Anatomy of an Efficient Minimal Cutsets Solver: the XFTA calculation engine

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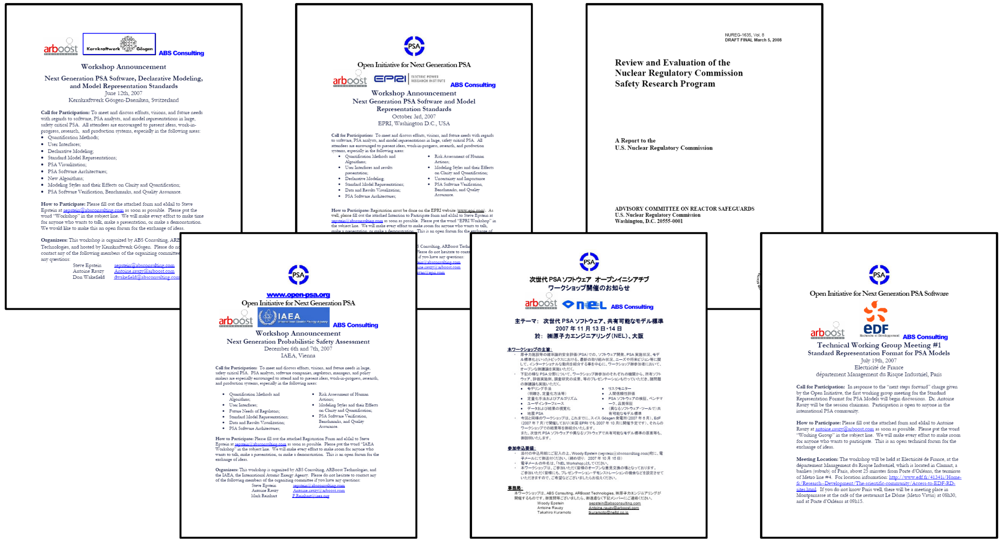
The Open-PSA Initiative

An Open and Transparent Public Forum to

- Disseminate information
- Independently review new ideas
- To develop better methods and software
  - Enhance quality and understanding
  - Encourage peer review
  - Allow transportability of models and methods
  - Define issues to be resolved



Workshop Announcement
Next Generation PSA Software, Declarative Modeling, and Model Representation Standards
June 12th, 2007
Kernkraftwerk Gösgen-Daeniken, Switzerland

Open Initiative for Next Generation PSA
Workshop Announcement
Next Generation PSA Software and Model Representation Standards
October 3rd, 2007
EPRI, Washington D.C., USA

NUREG-1635, Vol. 8
DRAFT FINAL March 5, 2008
Review and Evaluation of the Nuclear Regulatory Commission Safety Research Program
A Report to the U.S. Nuclear Regulatory Commission
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

www.open-psa.org
Open Initiative for Next Generation PSA
Workshop Announcement
Next Generation Probabilistic Safety Assessment
December 6th and 7th, 2007
IAEA, Vienna

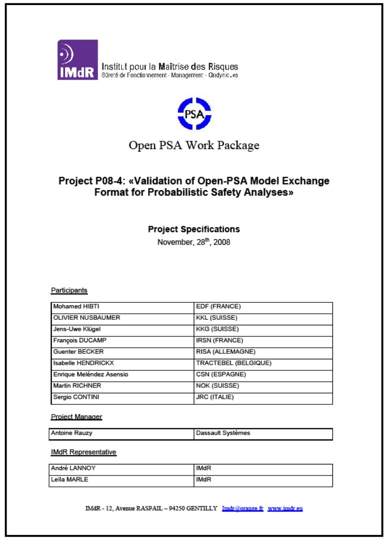
次世代 PSA ソフトウェア オープンイニシアチブ
ワークショップ開催のお知らせ
主テーマ: 次世代 PSA ソフトウェア、共有可能なモデル標準
2007 年 11 月 13 日·14 日
於: ㈱原子力エンジニアリング(NEL)、大阪

Open Initiative for Next Generation PSA Software
Technical Working Group Meeting #1
Standard Representation Format for PSA Models
July 19th, 2007
Electricité de France
département Management du Risque Industriel, Paris

The Open-PSA Model Exchange Format

An Exchange Format

- Public
- Fault Trees / Event Trees
- Large set of probability distributions (plus user defined ones)
- XML
- Extensible
- Validated [PSAM'10]



IMdR Institut pour la Maîtrise des Risques
Sûreté de Fonctionnement - Management - Cindyniques

PSA

Open PSA Work Package

Project P08-4: «Validation of Open-PSA Model Exchange Format for Probabilistic Safety Analyses»

Project Specifications
November, 28th, 2008

Participants

Mohamed HIBTI	EDF (FRANCE)
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Project Manager

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IMdR Representative

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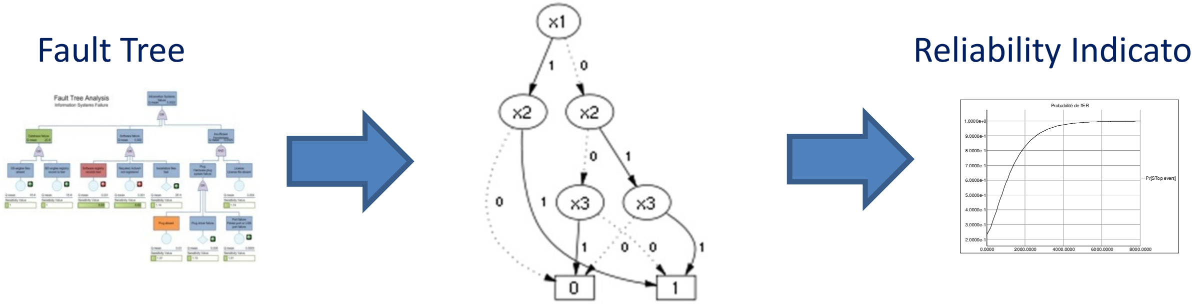
```
<define-fault-tree name="FT1" >
   <define-gate name="top" >
      <or>
         <gate name="G" />
         <basic-event name="C" />
      </or>
   </define-gate>
   <define-gate name="G" >
      <and>
         <basic-event name="A" />
         <basic-event name="B" />
      </and>
   </define-gate>
</define-fault-tree>
```

Fault Tree Assessment Algorithms

Because of repeated events, it is not possible to calculate reliability indicators straight from Fault Trees. An intermediate form has to be calculated.



Fault Tree

Reliability Indicators

Most efficient algorithms proposed so-far :

	Minimal Cutsets	Sum of Disjoint Products
Top-Down	MOCUS (RSAT – RiskSpectrum)	
Bottom-up	ZBDD (FTREX – Cafta)	BDD (Aralia – Riskman)
	• monotone approximation • efficient	• exact results • much more costly

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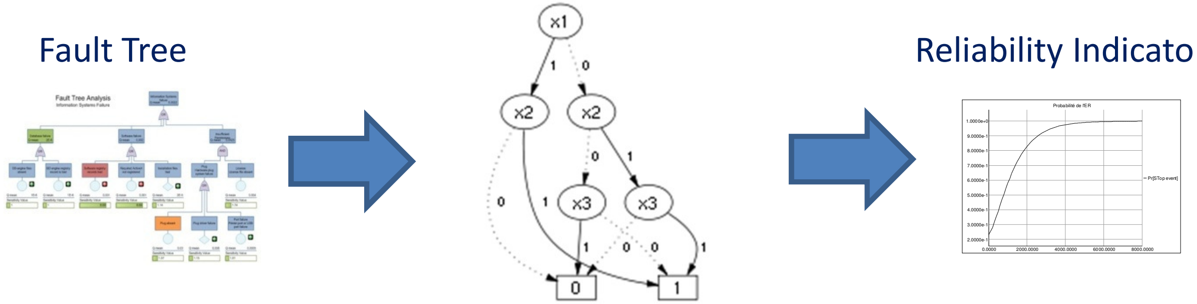

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Enumerative MCS Algorithms

Ingredient 1: equations

top = OR(S1, S2,S3)

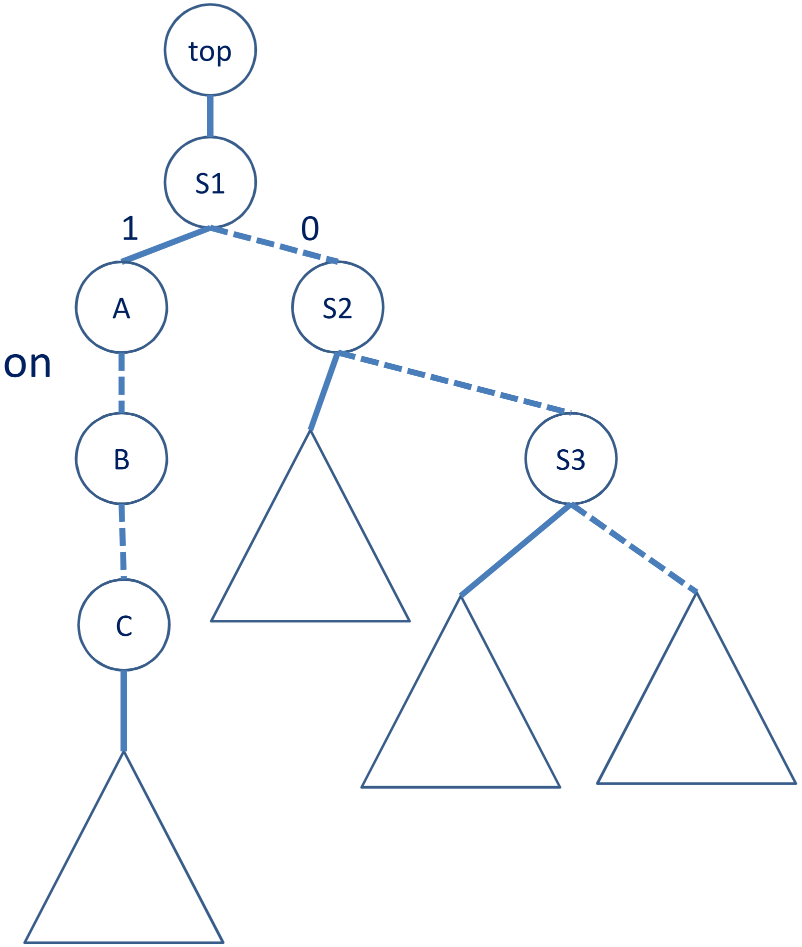
S1 = AND(-A,-B,C)

S2 = 3-out-of-4(-A,B,-C,D)

…

Ingredient 2: 4-valued logic

Ingredient 3: enumeration



Ingredient 4: unit propagation

ingredient 5: variable selection heuristics

ingredient 6: truncation (cutoff)

ingredient 7: minimality detection

ingredient 8: data structures

ingredient 9: rewriting/modularization

… more details in the article (PSAM'11)

The XFTA Project

Provide the community with a Fault Tree solver

- Open-Source (C++)
  - Free of use, even in commercial packages
- Supporting the Open-PSA Model Exchange Format
- Implementing State-of-the-Art algorithms
  - Works for coherent and non-coherent models
- Calculating (reliability) indicators of interest
  - Minimal Cutsets
  - Top Event Probability, Importance Factors
  - Sensitivity Analyses, Time Dependent Analyses, Safety Integrity Levels

Experiments (on my laptop)

	#gates	#BE	cutoff	#MCS	running time
PSA 1	2096	1055	1.0e-12	146831	30s53
PSA 2	2722	1430	1.0e-12	36717	15s46

Version 1.1 available on my web page (http://www.lix.polytechnique.fr/~rauzy)

Conclusion

With

- The Open-PSA Exchange Format, and
- XFTA

You have no more excuse not to cross check your calculations…

Les devises Shadok
Rouxel
IL VAUT MIEUX POMPER MÊME S'IL NE SE PASSE RIEN QUE RISQUER QU'IL SE PASSE QUELQUE CHOSE DE PIRE EN NE POMPANT PAS.