Deadline: 7.6.07 – 17:00

Question 5.4 *This question deals with the design of the* BARREL-SHIFTER(n) *depicted in Figure 5.5.*

1. *Prove the correctness of the design.*

2. *Is the functionality preserved if the order of the levels is changed?*

3. *Analyze the cost and delay of the design.*

4. *Prove the asymptotic optimality of the delay of the design.*

5. *Prove a lower bound on the cost of a combinational circuit that implements a cyclic shifter.*
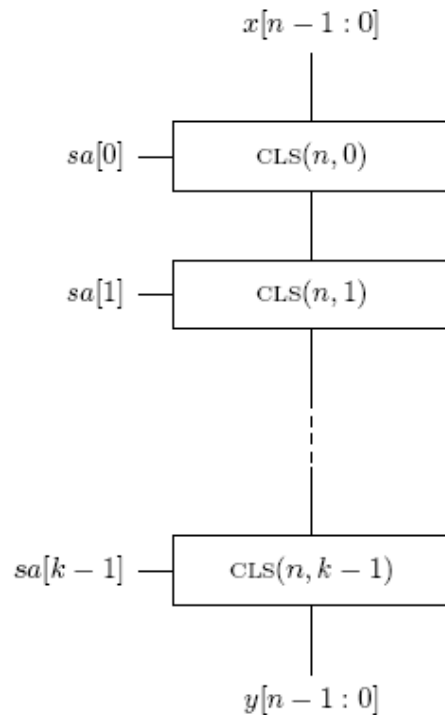
$$x[n-1:0]$$

$sa[0]$ —	CLS$(n, 0)$

$sa[1]$ —	CLS$(n, 1)$

$sa[k-1]$ —	CLS$(n, k-1)$

$$y[n-1:0]$$

Figure 5.5: A BARREL-SHIFTER(n) built of k levels of CLS(n, i) $(n = 2^k)$.

Question 5.6 *Consider the definitions of* CLS(n, i) *and* LBS(n, i). *Suggest an analogous definition* ARS(n, i) *for arithmetic right shift (i.e., modify the definition of* $\vec{x}'$ *and use* $(2 : 1)$*-*MUX*s). Suggest an implementation of an arithmetic right shifter based on cascading* ARS$(n.i)$ *circuits.*

Question: Design a bi-directional cyclic shifter. Such a shifter is like a cyclic left shifter but has an additional input $\ell \in \{0, 1\}$ that indicates the direction of the required shift. Hint: Consider reducing a cyclic right shift to a cyclic left shifter. To simplify the reduction you may assume that $n = 2^k - 1$ (hint: use one's complement negation). Suggest a simple reduction in case $n = 2^k$ (hint: avoid explicit subtraction!).