SECTION 1

BINARY SYSTEMS

Introduction by the Editors

In this section we have collected papers referring to the technique for reliability computation of systems which is usually called, mainly since the Reactor Safety Study [1]: "Fault-tree analysis". Essentially, this technique consists in a problem reduction based on the assumption that the behaviour of systems can be represented by an AND-OR graph linking the behaviour of a system with the behaviours of its subsystems.

AND-OR fault-trees came into use in the aerospace industry in the 1960's. Since then the technique has been progressively developed under many aspects. Two milestones in the development of this technique and concerning respectively the "logical" and the "numerical" analysis of the AND-OR graph merit to be mentioned. First was the non combinatorial algorithm, developed by Fussell [2] allowing the identification of minimal cut sets of the tree. Second was the finding of Vesely [3] that the failure intensity of a system can give an approximation for the failure rate, at least for highly reliable systems with repair times much shorter than the times to failure. This result opened the way for computing the reliability (probability of the first failure) of a system through the reliability of minimal cut sets.

In the most recent developments one can recognize various trends corresponding to different aims.

A first trend is towards the development of algorithms and better use of the computers in order to:

a) save time in fault-tree analysis;
b) assist the analyst for instance with interactive possibilities to make the technique more "reliable";
c) introduce in the analysis heuristic approaches to use qualitative and quantitative information and to exploit the hierarchical structure of this information;
d) allow fault-tree analysis by minicomputers.

A second trend is towards the extension of the modelling capability of the binary representation in order to deal with:

a) non-coherent systems;
b) multiphase systems;

c) common cause failures.

A third trend is towards the refinement of the numerical analysis in order to estimate:

a) effect of uncertainties on the overall results;
b) error introduced by various approximations.

Broadly speaking we can say that a part of these improvements aims to refine the capability of the technique and another part is aiming to give an answer to one of the most serious objections in its use in risk analysis: i.e. the difficulty in appreciating what is wrong or what has been left out in the representation of a complex system [4].

The papers included in this section touch upon most of the development areas we have listed.

The paper by Astolfi et al., "Fault Tree Analysis by List Processing Techniques", describes a set of algorithms, based on direct manipulation of graphs by list-processing techniques, which allow to extend the modelling capability of the binary representation. The algorithms introduce the NOT operator and qualitative (marks) information at the level of gates and primary events. This procedure allows to tackle in an efficient way the analysis of large fault-trees. The algorithms have been implemented in various computer codes used currently in the batch mode, but they could be particularly suitable for interactive analysis also on minicomputers.

The paper of Blin et al., "PATREC a Computer Code for Fault-Tree Calculation" views the most recent developments of a computer code for fault-tree analysis also based on list-processing technique. The code is oriented towards direct computation of the top event availability without the use of minimal cut sets.

The critical problem of multiphase repairable systems is dealt with in an exhaustive way in the paper by Clarotti et al., "Repairable Multiphase Systems". The problem is approached by the Markov graph technique which gives the exact solution and by the fault-tree technique which can give an approximated solution.

The paper by Henley and Ong, "Reliability Parameters for Chemical Process Systems", shows a modification of the KITT (Kinetic Tree Theory) computer program which allows the analysis components, e.g. storage tanks and components in cold or hot standby, having particular time-dependent behaviour.

The following three papers of this section are short papers aiming to clarify the meaning and the implications of some basic concepts and models used in fault-tree analysis. The first short paper by Amendola et al., "About the definition of Coherency in Binary System Representation", attempts to clarify with examples the concept of non-coherent systems and proposes an operational classification based on the characteristics of the corresponding boolean function.

The paper by Parry, "Regeneration Diagrams", introduces and discusses the implications of the important concepts of the time-structure of failure and repair processes for components and systems. As an application the limitation of Vesely's approach to the system reliability is definitely clarified. It is interesting to remark the adaptation of the Faynman diagrams to reliability analysis as proposed by Parry. This technique is actually fairly exotic for reliability analysts.

Finally, the paper by Colombo, "Uncertainty Propagation in Fault Tree Analysis", shows how the structure of a fault-tree and the types of distribution can affect the uncertainty propagation in a fault-tree and gives some practical suggestions.

The papers in this section report achievements and they also show many directions in which we can expect significant developments in the near future, e.e.g non-coherent systems, computer aided fault-tree handling techniques.

REFERENCES

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