# Unit-10: Algorithms for CTL

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*NPTEL-course*

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# Module 4:

# State-space explosion

```
MODULE main
VAR
     x:  boolean;
```

```
MODULE main
VAR
     x:  boolean;
```

Transition system of above NuSMV program has **2 states**

`x=FALSE` and `x=TRUE`

```
MODULE main
VAR
     x:  boolean;
     y:  boolean;
```

```
MODULE main
VAR
     x:  boolean;
     y:  boolean;
```

Transition system of above NuSMV program has **4 states**

| | | | |
|---|---|---|---|
| x=FALSE | x=FALSE | x=TRUE | x=TRUE |
| y=FALSE | y=TRUE | y=FALSE | y=TRUE |

```
MODULE main
VAR
    x:  boolean;
    y:  boolean;
    input:  sys();

MODULE sys()
VAR
    state:  { s1, s2, s3, s4, s5 };
```

```
MODULE main
VAR
    x:  boolean;
    y:  boolean;
    input:  sys();

MODULE sys()
VAR
    state:  { s1, s2, s3, s4, s5 };
```

Transition system of above NuSMV program has $2 * 2 * 5$ **states**

If NuSMV program has 10 **boolean variables**, transition system will have $2^{10}$ states!

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If NuSMV program has 10 **module variables**, each of which has 10 **states**, the transition system will have $10^{10}$ states!

# State space explosion

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# Tackling state space explosion

- **Efficient data structures:** Binary Decision Diagrams
- **Abstraction**: Interpret model with fewer variables relevant to property
- **Partial order reduction**: for asynchronous systems, combining several interleavings
- **Composition**: Break verification into simpler verification problems
- **Bounded model-checking:** Unroll transition system upto a fixed length of paths

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and research is still on...