Large-scale Combinatorial Testing with Adobe

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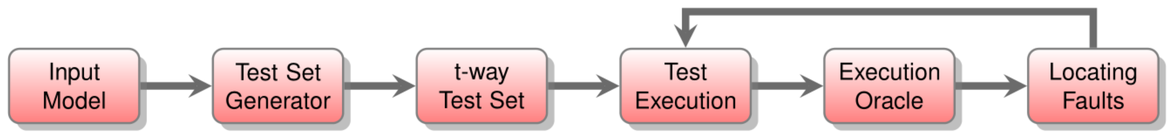
MATRIS

Combinatorial Testing

Combinatorial Testing

- Combinatorial Testing allows for efficient testing of large systems while maintaining certain coverage guarantees.
- In a combinatorial test set, every t-way interaction appears in at least one tests, where t is called the strength of the test set.
- Studies have shown that the majority of faults can be detected with combinatorial test sets of strength $t \leq 6$.



Challenges for Large-scale Combinatorial Testing:

- Modelling of the system under test.
- Construction of reasonably small combinatorial test sets for systems with a large number of parameters is a difficult optimization problem.
- Sufficient Input Bandwidth necessary.

Generation of Large Combinatorial Test Sets

Greedy test set generation with CAgen:

- Generate test sets with a small number of rows with the FIPOG algorithm
- Significantly faster generation than other state of the art tools

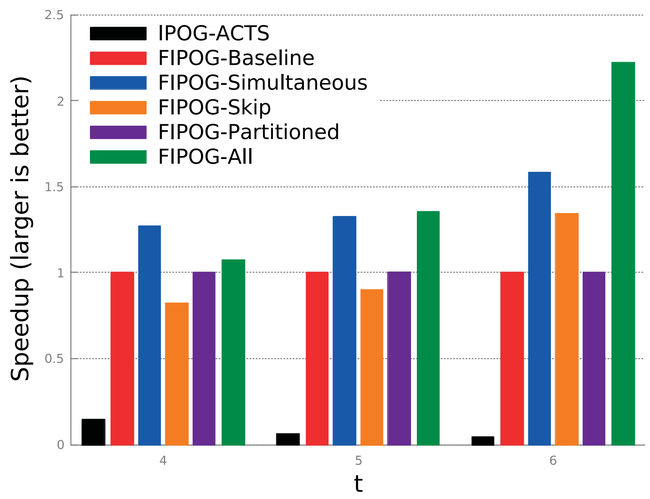


Figure 1: Speedup of CAgen compared to the state-of-the-art tool ACTS

- However: For the generation of combinatorial test sets for large systems, using greedy algorithms is no longer feasible.

Roux-type construction:

- Covering Arrays (CAs) are the mathematical structure underlying combinatorial test sets.
- Doubles the number of columns of a given CA.
- Concatenates permutations of CAs of lower strength to ensure coverage of all t-way interactions.

$$\mathsf{E}_1 = \begin{pmatrix} \mathsf{A} \\ \mathsf{A} \end{pmatrix},$$

$$\mathsf{E}_2 = \begin{pmatrix} \mathsf{B} & \mathsf{B} & \cdots & \mathsf{B} \\ \mathsf{B}^{\pi^1} & \mathsf{B}^{\pi^2} & \cdots & \mathsf{B}^{\pi^{v-1}} \end{pmatrix},$$

$$\mathsf{E}_3 = \begin{pmatrix} \mathsf{C} & \mathsf{C} & \cdots & \mathsf{C} & \mathsf{C}^{f_1} & \mathsf{C}^{f_2} & \cdots & \mathsf{C}^{f_{N_1}} \\ \mathsf{C}^{f_1} & \mathsf{C}^{f_2} & \cdots & \mathsf{C}^{f_{N_1}} & \mathsf{C} & \mathsf{C} & \cdots & \mathsf{C} \end{pmatrix},$$

$$\mathsf{E}_4 = \begin{pmatrix} \mathsf{C} & \mathsf{C} & \cdots & \mathsf{C} & \mathsf{C}^{g_{1,2}} & \mathsf{C}^{g_{1,3}} & \cdots & \mathsf{C}^{g_{v,v-1}} \\ \mathsf{C}^{g_{1,2}} & \mathsf{C}^{g_{1,3}} & \cdots & \mathsf{C}^{g_{v,v-1}} & \mathsf{C} & \mathsf{C} & \cdots & \mathsf{C} \end{pmatrix},$$

$$\mathsf{E}_5 = \begin{pmatrix} \mathsf{C} & \mathsf{C} & \cdots & \mathsf{C} & \mathsf{C}^{\tilde{g}_{1,2}} & \mathsf{C}^{\tilde{g}_{1,3}} & \cdots & \mathsf{C}^{\tilde{g}_{v,v-1}} \\ \mathsf{C}^{\tilde{g}_{1,2}} & \mathsf{C}^{\tilde{g}_{1,3}} & \cdots & \mathsf{C}^{\tilde{g}_{v,v-1}} & \mathsf{C} & \mathsf{C} & \cdots & \mathsf{C} \end{pmatrix},$$

$$\mathsf{E}_6 = \begin{pmatrix} \mathsf{C} & \mathsf{C} & \cdots & \mathsf{C} & \mathsf{C}^{h_{1,2}} & \mathsf{C}^{h_{1,3}} & \cdots & \mathsf{C}^{h_{v,v-1}} \\ \mathsf{C}^{h_{1,2}} & \mathsf{C}^{h_{1,3}} & \cdots & \mathsf{C}^{h_{v,v-1}} & \mathsf{C} & \mathsf{C} & \cdots & \mathsf{C} \end{pmatrix}.$$

Two-stage approach:

- Combines greedy methods with a mathematical doubling construction.
- CAgen generates seed arrays with as many columns as possible.
- Roux-type construction extends the seed arrays to the desired combinatorial test sets.

Large-scale Combinatorial Testing at Adobe

- Collaboration with Adobe.
- Application of largest combinatorial test sets documented in research.
- We generated test sets for models with more than 2000 parameters and 10 values:

N	t	k	v
6337	4	2127	3
107514	5	2127	3
87669	5	2127	3
322	2	2127	7
7439	3	2127	7
688	2	2127	10
23422	3	2127	10

Adobe

Adobe Analytics

Testing Results

- New faults found in each subject system.

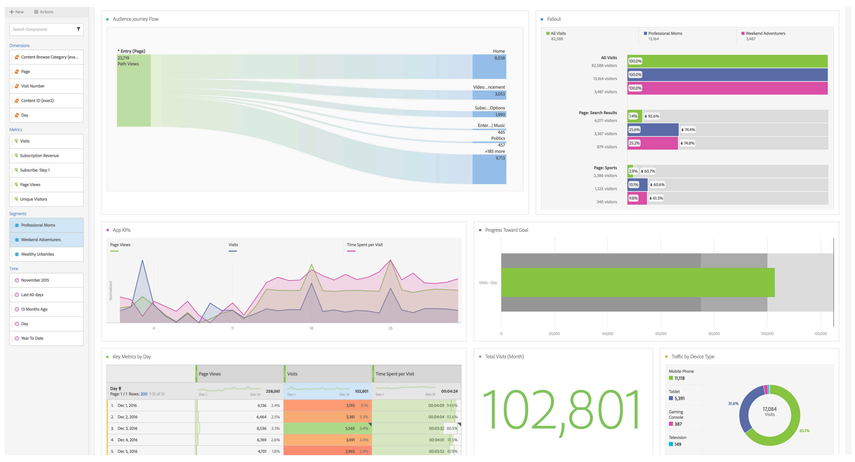


Table I. REZZER FAULTS DETECTED BY COMBINATORIAL TESTING

Fault Descriptions, Causes, and Resolutions		
Description	***Cause***	***Resolution***
Flag-type fields throw error	Undocumented value constraint	Update input space model
Event-type fields throw error	Undocumented format constraint	Update input space model
Parser throws error (CDS)	Undocumented value constraint	Update input space model
Parser throws error (JSON)	Undocumented format constraint	Add input validation
Invalid date fields interaction	Undocumented value constraint	Update input space model

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FWF Der Wissenschaftsfonds.
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