Sequence Assembly-II

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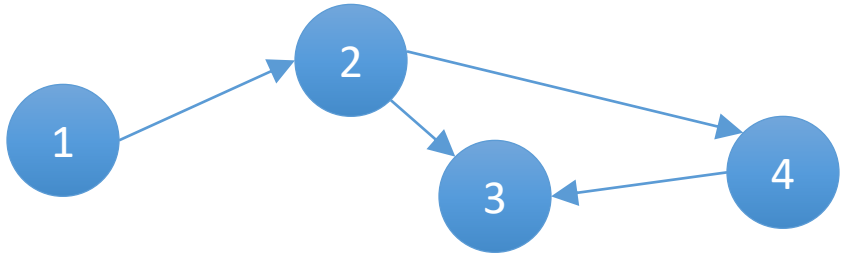
Graph Basics

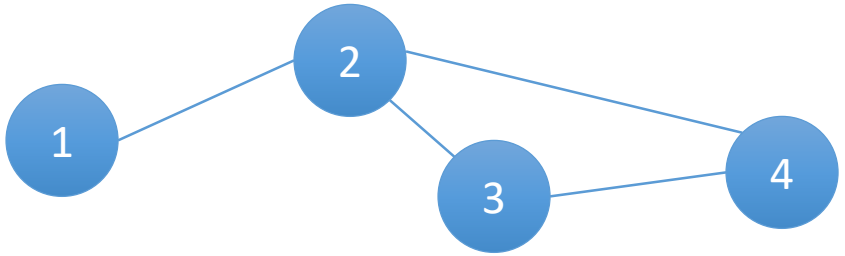
- A graph (*G*) consists of vertices (*V*) and edges (*E*)

$$G = (V,E)$$

- Edges can either be *directed* (*directed graphs)*

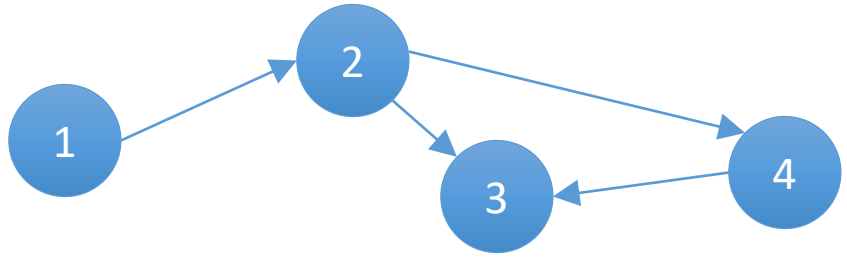


- or *undirected* (*undirected graphs)*



Vertex degrees

- The *degree* of a vertex: the # of edges incident to that vertex
- For directed graphs, we also have the notion of
  - *indegree:* The number incoming edges
  - *outdegree:* The number of outgoing edges



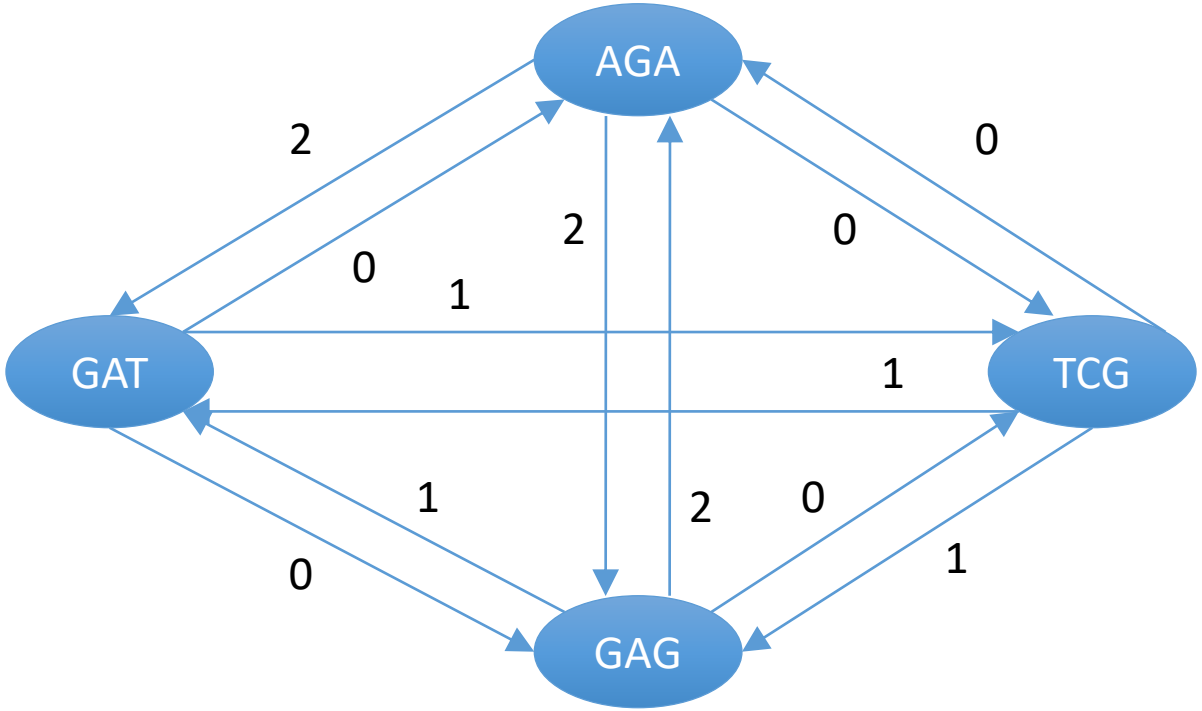
degree(v_2) = 3
indegree(v_2) = 1
outdegree(v_2) = 2

Overlap graph

- For a set of sequence reads S, construct a directed weighted graph *G = (V,E,w)*
  - with one vertex per read (v_i corresponds *to* s_i)
  - edges between all vertices (a *complete* graph)
  - $w(v_i,v_j)$ = *overlap*(s_i,s_j) = length of longest suffix of s_i that is a prefix of s_j

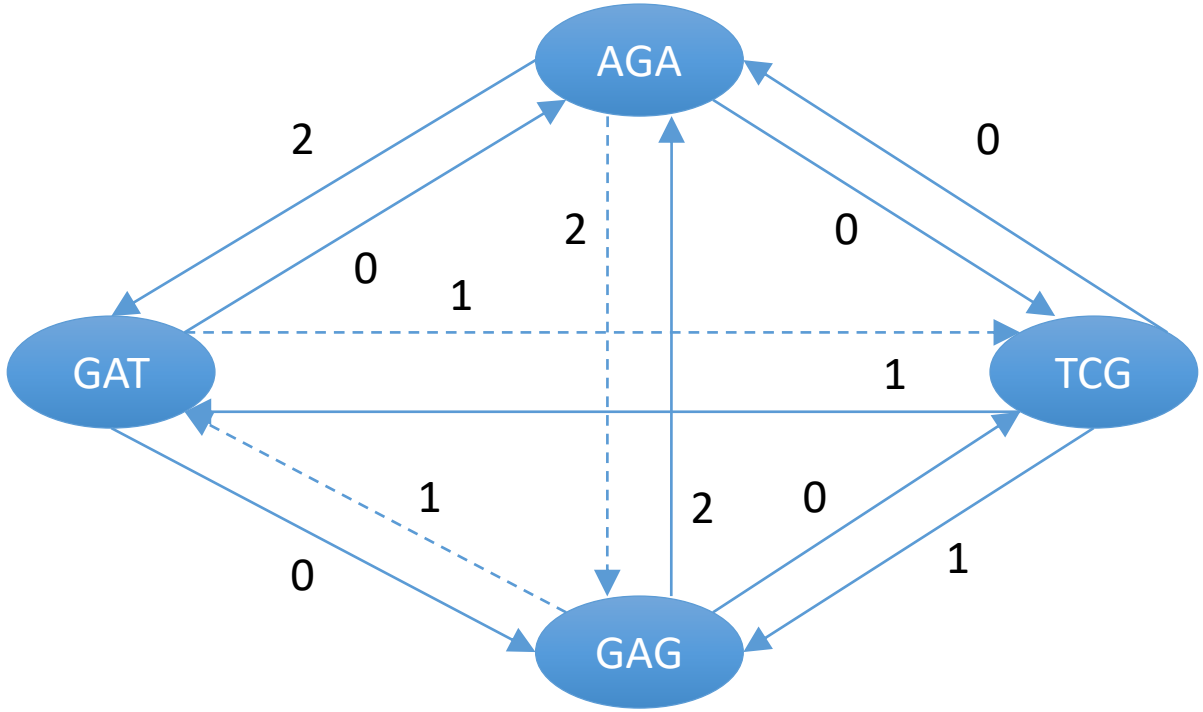
Overlap graph example

- Let S = {AGA, GAT, TCG, GAG}



Assembly as Hamiltonian Path

- *Hamiltonian Path*: path through graph that visits each vertex exactly once

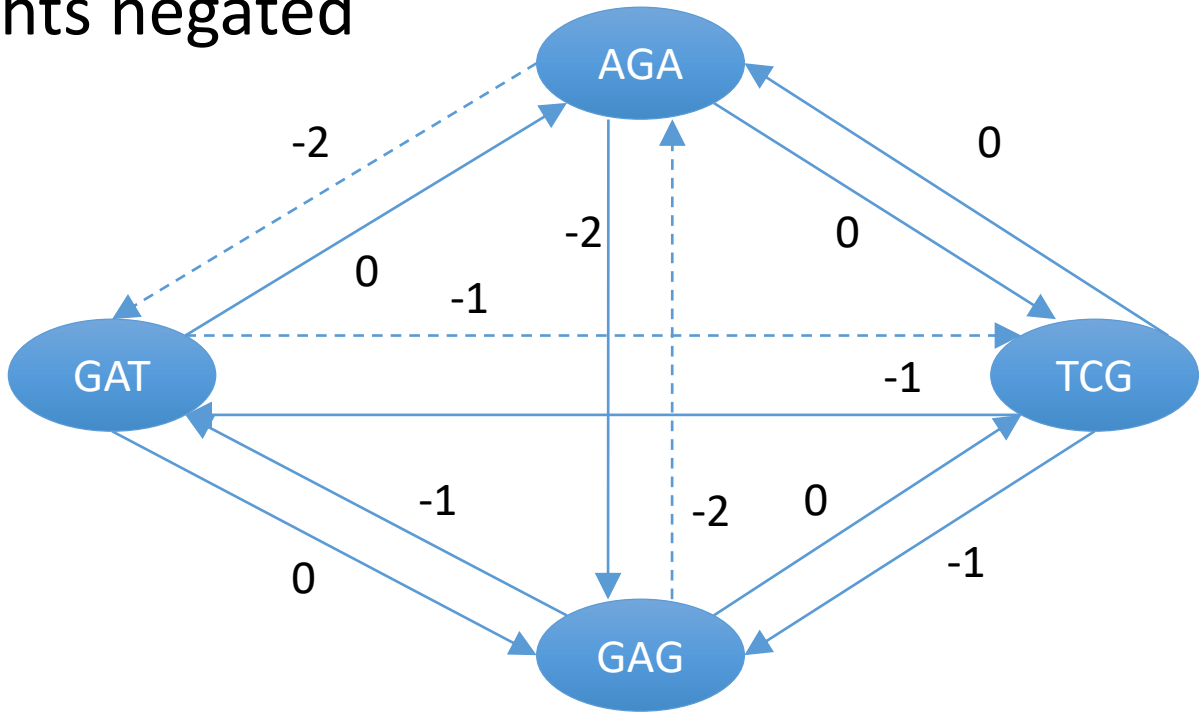


Path: AGAGATCG

Shortest superstring as TSP

- minimize superstring length ➔minimize hamiltonian path length in overlap graph with edge weights negated

Path: GAGATCG
Path length: -5
String length: 7



- This is essentially the Traveling Salesman Problem (also *NP*-complete)

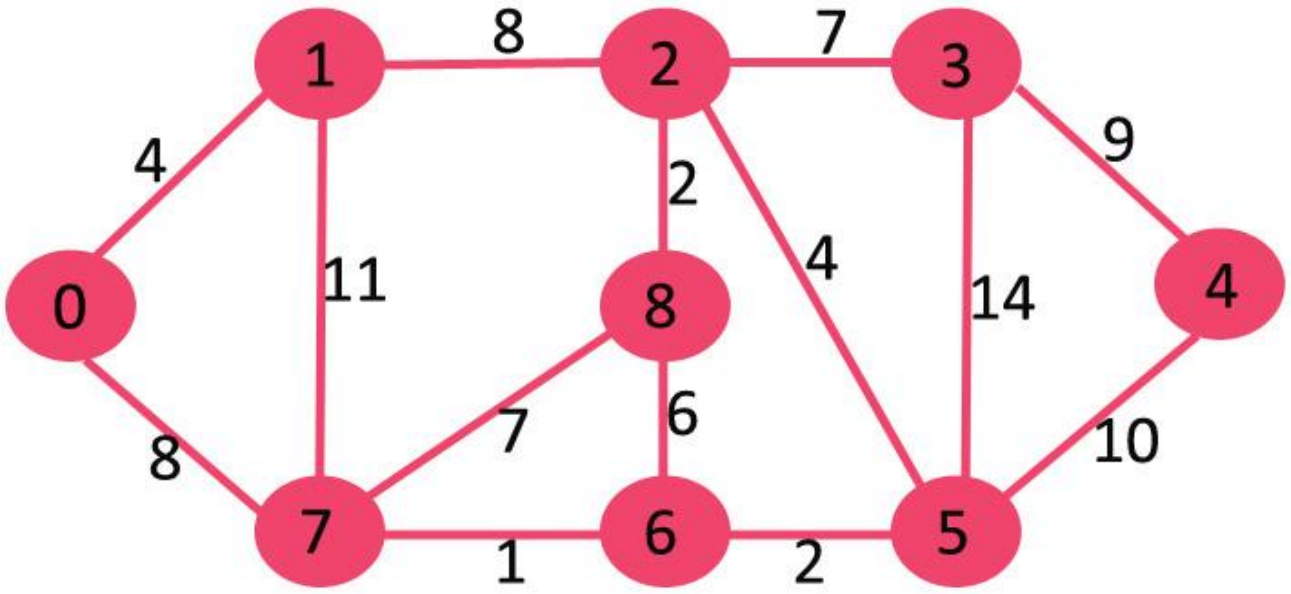
Greedy Algorithms

- **Definition**: An algorithm that always takes the best immediate, or local, solution while finding an answer.
- Greedy algorithms find the overall, or globally, optimal solution for some optimization problems, but may find less-than-optimal solutions for some instances of other problems.

Paul E. Black, "greedy algorithm", in Dictionary of Algorithms and Data Structures [online], Paul E. Black, ed., U.S. National Institute of Standards and Technology. 2 February 2005. http://www.itl.nist.gov/div897/sqg/dads/HTML/greedyalgo.html

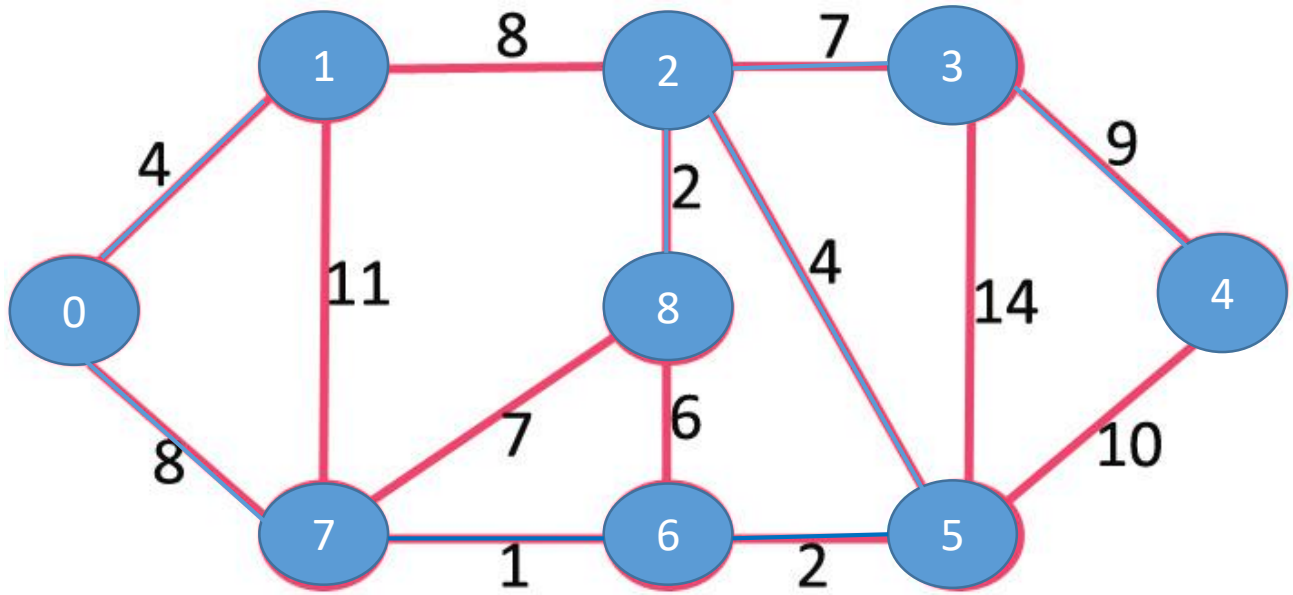
Greedy Algorithm Examples

- Kruskal's Algorithm for Minimum Spanning Tree
  - Minimum spanning tree: a set of n-1 edges that connects a graph of n vertices without any cycles and that has minimal total weight
  - Kruskal's algorithm adds the edge that connects two components with the smallest weight at each step without introducing a cycle
    - Proven to give an optimal solution



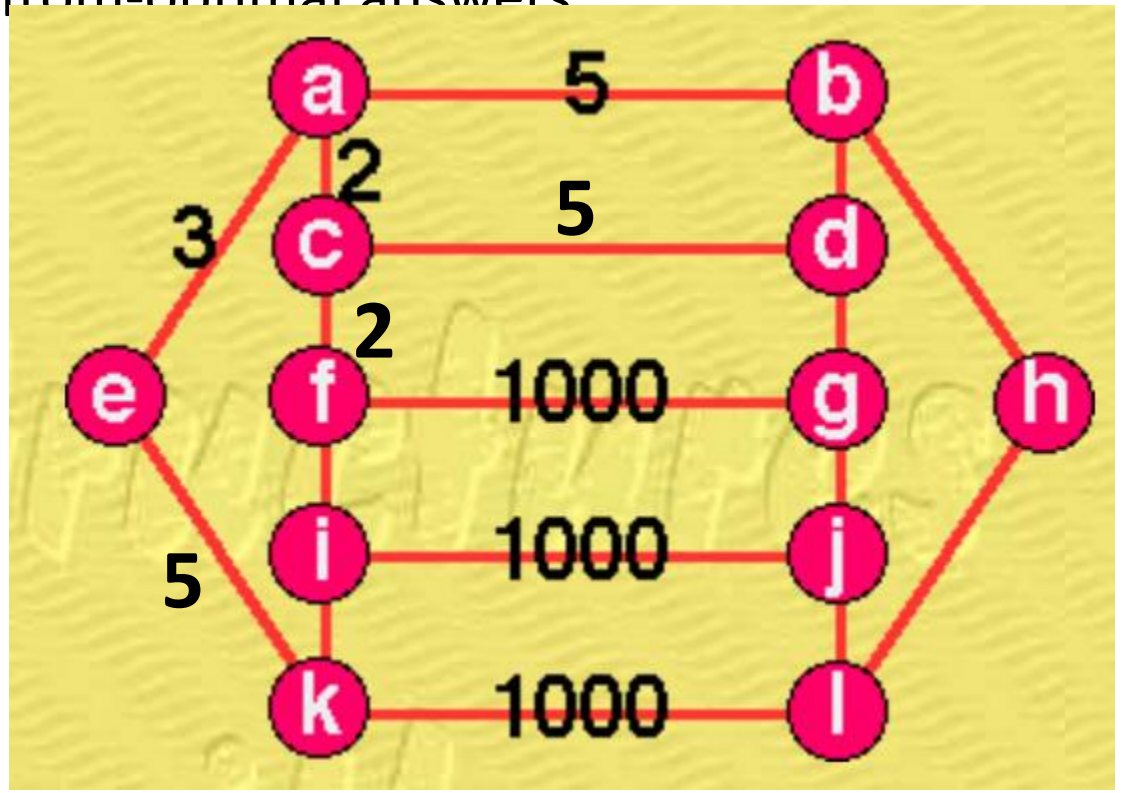
Greedy Algorithm Examples

Weight	Src	Dest
1	7	6
2	8	2
2	6	5
4	0	1
4	2	5
6	8	6
7	2	3
7	7	8
8	0	7
8	1	2
9	3	4
10	5	4
11	1	7
14	3	5



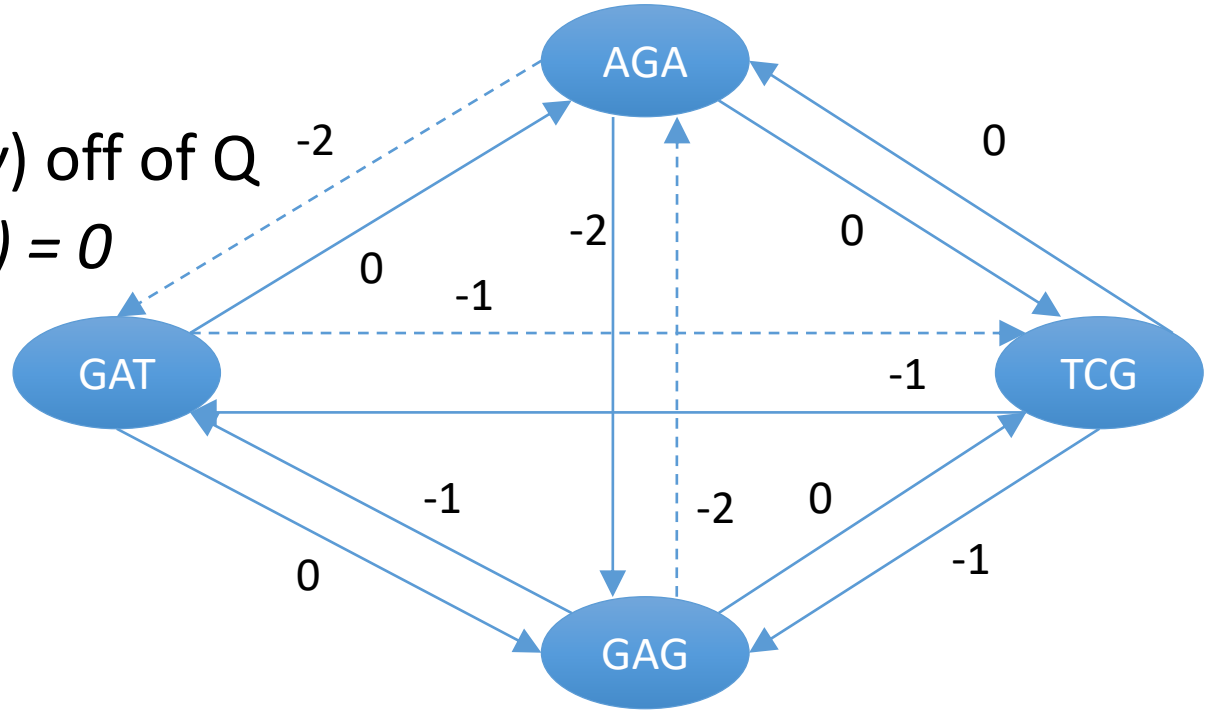
Greedy Algorithm Examples

- Traveling Salesman Problem
  - Greedy algorithm chooses to visit closest vertex at each step
  - Can give far-from-optimal answers



The Greedy Algorithm

- Let *G* be a graph with fragments as vertices, and no edges to start
- Create a queue, Q, of overlap edges, with edges in order of increasing weight
- While *G* is disconnected
  - Pop the next possible edge *e* = (*u*,*v*) off of Q
  - If *outdegree(u) = 0* and *indegree(v) = 0* and *e* does not create a cycle
    - Add *e* to *G*



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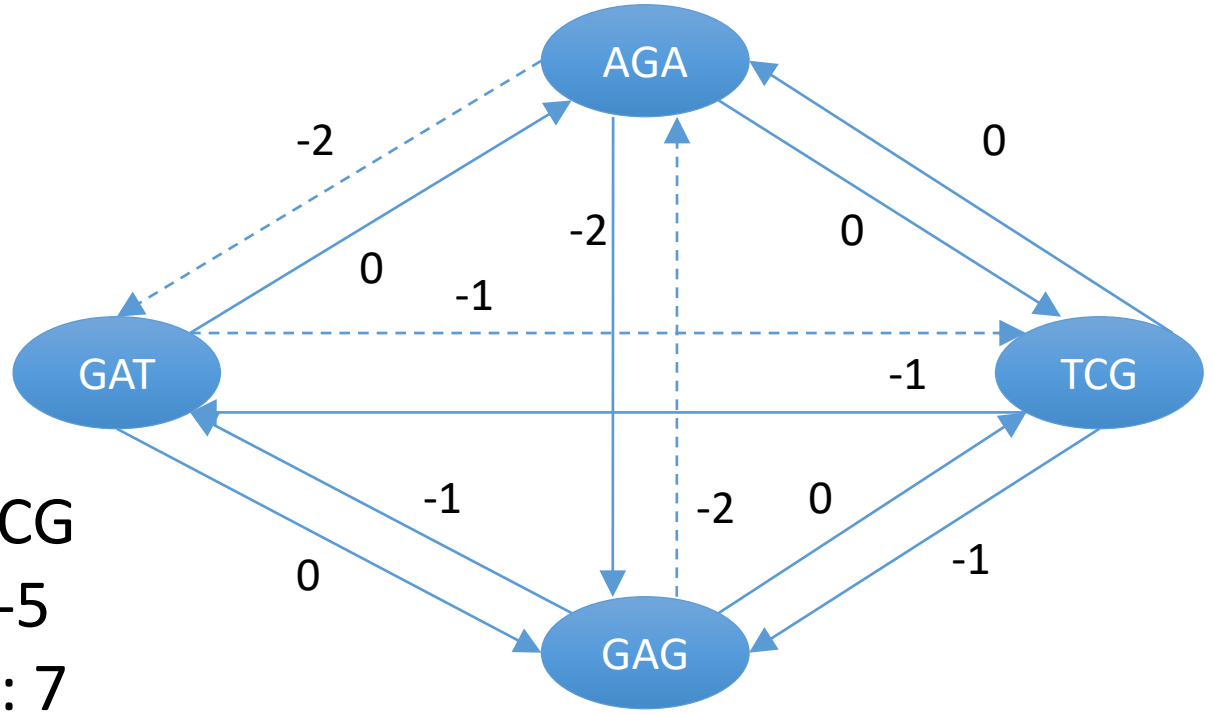
- GAG -> AGA -2
- AGA -> GAG -2
- AGA -> GAT -2
- GAG -> GAT -1
- TCG -> GAT -1
- TCG -> GAG -1
- GAT -> TCG -1



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