Ferramentas para Síntese Automática de Circuitos Integrados

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Síntese Lógica

Logic Synthesis

- Introduction and ROBDDs
  - Basic concepts and terms
  - Function representations
  - ROBDDs
- Two-level combinational logic synthesis
- Multi-level combinational logic synthesis
- Sequential Logic Synthesis
- Technology Mapping

Basic Concepts and Terms

- Boolean Function : m inputs, n outputs

  $f : B^m \rightarrow B^n$, $B=\{'0','1'\}$
- Incompletely specified : don't cares

  $f : B^m \rightarrow Y^n$, $Y=\{'0','1','-'\}$

  on-set

  off-set

  dc-set
- Variables $x_1,\ldots,x_m$ are associated to B^m space

Boolean Spaces

Terms

- Literal

  A boolean variable or its complement

  Any point in B^m is a product of m literals: minterm
- Cube

  A product in each some variables may not appear
- Canonical Form

  A boolean function can be completely specified by a sum of minterms

  Input space with m variables has 2^m points

  Canonical form has therefore $O(2^m)$ minterms

Implication

- Implicant Cube

  A cube whose points are in the on-set ∪ dc-set
- Prime Implicant

  Not contained in any other implicant and has at least one point in the on-set
- Example
- Irredundant prime cover
- Minimization does not lead to canonical form

"Curiosities"

- Blake's canonical form
  Complete set of prime implicants
- Parity function
  Cannot be simplified by using cubes

Two Main Problems

- To find a good representation

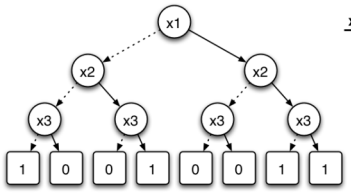
  ROBDDs

- To obtain a minimal sum-of-products

  Quine MacKluskey, Multi-level, etc…

ROBDD

- Reduced Ordered Binary-Decision Diagram
- BDDs are Tree representations of a Truth Table, and can be simplified



x1	x2	x3	f
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

Restriction (a bit of theory)

- Substitution of a constant value for a variable
- Gives positive and negative cofactors
- The "Shannon Expansion" is:

Uniqueness

- Shannon Expansion is unique for a given variable ordering
- Means that BDDs are canonical for each variable ordering
- But variable ordering can still be (is) a real problem

OBDD s and ROBDDs

- An ordered BDD is a BDD tree with the same variable in all nodes at each level
- The reduction to build a ROBDD is:

1. Replace all leaf vertices with the same value;
2. Process from bottom to top: if two vertices have the same children and variable, substitute one;
3. If both children are the same, eliminate this node;

ROBDD Example

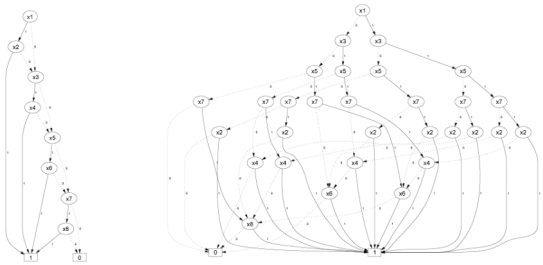
Properties

- Canonical
- Good and Bad orderings (for most functions)
- There are functions with exponentially growing number of vertices.
- Ex: multiplication

  k bits x k bits leads to 2k bits

  Bryant: at least on of the 2k outputs needs a ROBDD whose size is an exponential function of k
- But…

Good and Bad ordering



Importance

- ROBDDs are very efficient in most situations

Importance

- Most Logic Synthesis tools use ROBDDs today

ROBDD Packages

- There are many, commercial, free…
- Abstract Data Type (=class)
- Multiple functions in the same ROBDD
- Input Conversion
- Manipulation = create new functions
- Output generation

ROBDD Data Type

- A Vertex is:
  - Variable
  - Left Son
  - Right Son
- An ROBDD is:
  - A Table of unique vertices (v,l,r)
  - Hash Table
  - Function returns a node or creates a new one

ROBDD creation

- Process Shannon Expansion recursively
- Starting with '0' and '1' leaves
- Return or create new node

ROBDD Manipulation

- Create new functions
- by applying binary operations
- by function composition

Variable Ordering

- Static
- Dynamic
  - Interchanging x_i and x_{i+1} has only local effect
  - We can try each variable on every place and remember the best position

Applications

- Gerez provides some examples for verification and two-level synthesis…

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Quine McCluskey

Other ppt

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Boolean Network

- Intermediate structural/behavioral graph
- It's a graph (structure) of functions (behavior)
- At one extreme: a single node with the circuit's main function
- At the end: a mapped netlist composed of funcions availabel in a library
- In between: a mixed representation that allows optimization tasks to be applied

Multi-level

Pdf with operations according to DeMichelli

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Sequential Logic Synthesis

- Sequential logic is Comb. Logic + State
- Problems in Sequential Logic Synthesis are:
  - State assignment
  - Re-timing

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Technology Mapping

- Is the task of mapping an optimized netlist to cells available in a particular technology
- Can be done bottom-up with dynamic programming
- Cell matching is a significant concern. ROBDDS can be used
- Can be depth-limited by a window