CS130 Software Engineering

Assignment 2 - Verification and Monitoring

Due Mar 9 2025 23:55pm

Problem 1

```
def process_age(age):
    if age < 0:
        return "Invalid"
    if age < 18:
        return "Minor"
    if age > 65:
        return "Senior"
    if age < 0:  # Unreachable!
        return "Error"
    return "Adult"
```

a) Write SMT formulas for each path.
b) Write one test input for each path.
c) What is the minimum set of test cases needed for 100% branch coverage?

```
# Assume input array has array size 3
def sum_until_negative(numbers):
    total = 0
    i = 0
    while i < len(numbers) and numbers[i] >= 0:
        total += numbers[i]
        i += 1
    return total
```

a) Write SMT formulas for each path.
b) Write one test input for each path.
c) What is the minimum set of test cases needed for 100% branch coverage?

```
def classify_sequence(numbers):
    if len(numbers) == 0:
        return "Empty"

    count = 0
    i = 0
    while i < len(numbers) and i < 5:  # Process at most 5 numbers
```

```
        if numbers[i] > 0:
            count += 1
        i += 1

    if count == 0:
        return "AllNonPositive"
    elif count == i:
        return "AllPositive"
    else:
        return "Mixed"
```

a) For an input array of size 3, identify major paths through the code.
b) Write SMT formulas for achieving each return value. Use predicate logic + propositional logic if needed:
- "Empty"
- "AllNonPositive"
- "AllPositive"
- "Mixed"

c) Write a python code to implement your “All Positive” SMT constraint using Z3 and solve for the answer(ref 1,2).
d) Write test inputs for each case
e) Now assume the input array has no size limit, What special cases should be tested? (Think about boundary conditions)

Problem 2

Your company runs a cloud service that processes user requests. The system monitors latency (response time in ms) and failure rate (percentage of failed requests), which follow a Poisson distribution. If these metrics exceed defined thresholds, an alert is issued.

Alerts have different severities:
- P0 (Critical): Latency > 2000ms or Failure Rate > 10%
- P1 (Major): Latency > 1000ms or Failure Rate > 5%
- P2 (Minor): Latency > 500ms or Failure Rate > 2%

Alerts must repeat notifications at:
- P0: Every 2 hours
- P1: Every 12 hours
- P2: Every 48 hours

If an alert condition resolves, it should be removed from active alerts.

Requirements
- Simulate Incoming Metrics:
    - Generate latency and failure rate data via simulation.
        - say Poisson distribution with manual tuning (to show persistent error behaviour).

        - The flaky metric can be transient (disappear in a few minutes) or persistent (last for a few days).
    - Generate new metrics every 5 minutes.
- Trigger Alerts Based on Thresholds:
    - Classify alerts as P0, P1, or P2 based on the metric values.
    - If things are getting worse, priority shall go up.
    - Priority will not downlevel.
- Notification Handling:
    - Send an initial alert notification when an issue is detected.
    - Resend unresolved alerts based on their priority timing (P0 - 2h, P1 - 12h, P2 - 48h).
    - An email shall be sent out to a team address (mock this behaviour by printing).
    - An email shall be sent out to the team's skip-level boss if not resolved in 5x of the alert active time (mock this behaviour by printing).
- Alert Resolution:
    - If this is a persistent issue, mock the resolving operations by printing some PRs are merged.
    - If a metric returns to normal, mark the alert as resolved.
- Logging & Reporting:
    - Maintain a log of active alerts with timestamps.
    - Maintain a log current system status every 5 minutes.
    - Delete stale logs after 90 days.

Sample output on a running console

```
[2025-02-23 12:00:05] Latency: 1200ms, Failure Rate: 6.2% -> P1 Alert Triggered!
[2025-02-23 14:00:05] ALERT: Resending P1 alert (Still unresolved)
[2025-02-23 16:00:05] ALERT: Resending P1 alert (Still unresolved)
……
[2025-02-25 08:00:00] INFO: Commit 3a4b6c submiited
[2025-02-25 08:05:00] INFO: Commit 3b4b6f submitted
……
[2025-02-25 10:00:05] ALERT: Resending P1 alert (Still unresolved)
……
[2025-02-26 16:05:00] INFO: Commit 3c4b6a submitted
……
[2025-02-27 12:00:05] INFO: Latency Normalized. Resolving P1 alert.
```