# D-алгоритм Рота

Данный метод является основным методом направленного построения тестов. Если существует тест, покрывающий неисправность, то метод Рота его обязательно найдёт.

Метод заключается в активизации всех возможных путей от места неисправности ко всем входам. Изначально метод назывался «методом активизации двумерного пути». Метод Рота основан на описании элементов и всей схемы кубическим покрытием.

Введём основные понятия:

1. Сингулярное или вырожденное покрытие вентилей – это упрощённое представление таблицы истинности

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 11  *a*  *b*    *c* | ИЛИ   |  |  |  |  | | --- | --- | --- | --- | | 1 | x | x | 1 | | x | 1 | x | 1 | | x | x | 1 | 1 | | 0 | 0 | 0 | 0 | | |  |  |  |  | | --- | --- | --- | --- | | 0 | 0 | d | d | | 0 | d | 0 | d | | d | 0 | 0 | d | |
| 11  *a*  *b*    *c* | ИЛИ-НЕ   |  |  |  |  | | --- | --- | --- | --- | | 1 | x | x | 0 | | x | 1 | x | 0 | | x | x | 1 | 0 | | 0 | 0 | 0 | 1 | | |  |  |  |  | | --- | --- | --- | --- | | 0 | 0 | d | d’ | | 0 | d | 0 | d’ | | d | 0 | 0 | d’ | |
| &&&  *a*  *b*    *c* | И   |  |  |  |  | | --- | --- | --- | --- | | 0 | x | x | 0 | | x | 0 | x | 0 | | x | x | 0 | 0 | | 1 | 1 | 1 | 1 | | |  |  |  |  | | --- | --- | --- | --- | | 1 | 1 | d | d | | 1 | d | 1 | d | | d | 1 | 1 | d | |
| &  *a*  *b*    *c* | И-НЕ   |  |  |  |  | | --- | --- | --- | --- | | 1 | x | x | 1 | | x | 1 | x | 1 | | x | x | 1 | 1 | | 1 | 1 | 1 | 0 | | |  |  |  |  | | --- | --- | --- | --- | | 1 | 1 | d |  | | 1 | d | 1 |  | | d | 1 | 1 |  | |

1. D-куб или простейший D-куб элемента – это есть описание способности определённого входа управлять значением на выходе

,

Рот дал алгоритм построения простого D-куба. Для формального построения D-кубов мы организуем пересечение кубов вырожденного покрытия вентиля:

Идея d-алгоритма состоит в следующем: Выбирается тест для заданной неисправности на языке входов и выходов неисправного вентиля. Затем генерируются всевозможные пути следования неисправности по всем выходам одновременно. На каждом этапе следования осуществляется проверка на запрет, который обусловлен схождением ветвлений и отказом от путей, на которых это происходит. Такой этоп называется d-проходом. Затем пытаемся построить непротиворечивый входной вектор, который реализует все, выработанные на этапе d-прохода. Этот шаг называется операцией доопределения.

## Построение D-куба неисправности

D-куба неисправностей задаёт тест для обнаружения неисправности на уровне вентиля.

Для неисправности на выход элемента ИЛИ d-куб неисправности выглядит следующим образом:

|  |  |  |
| --- | --- | --- |
| 11  *a*  *b*    *c* |  | 1xxd  x1xd  xx1d |
| 11  *a*  *b*    *c* |  | 1xx  x1x  xx1 |

D-куб 1xxd указывает, что в исправной схеме на выходе будет «1», в неисправной – «0».

## D-пересечения

Предположим, что есть схема (два вентиля связаны между собой):

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 1 | 2 | 3 | 4 | 5 |  | | d | 1 | x | d | x | Для И | | x | x | 0 | d | d | Для ИЛИ | |

1. Прономеруем линии схемы в порядке распространения сигналов;
2. Активизируем путь от вершины 1 к вершине 5;
3. Запишем d-кубы для этих вентилей;
4. Для активизации пути следует пересечь два куба. Пересечение производится по таблице пересечения кубов;

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | 0 | 1 | x | d | d’ | | 0 | 0 | ∅ | 0 | ψ | ψ | | 1 | ∅ | 1 | 1 | ψ | ψ | | x | 0 | 1 | x | d | d’ | | d | ψ | ψ | d | μ | λ | | d’ | ψ | ψ | d’ | λ | μ |   Таблица пересечения кубов | ∅-пересечение отсутствует из-за конфликта; |

Для активизации пути необходимо выполнить пересечение:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ⋂ | d | 1 | x | d | x |
| x | x | 0 | d | d |
|  | d | 1 | 0 | d | d |

Пример № 1:



|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | | x | x | x | x | x | x | x | x | x | x | x | |  |  |  |  |  | 1 |  | 1 | d’ |  |  | | x | x | x | x | x | 1 | x | 1 | d’ | x | x | |  |  | d |  |  |  |  |  | 1 | d |  | | x | x | d | x | x | 1 | x | 1 | ψ | d | x | | x | x | x | x | x | 1 | x | 1 | d’ | x | x | |  |  | 1 |  |  |  |  |  | d’ | d’ |  | | x | x | 1 | x | x | 1 | x | 1 | d’ | d’ | x | |  |  |  |  |  |  | 0 |  |  | d’ | d’ | | x | x | 1 | x | x | 1 | 0 | 1 | d’ | d’ | d’ | | 0 | x |  |  |  |  | 0 |  |  |  |  | | 0 | x | 1 | x | x | 1 | 0 | 1 | d’ | d’ | d’ | |  |  |  | 0 | 0 |  |  | 1 |  |  |  | | 0 | x | 1 | 0 | 0 | 1 | 0 | 1 | d’ | d’ | d’ | | 1. Нумеруем исходное состояние; 2. Найдём D-куб неисправности, который бы описывал неисправность 3. Выбираем путь и продвигаемся по данному пути; 4. После появления d или на выходе схемы… 5. Определяем сигналы по остальным линиям |

Пример № 2:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | x | x | x | x | x | x | x | x | |  |  | d |  |  |  |  |  | | x | x | d | x | x | x | x | x | | 1 |  | d |  | d |  |  |  | | 1 | x | d | x | d | x | x | x | |  | 1 | d |  |  | d |  |  | | 1 | 1 | d | x | d | d | x | x | |  |  | d | 1 |  |  | d |  | | 1 | 1 | d | 1 | d | d | d | x | |  |  |  |  | d | d | d | d | | 1 | 1 | d | 1 | d | d | d | d | |

Выпишем простые D-кубы:

|  |  |  |  |
| --- | --- | --- | --- |
| d | 0 | 0 | d |
|  | 0 | 0 |  |
| 0 | d | 0 | d |
| 0 | 0 | d | d |

## Контр пример Шнейдера

Задача:

Поспорить тест для неисправности const 0 на шестой линии.



Таблица Рота.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | 0 | 1 | x | d | d’ | | 0 | 0 | ∅ | 0 | ψ | ψ | | 1 | ∅ | 1 | 1 | ψ | ψ | | x | 0 | 1 | x | d | d’ | | d | ψ | Ψ | d | μ | λ | | d’ | ψ | Ψ | d’ | λ | μ | |  | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | 0 | 1 | x | d | d’ | | 0 | 0 | ∅ | 0 | ∅ | ∅ | | 1 | ∅ | 1 | 1 | ∅ | ∅ | | x | 0 | 1 | x | d | d’ | | d | ∅ | ∅ | d | d | ↔ | | d’ | ∅ | ∅ | d’ | ↔ | d’ | | Пересечение ψ не существует. |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | x | x | x | x | x | x | x | x | x | x | x | x | |  | 0 | 0 |  |  | d |  |  |  |  |  |  | | x | 0 | 0 | x | x | d | x | x | x | x | x | x | | 0 |  |  |  |  | d |  |  | d’ |  |  |  | | 0 | 0 | 0 | x | x | d | x | x | d’ | x | x | x | |  |  |  | 0 |  | d |  |  |  | d’ |  |  | | 0 | 0 | 0 | 0 | x | d | x | x | d’ | d’ | x | x | |  |  |  |  |  |  |  | 0 | d’ | d’ | 0 | d | | 0 | 0 | 0 | 0 | x | d | x | 0 | d’ | d’ | 0 | d | |  | x |  |  | 1 |  |  | 0 |  |  |  |  | | 0 | 0 | 0 | 0 | 1 | d | x | 0 | d’ | d’ | 0 | d | |  |  | x |  |  |  | 1 |  |  |  | 0 |  | | 0 | 0 | 0 | 0 | 1 | d | 1 | 0 | d’ | d’ | 0 | d | | Неопределяемый состав линий d-кубов неисправности.  транспортировка через № 9  транспортировка через № 10  транспортировка через № 12    Начало этапа доопределения; обратный проход |