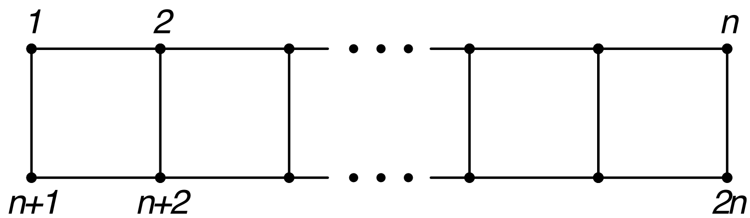
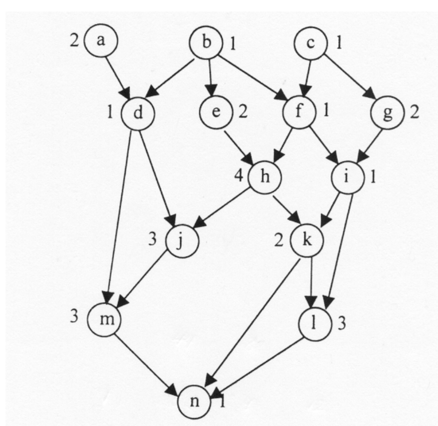
CS 6135 VLSI Physical Design Automation
Final Exam: 3:30 p.m. - 6:20 p.m., June 13, 2017

1. (5 points) Vertex 1 and vertex 2 are two vertices in an edge-weighted complete graph, where the weight of each edge is a non-negative integer. Suppose that the vertex set of this graph is partitioned into two subsets, and vertices 1 and 2 are not in the same subset. Assume that the respective internal and external costs of vertex 1 are 6 and 2, and the respective internal and external costs of vertex 2 are 3 and 6. Can the cut cost be reduced by swapping vertices 1 and 2? Justify your answer.

2. (5 points) Consider the following ladder graph with $2n$ vertices, and an initial bipartition $A=\{1, 2,\ldots, n\}$ and $B=\{n+1, n+2,\ldots, 2n\}$. What is the resulting bipartition if one pass of the KL algorithm is applied?



3. (15 points) Assume the area of each gate is 1 unit, the area constraint of each cluster is 4 units, and the interconnection delay between two clusters is 5 units. The gate delay is given next to each gate. Show your work by applying the clustering algorithm discussed in class to find l(f), l(h), l(i), l(k), *cluster*(f), *cluster*(h), *cluster*(i), and *cluster*(k).

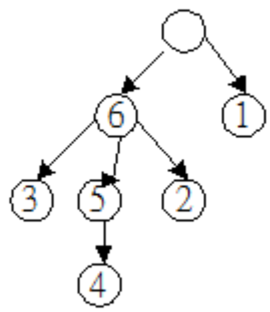


4. Consider the Polish expression $E=12H34VH56HV$.
   (a) (3 points) Does E have the balloting property? Justify your answer.
   (b) (3 points) Draw the slicing tree for E and determine whether it is skewed.
   (c) (9 points) Assume modules 1, 2, ..., 6 are all hard modules with shapes given in the following table. Besides, each module can be rotated by 90-degree. Use the Stockmeyer algorithm to find a minimum-area floorplan for E as well as the shape of each module that achieves the minimum-area floorplan.

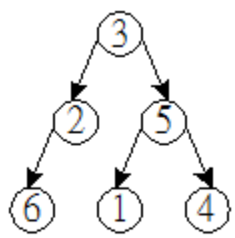
Module	Width	Height
1	2	4
2	1	2
3	2	2
4	4	3
5	2	3
6	2	1

5. Consider the set of modules given in Problem 4, but assume that module rotation is not allowed.
   (a) (7 points) Show your work for finding a minimum-area placement for the sequence-pair (123456, 653421).

   (b) (4 points) Show the placement for the following horizontal O-tree.



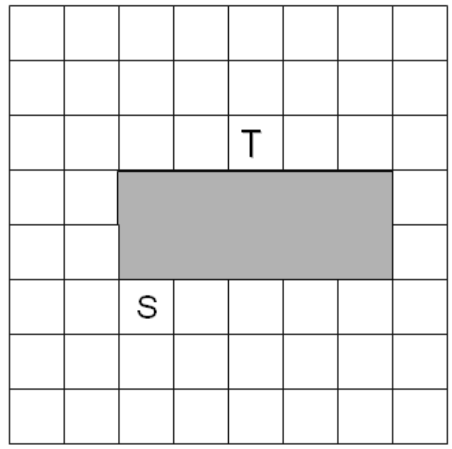
   (c) (4 points) Show the placement for the following B*-tree.



6. (10 points) Prove that half-perimeter wirelength (HPWL) is a lower bound of rectilinear Steiner minimal tree (RSMT) wirelength.

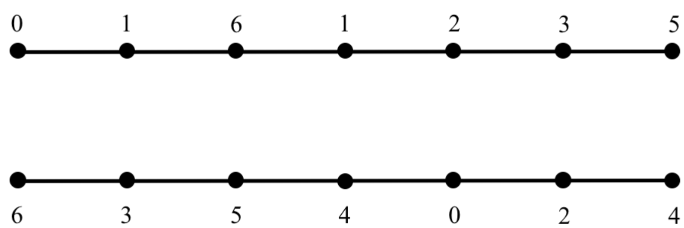
7. (10 points) In class we claimed that the BoundingBox net model (or called the Bound2Bound model) can accurately model HPWL in a quadratic placement framework. Prove this claim for the x direction.

8. (5 points) Given the following routing instance with a shaded blockage,use the Lee algorithm to find a shortest path between S and T.



9. (10 points) X-architecture routing allows vertical, horizontal, 45-degree, and 135-degree wire segments. Describe how to extend the Lee algorithm for X-architecture routing.

10. Consider the following two-layer channel routing instance under the reserved HV routing layer model.



(a) (3 points) Draw the vertical constraint graph.
(b) (7 points) Suppose the tracks are added from the bottom to the top (rather than from the top to the bottom as introduced in class) by the constrained left-edge algorithm. Use the constrained left-edge algorithm to route the channel under the HV routing layer model.