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Collecting, Analyzing and Archiving Results from Fault Injection Experiments

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Outline

Statement of the Problem

- The Context
- Experimental Data and User Viewpoint
- Managing Experiment Outcomes
- Concluding Remarks



Output Domain: Experiment Data

- Evaluation of the coverage of FT mechanisms and of failure modes
- Detailed examination of the observation and analysis of experimental outcomes
- Developer vs. End-user viewpoints
- Experimentation: tedious, often costly, time-consuming exercise
- How to enhance result usage:

--> Try to get the most out of it! ©

About Fault Injection Research

- Target System: an "ever moving target"
- Assessment of a fault-tolerant system and of its FT algorithms & mechanisms
- Dependability Benchmarking: Fair and reproducible comparison of systems and components wrt Dependability features
- —> Disclosure of procedure and results Repeat experiments for confirmation

The AMBER project Data Repository

Experimental Data and User Viewpoint

Weighting of Experimental Results

Ordering and Severity of the Observed Outcomes

Conducting a FI experiment (1/2)

Clustering of data

Target System



<u>Module</u>	1	2	3	Total/Avge
# Faults	150	150	150	450
# Detections	100	110	140	350
Coverage (%)	67	73	93	78

Conducting a FI experiment (2/2)

Clustering of data

Target System



Fault Type	MFC	MIFS	WEC	Total/Avge
# Faults	252	145	53	450
# Detections	198	125	27	350
Coverage (%)	79	86	51	78

Weighting of Experimental Results

Clustering of data

Target System



<u>Module</u>	1	2	3	Total
Failure rate = λ_i (h ⁻¹)	80 10 ⁻⁶	15 10 ⁻⁶	5 10 ⁻⁶	10 ⁻⁴
$P\{fault\} = pf_i (\%)$	100	110	140	100

 $C_D = \sum C_{DMi} \times pf_{Mi} = 69\%$

 $pf_i = \lambda_i / \sum \lambda_i$

Arlat & Moraes

Ordering & Severity of Outcomes (1/2)



Ordering & Severity of Outcomes (2/2)

	Notification		WL Failure		First	Priority to		
	EC	XC	WA	WI	event?	1st event	Notif.	Failure
1	0	0	0	0	N/A	N/A	N/A	N/A
2	1	0	0	0	EC	D	D	D
3	0	0	0	1	WI	F	F	F
4	1	0	0	1	EC	D	D	F
5	0	1	0	1	WI	F	D	F
6	0	0	1	1	WI	F	F	F
7	1	1	0	0	EC	D	D	D
8	1	0	1	0	EC	D	D	F

EC: Error Code **WA:** WL Aborted XC: Exception

WI: WL Incorrect

4: Detection, then Failure 5: Failure prior to Detection

Ordering & Severity of Outcomes (2/2)

End-user Viewpoint

	Notification		WL Failure		First	Priority to		
	EC	XC	WA	WI	event?	1st event	Notif.	Failure
1	0	0	0	0	N/A	N/A	N/A	N/A
2	1	0	0	0	EC	D	D	D
3	0	0	0	1	WI	F	F	F
4	1	0	0	1	EC	D	D	F
5	0	1	0	1	WI	F	D	F
6	0	0	1	1	WI	F	F	F
7	1	1	0	0	EC	D	D	D
8	1	0	1	0	EC	D	D	F

EC: Error Code WA: WL Aborted **XC:** Exception

WI: WL Incorrect

Safety Responsiveness

Managing Experimental Outcomes

Planning the Experiments

Collecting the Outcomes

Planning the Experiments

- Fault Injection Experiments = Controled Experimentation
- Interplay between Input and Output Domains



About Data and Timing Measurements

Timing measurement usually quite demanding

Accuracy vs. intrusiveness [Freeze clock!]



Concluding Remarks

- Experiment data repository (e.g., AMBER) very much useful and probably a "must"
- Perennial management: community, professional Societies,...?
- Raw data should be documented to make it parsable and exploitable by end-users
- Sharing data via relational database
 —> better analysis, manipulation & updating
- From: "I have the feeling that it is (resp. not) working well"
 - To: "I have evidence that it is (resp. not) working well"

The Way Forward

Combining Analytical and Empirical Approaches



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