Extra-functional Properties of Programs

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• Examples of policies:
  – Reliability requirements
  – Timeliness requirements
    • Precision requirements
  – Power and other resources
• Neither exhaustive nor orthogonal
• Policies change in real-time
Typical Examples

- Produce the best result in this estimation loop in 2 milliseconds.
- Use sequential-TMR for attitude control for the next 3 hours.
- Run a low-overhead checker on the gyro’s output.
- You have 3 watts for entry.
- Do this in 2 milliseconds, or quit.
- If a processor or comm link fails, try again once.
Requirements

• It must be system code and operate automatically
• It must not involve the programmer
• Operates in real-time
The Extra-functional Properties

• To implement the above, the affected programs need to be able to
  – Start/stop/restart
  – Copy/reproduce
  – Move
  at arbitrary points.

• One way to achieve these properties is by writing programs that are functions.
  – But not necessarily.
How Do We Implement the System?

- Extra-functional code wraps the affected programs
- Policy implementation can take place at each function call in user’s program
Example: Reliability

• “Use sequential-TMR on acs for the next three hours.”

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Example: Reliability

\[ \text{save}(x) \]
\[ y_1 = \text{acs}(x) \parallel y_2 = \text{acs}(x) \]
\[ \text{if } y_1 == y_2 \text{ then } y_1 \]
\[ \text{else } \{ y_3 = \text{acs}((\text{retrieve}(x)) \]
\[ \text{if } y_1 == y_3 \text{ or } y_2 == y_3 \text{ then } y_3 \]
\[ \text{else fail } \}
\[ \text{release}(x) \]

Sequential-TMR(acs)

Mini-checkpoint: not part of a large, coordinated checkpoint
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Example: Timeliness

• “Get the best estimate you can in 2 ms.”
Example: Power Policy

• “You have 3 watts to do entry.”

let \( f(x) = \{ \ldots g(u) \ldots h(v) \ldots \} \)

where \( g(x) = \{ \ldots g'(\cdot) \ldots g''(\cdot) \ldots \} \)
\( h(x) = \{ \text{etc.} \} \)

\( \text{P} \) is the set of processors allocated by the system to run \( f \) and is instantiated at run-time.

This might translate into an assignment of 4 cores to function \( f \) rather than the usual 1 core.

|P| = 4 vs. 1
Summary

• *Policy-based computing* requires extra-functional properties that can apply (almost) everywhere

• The extra-functional properties of interest are
  – Start/stop/restart
  – Copy/reproduce
  – Move

• These properties are assured when the programs are functions.