.
7. Organize the data and ensure principles underlying SPC hold (e.g., homogeniety)
10 Steps to Get Started - 2

8. Plot/graph data.

9. Examine each plot/graph for process stability, process shifts, and assignable causes.
   (a) If process NOT STABLE, THEN:
       - cannot determine the capability of the process
       - no basis to predict outcomes
       - action: understand why the process is not stable and determine what steps can be taken to achieve stability
   (b) If process is STABLE, THEN:
       - capability of the process can be determined and used to compare future process performance
       - action: predict future performance and/or examine other process constituents

10. Run additional analysis as situation requires.