Combinatorial sequences for the generation of crisis exercises

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Scenarios for crisis exercises

The effects of crisis events on a system are dependent on certain parameters, such as the order in which they appear, with specific sequences of events even potentially leading to critical failures.

In order to evaluate a systems resilience against crises, it is therefore imperative to examine and train as many different sequences of crisis events as possible within scenarios as part of exercises.

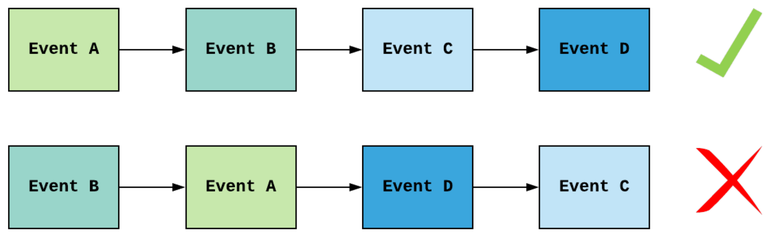


Figure 1: Two different sequences of events.

Goals of crisis exercises

- Planning of ressource requirements, allocation and distribution.
- Identification of critical scenarios.
- Development and evaluation of relief strategies.
- Training and preparation of emergency personnel for actual crises.

Combinatorial framework for crisis exercises

We present a general conceptual modelling- and scenario generation framework based on methods from discrete mathematics used for the **automated generation of crisis exercises**.

- Combinatorial sequence structures provide broad range of modelling capabilities to exercise designers.
- Exercises generated using combinatorial methods satisfy different notions of combinatorial sequence coverage and thus enable the detection of sequence specific errors and vulnerabilities.
- Applicable to man-made and non-man-made crises.

Methodology

- Identification of suitable crisis events by domain experts.
- Selection of desired scenario and exercise characteristics.
- Selection of appropriate class of sequence structures satisfying all required properties, e.g. *Sequence Covering Arrays* (SCAs).
- Automated generation of a combinatorial sequence structure based on the previous selection.
- The elements of the structure define the **scenarios** of the exercise.
- Carry out the scenarios within a crisis management exercise.

Framework

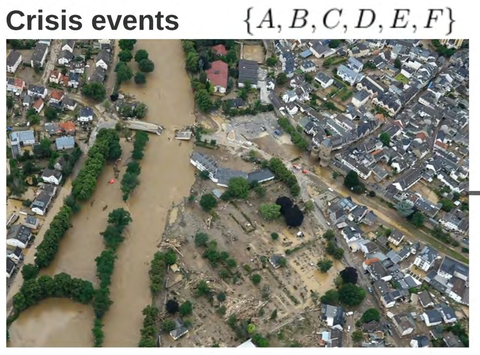
Linking the two domains

Disaster exercise domain	Combinatorial sequence testing domain
Exercise	Sequence test set (i.e., SCA of strength t or t-way sequence test set with constraints)
Exercise complexity	Strength t
Scenario	Element in sequence test set
Scenario length	Length of test sequence
Story	t-way permutation or target sequence of length t
Events	Event symbols
Multiplicities of events in scenarios	Repetition of event symbols in sequences by constraints
Constraints between events	Constraints between event symbols

Combinatorial generation of scenarios

Scenarios	Sequences					
Scenario 1	A	B	C	D	E	F
Scenario 2	D	A	F	C	E	B
Scenario 3	B	D	E	A	C	F
Scenario 4	E	D	B	F	C	A
Scenario 5	E	C	A	F	B	D
Scenario 6	C	B	F	E	A	D
Scenario 7	F	A	E	D	B	C
Scenario 8	F	C	D	B	A	E

Crisis events $\{A, B, C, D, E, F\}$



Crisis exercise

Figure 2: Generation of crisis scenarios via SCAs.

Future work

- Practical evaluation of the proposed approach for different types of exercises (Planspiele, drills, . . .) for man-made as well as non-man-made disasters.
- Broadening, extending and strengthening the employed combinatorial structures to accommodate additional scenario requirements (e.g. interdependencies and constraints of events, prioritisation of scenarios).
- Using combinatorially generated scenarios as input to simulations.
- Integration of precise coverage guarantees provided by different notions of combinatorial sequence coverage into general vulnerablility, risk and impact analysis assessments of crisis threats.

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