Fault Injection for Failure Prediction assessment and improvement

CISUC Workshop
DEI/CISUC, September 17th, 2013

Ivano Irrera
Software and Systems Engineering group (SSE)
Faults and failures
Faults and failures
Faults and failures
Faults and failures
Online Failure Prediction

- Technique that allows predicting a failure that may occur in the near future, monitoring the system status and using past failure data.

- Methods used:
  - Machine learning, pattern recognition, ...

- Data used:
  - Numerical variables (free memory, mutexes/s, buffer length, ...)
  - Events (errors, ...)

- It can improve system dependability attributes by:
  1. Observe (monitoring)
  2. Reason (predicting a failure)
  3. React (save data, reboot, component hot-swap, ...)

17/09/2013
Failures are rare events!
...and must come from the target system

It is hard to:
- train a predictor in short time
- optimize the predictor
- evaluate different failure prediction algorithms
- adapt a predictor when the system changes

17/09/2013
Software fault injection

if ( a==3 && b==4 ) {
    do something
}

if ( a==3 && b==4 ) {
    do something
}

cmp dword ptr off_a[ebp],3
jne short ahead
cmp dword ptr off_b[ebp],4
jne short ahead
; ... do something ...
ahead:
...

; remaining prog. code

cmp dword ptr off_a[ebp],3
jne short ahead
cmp dword ptr off_b[ebp],4
nop
nop
nop
; ... do something ...
ahead:
...
Ph.D. thesis proposal

- **Improve** the usage of Failure Prediction, by using **software fault injection** technique, to:
  - **Build** and **optimize** failure predictors
  - **Benchmark** different failure prediction techniques
  - **Continuously train** predictors

- Our final goal is to spot the **advantages** and the **limitations** of using **fault injection** for promoting Failure Prediction usage

17/09/2013
Ph.D. outline

- **Variable selection based on fault injection**
  - identify the best variable to predict failures

- **Benchmark for failure prediction methods**
  - a rigorous approach to evaluate different failure predictors

- **Adaptive Failure Prediction framework**
  - for using failure prediction in evolving systems (e.g.: web-servers)

- **Other:**
  - new failure prediction algorithms
  - virtualization as a sandboxing solution for generating failure data

17/09/2013
Variable selection

- **Inject** software faults to
  - identify symptoms of incoming failures in a set of variables
  - rank each monitored variables, on the basis of the correlation between symptoms and the failures occurred

17/09/2013
Variable selection

- **Inject** software **faults** to
  - identify symptoms of incoming failures in a set of variables
  - rank each monitored variables, on the basis of the correlation between symptoms and the failures occurred

![Diagram showing system variables with red dots indicating high correlation areas.](image-url)
A Benchmark for Failure Prediction Algorithms

- **A rigorous** approach to choose a predictor, to be implemented on the target system.

- The proposed benchmark makes use of **virtualization**, for generating failures without influencing the target:
  - the system (or a part) is copied into a virtual machine.
Adaptive Failure Prediction framework (ongoing work)

- **Real systems are dynamic**
  - Updates/patches, upgrades, workload changes, ...
  
- The predictor is optimized for a given system configuration -> **re-train**
  
- **Re-train** needs **failure data**, and a **sandbox** for injecting faults
  
- A **framework** for adapting failure prediction in evolving software systems using **fault injection** and **virtualization**
  
- At the present time, we are defining and implementing the framework:
  - XEN hypervisor running an Apache Tomcat webserver + TPC-W workload

17/09/2013
Open issues

- Study the **representativeness** of the failures generated
  - can the faults injected cause realistic failures?

- Study different **sandbox** solutions to generate failure data
  - and how to replicate the workload of the original system

- Define **failure prediction + fault injection frameworks** for different kinds of systems
  - personal computers, clusters/clouds, ...
Questions?

Ivano Irrera
Department of Informatics Engineering
University of Coimbra
ivano@dei.uc.pt