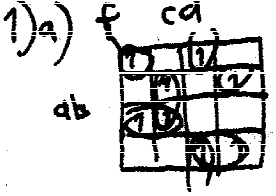
Robert Dick ECE 303 Midterm Soln, Spring 2005

3 May 2005

1)a) 

$f = \bar{a}\bar{b}\bar{c}\bar{d} + \bar{a}bc\bar{d} + ab\bar{c} + b\bar{c}d + a\bar{b}c + \bar{b}cd$

cube	kernel?	benefit
$\bar{a}$	~~$b\bar{c}d+bc\bar{d}$~~	n.a.
a	$b\bar{c}+\bar{b}c$	1
$\bar{b}$	$\bar{a}\bar{c}\bar{d}+cd+ac$	2
b	$a\bar{c}+\bar{c}d+\bar{a}c\bar{d}$	2
$\bar{c}$	$\bar{a}\bar{b}\bar{d}+bd+ab$	2
c	$\bar{b}d+a\bar{b}+\bar{a}b\bar{d}$	2
$\bar{d}$	~~$a\bar{b}\bar{d}+\bar{a}bc$~~	n.a.
d	$bc+\bar{b}c$	1
$\bar{b}c$	$d+a$	same
$b\bar{c}$	$a+d$	Actual benefit = 6
$\bar{a}\bar{d}$	$\bar{b}\bar{c}+bc$	2

$f = \bar{a}\bar{b}\bar{c}\bar{d} + \bar{a}bc\bar{d} + (a+d)(b\bar{c}+\bar{b}c)$

cube	kernel?	benefit
$\bar{a}$	~~$b\bar{c}\bar{d}+bc\bar{d}$~~	n.a.
$\bar{d}$	~~$\bar{a}\bar{b}\bar{c}+\bar{a}bc$~~	n.a.
$\bar{a}\bar{d}$	$\bar{b}\bar{c}+bc$	2

$$f = \bar{a}\bar{d}(\bar{b}\bar{c}+bc) + (a+d)(b\bar{c}+\bar{b}c)$$

1)b) $g = \bar{b}\bar{c}+bc$ (4 lit.)

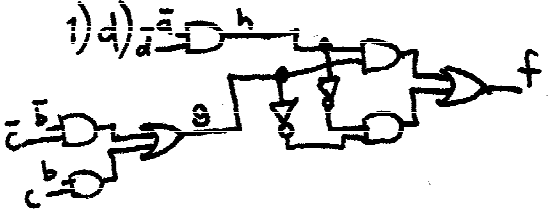
$h = \bar{a}\bar{d}$ (2 lit.)

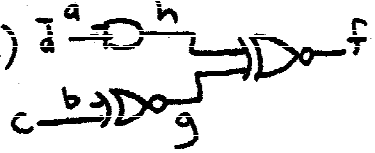
Thus, $\bar{g} = b\bar{c}+\bar{b}c$ and $\bar{h} = \overline{\bar{a}\bar{d}} = a+d$

so $f = hg + \bar{h}\bar{g}$ (4 lit.)

1)c) 12 literals for kernel extraction

10 literals for kernel extraction and decomposition

1)d) 

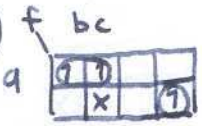
1)e) 

2)a) power down linear
performance down linear
energy constant (if switching power dominates leakage p

2)b) power down quadratic ($P = IV = V^2/R$)
performance down linear (to compensate)
energy down linear

2)c) Switching power consumption results from current when gate outputs change. Leakage power is constant and results from some current flow through channels of off MOSFETs. It gets worse as $V_{DD} \to V_{TH}$

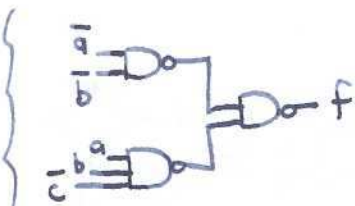
2)d)

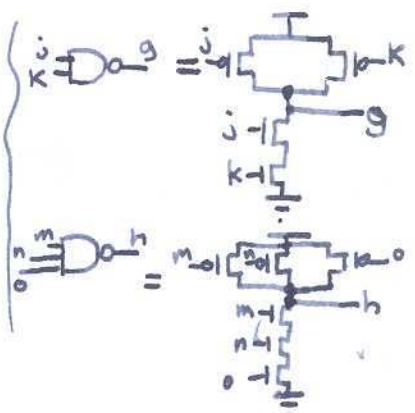


$$f = \bar{a}\bar{b} + ab\bar{c}$$

$$f = \overline{\bar{a}\bar{b} + ab\bar{c}}$$

$$f = \overline{\bar{a}\bar{b} \cdot ab\bar{c}}$$





3)a) Given a table with entries of 1 and 0, select a subset of columns s.t. each row contains at least one 1 in a selected column and the cardinality or cost of the columns is minimized.

3)b) A set of problems for which nobody has found optimal polynomial-time ~~algorithms~~. Any instance of an NP-complete problem may be converted to an instance of another NP-complete problem in polynomial time. Solutions can be verified in polynomial time.

3)c) The second stage of 2M can be solved in polynomial time, i.e., two-level logic minimization can be done optimally in polynomial time.

3)d) All can be solved in polynomial time by conversion of instances.

4)a)

000	000✓	00X	
001	001✓		
101		X01✓	X X 1
111	101✓	0X1✓	
x 011	011✓		
	111✓	1X1✓	
		X11✓	

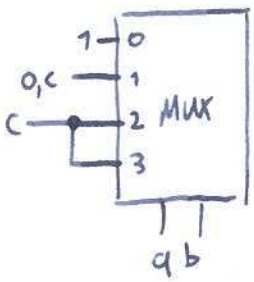
	00X	X X 1
000	1	
001	1	1
101		1
111		1

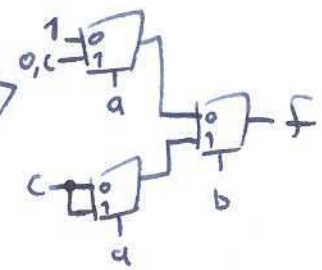
$f = \bar{a}\bar{b} + c$

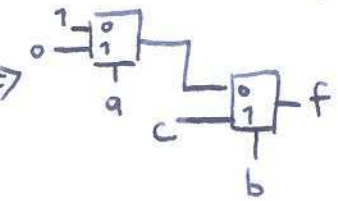
4)b) Yes. All primes essential. Two-level minimization is hard because unate covering can require backtracking

4)c)

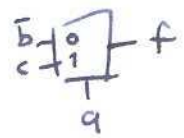
a b c	f
0 0 0	1
0 0 1	1
0 1 0	0
0 1 1	X
1 0 0	0
1 0 1	1
1 1 0	0
1 1 1	1



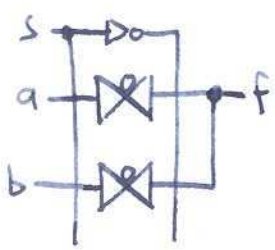




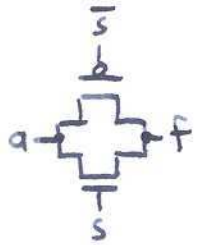
Better possible:



4)d)



4)e)



5)a) PAL/PLA: Simple, two-level prog. logic.

ROM/PROM/EPROM: Non-volatile data storage.

Flash memory: Writable non-volatile storage.

FPGAs: Powerful general reconfigurable logic. Volatile. Expensive in volume

Full Custom: Fast, low-power. Cheap in volume but requires difficult design and expensive mask/process.

5)b) ROM: Read-only memory. Cannot be programmed

PROM: May be programmed once.

EPROM: May be erased and reprogrammed. Erasing requires exposure to UV light

EEPROM: May be electrically erased.

Flash memory: May have devices erased in blocks to increase speed.