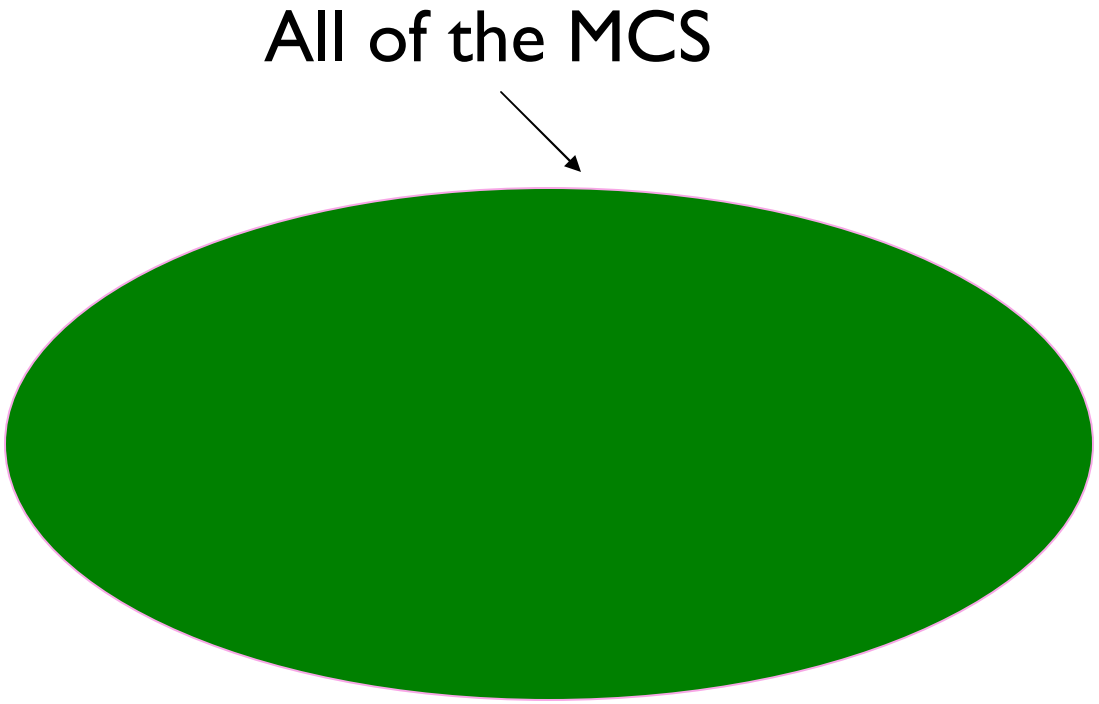
The MCS to BDD Algorithm

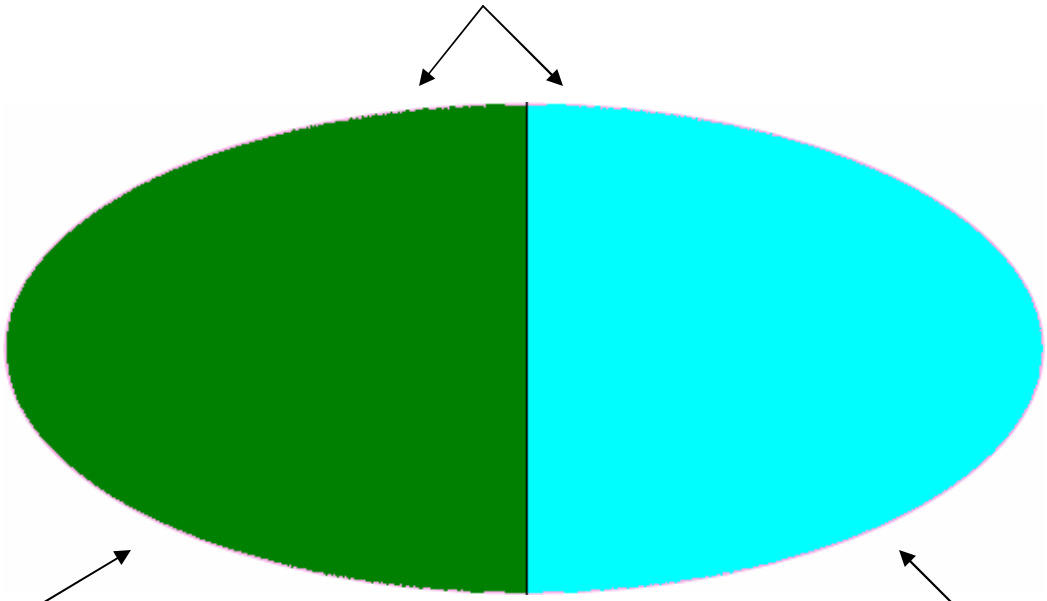
1. Generate the MCS with truncation;
2. create a BDD from the MCS;
3. calculate the exact value of the cutsets from the BDD.



1e-15 — b bdd — m mcub — r rea — 1e-05

1e-15 b/bdd m/mcub r/rea 1e-05

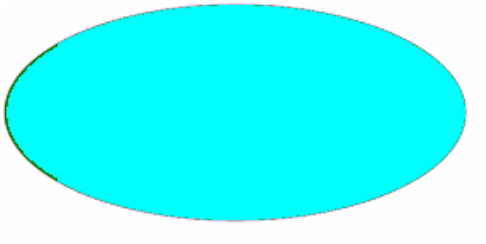
All of the MCS



The discarded MCS

The retained MCS

1e-15 b/bdd m/mcub r/rea 1e-05



… if there is no truncation …

b	m	r
bdd	mcub	rea

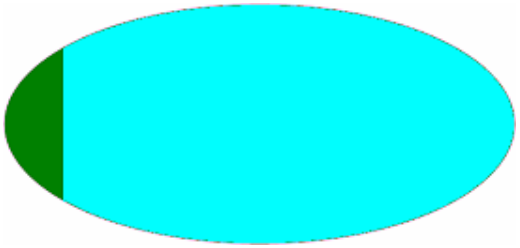
Retained MCS

1e-15 ——— 1e-05

All MCS

b	m	r
bdd	mcub	rea

With no truncation, BDD(Retained) = BDD(All).



… but as truncation grows …

b	m	r
bdd	mcub	rea

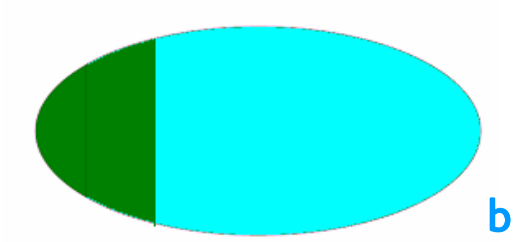
Retained MCS

1e-15 ——— 1e-05

All MCS

b	m	r
bdd	mcub	rea

With ANY truncation, the BDD(Retained) is guaranteed to be the LEAST CONSERVATIVE estimation of the system.



… and grows …

b m r

bdd mcub rea

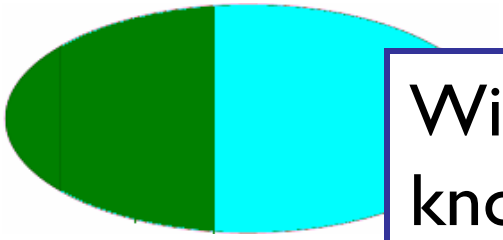
Retained MCS

1e-15 1e-05

All MCS

b	m	r
bdd	mcub	rea

Here, MCUB is the best CONSERVATIVE value, but cannot be used in non-coherent systems nor systems with events with high probability, like initiating events.



With any large system we do not know the exact value, therefore we do not know which of these cases truly apply.

b

bdd

1e-15 1e-05

All MCS

bdd	mcub	rea

… then the Rare Event Approximation of the retained MCS may be the best CONSERVATIVE approximation to the exact value of all of the MCS, and sometimes is an UNDER ESTIMATION of the exact values of the system if truncation is severe.

… for example the SWS system of Seabrook …

There are 101,639 MCS which are retained.

Rare Event Approximation: 2.2767e-09

… but the true value of the system …

Binary Decision Diagram: 2.8499e-08

The REA is an UNDER ESTIMATION of the exact value

… and in a simple example to further illustrate the point …

A Small Backup Cooling System

Rare Event Approximation: 5.6465e-04

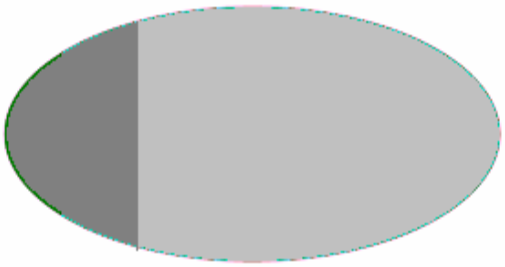
Min Cut Upper Bound: 5.6458e-04

BDD of the MCS: 5.6410e-04

… but the true value of the system …

5.6882e-04

The REA of the MCS is the best approximation to the exact value of the system.



… and grows …

b m r

bdd mcub rea

Retained MCS

1e-15 1e-05

Here, MCUB is the best

not

s

gh

Know What Problem You Are Trying to Solve

We are not interested in the exact value of the RETAINED MCS.

We are interested in the exact value of the system, and the best approximation of that value.

1e-15 1e-05

b m r

All MCS

bdd mcub rea

… then the Rare Event Approximation of the retained MCS may be the best CONSERVATIVE approximation to the exact value of all of the MCS, and sometimes is an UNDER ESTIMATION of the exact values of the system if truncation is severe.