Allocating radio frequencies using graph coloring

BY

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PLAN FOR THE TALK

- Real world problem description
- Graph construction from the problem
- Graph coloring
- Np hard problem
- Special properties
- Solution to real world problem

Real world problem description

- The real world problem is allocating the radio frequencies to the towers in a location.
- Suppose in a location Some of the transmitters are located so close. so that they can overlap and all overlapped towers transmit the data at a time.
- we have to allocate the different frequencies to the towers which are too close to each other in a location.

Real world problem

- When we change the frequency on radio, there will be a change in station what we are listening to.
- The frequencies must be allocated to their respective radio towers or transmitters in order to get the communication from that tower.
- Suppose when we are travelling from one place to another place when we are listening to (FM) after certain distance we will move away from the broadcasting tower so that the signal become weak and there will be a disturbance.
- After some time if we move closer to another tower we will get connect to different station which is operating under same frequency.

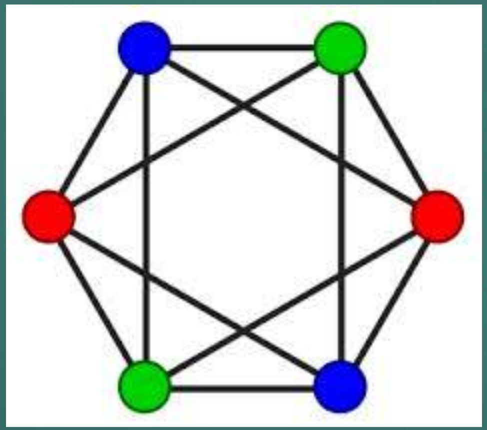
Graph construction

- Here the mission is to assign different frequencies to towers in a location which are too close to each other. This can be assigned using the graph coloring.
- By using the graph coloring the radio frequencies are assigned. graph coloring have the property that no two adjacent vertices will have the same color.
- The towers are considered as the vertices and frequencies are assigned using colors.
- The colors are assigned using the condition that no two adjacent vertices will get the same color for assigning the frequencies.

Graph coloring

Graph coloring is the concept which uses the different colors for the vertices. The main property of graph coloring is to assign the colors to vertices where the no two adjacent vertices will have the same colors.

Graphical representation



Np hard problem

- At present there is no standard mechanism available for the allocation of radio frequencies dynamically.
- This problem can be described as an np hard problem it means it cannot be solved in polynomial time algorithm.
- This type of NP-Hard problem can be efficiently solved using graph coloring when compared to general graphs.

Special properties

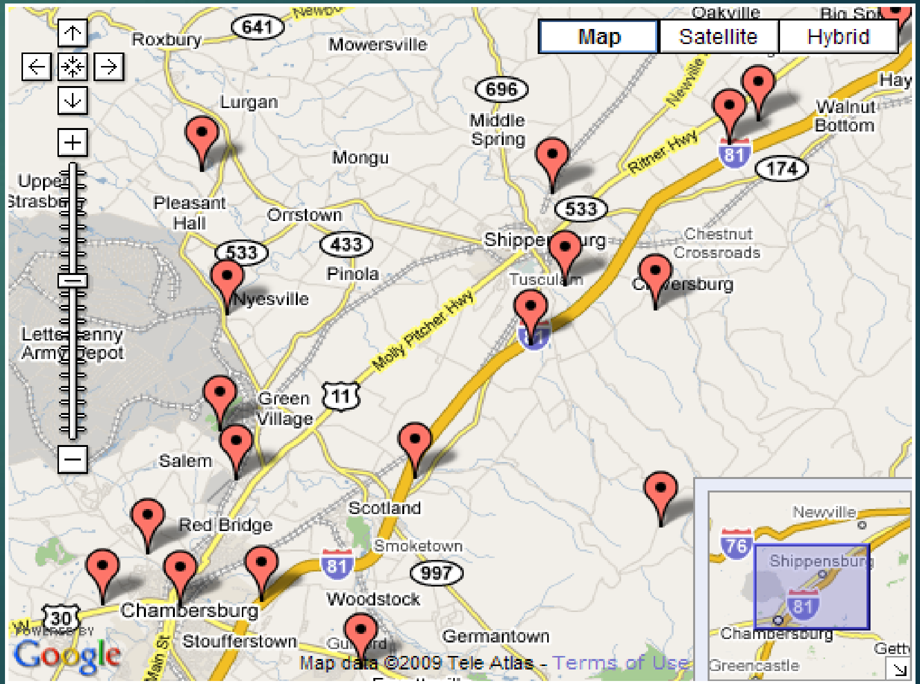
- The chromatic number of the graph G is the smallest number of colors used to color the vertices so that no two adjacent vertices will get the same color.
- The chromatic number is denoted by $\chi(G)$.
- The graphs that can be 1-colored are called edgeless graphs.
- Every bipartite graph which is having at least one edge has the chromatic number 2.
- According to the four color theorem every planar graph can be 4 colored.

Special properties

- Assignment of different colors to different vertices always gives a proper coloring ie $1 \leq \chi(G) \leq n$.
- If a graph G contains a clique of size k then we need at least k-colors are needed to color the clique.
- $\chi(G) \leq \Delta(G)$ for connected G, unless the graph G is a complete graph (Brooks' theorem).

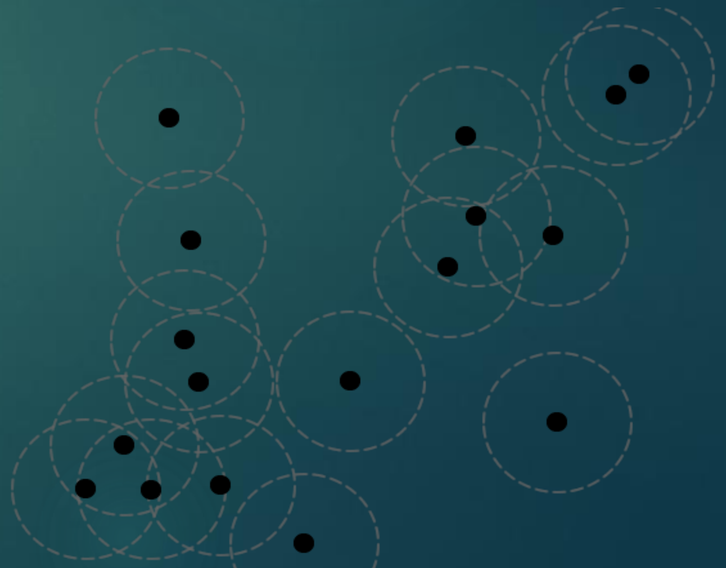
Solution to real world problem

- Let us consider a location with the radio broadcasting towers.
- Every tower has some range for broadcasting which is known as broadcasting range.



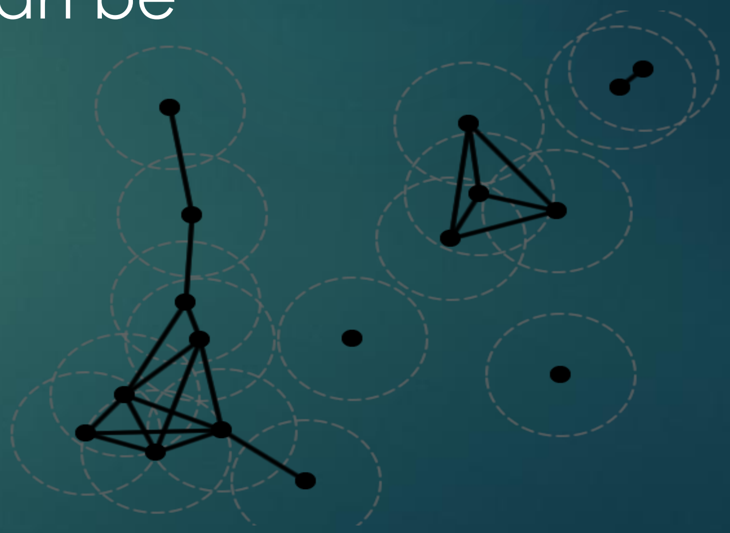
Solution to real world problem

- Let us take a graph to demonstrate the real world problem
- The graph shows an area with the towers where the two towers are connected if the areas overlap with each other.
- The overlapped towers have to be assigned With the different frequencies otherwise all stations play at same time.
- Here each radio tower will be represented by "vertex".
- The radio frequencies are represented using "Colors".



Solution to real world problem

- Now after connecting the edges to the towers which overlap in that area the graph is as follows
- By using the proper coloring we will be coloring that the two towers that are too close to each other can be colored with "different colors"

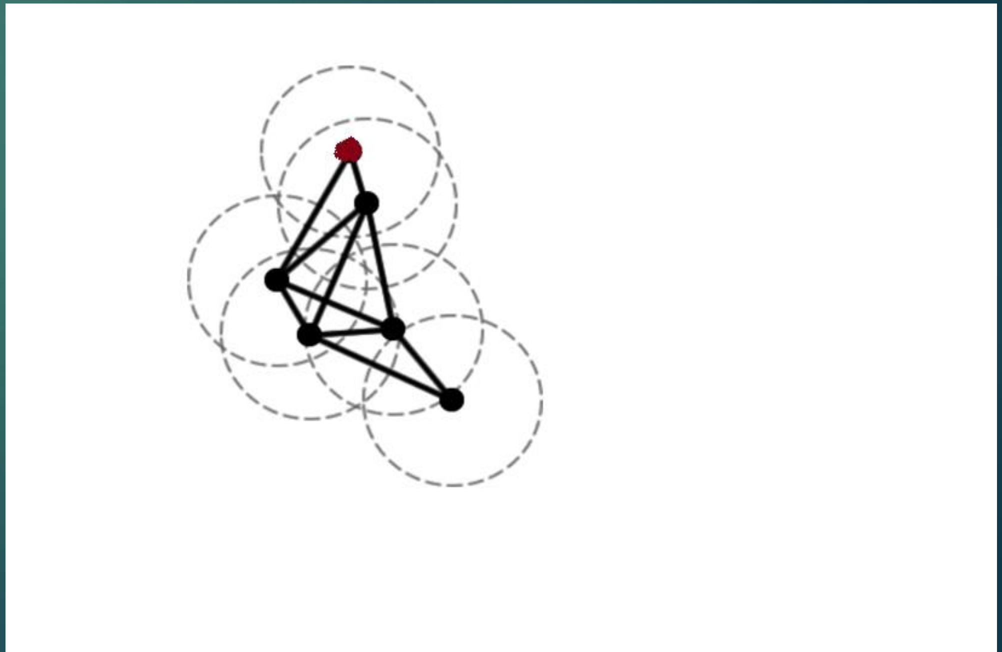


Solution to real world problem

- The proper coloring is done by taking the frequencies as "colors".
- In the above graph let us consider the towers which are too close to each other and the graph is shown as.
- This graph shows the towers which are too close.

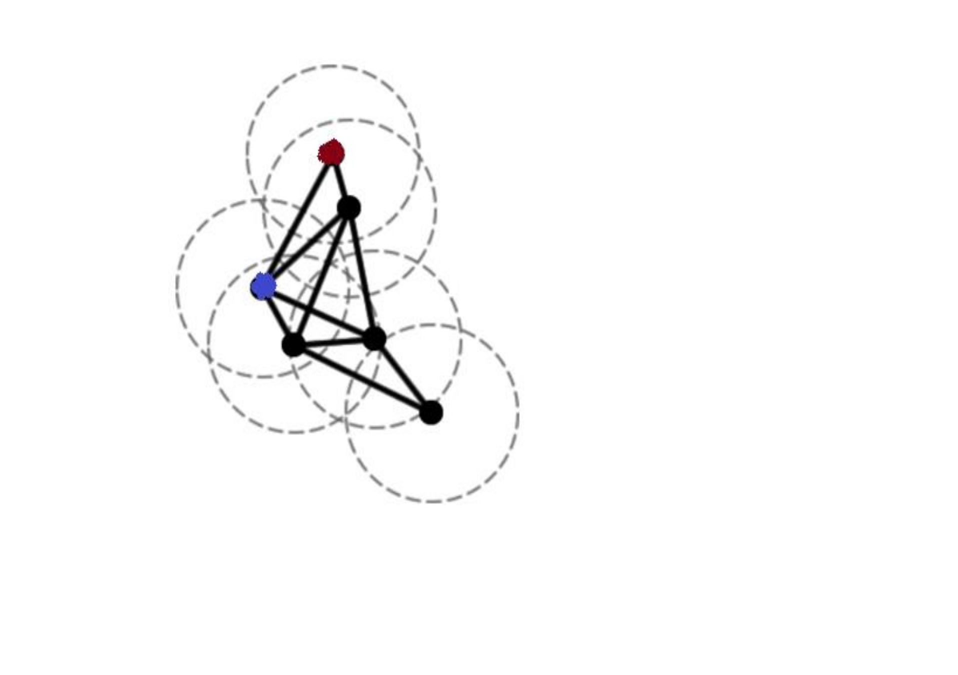
Solution to real world problem

- Let us take different colors for coloring the graph.
- Let us take colors like red, blue, green and yellow.
- At first tower 1 is colored with the "red" color.



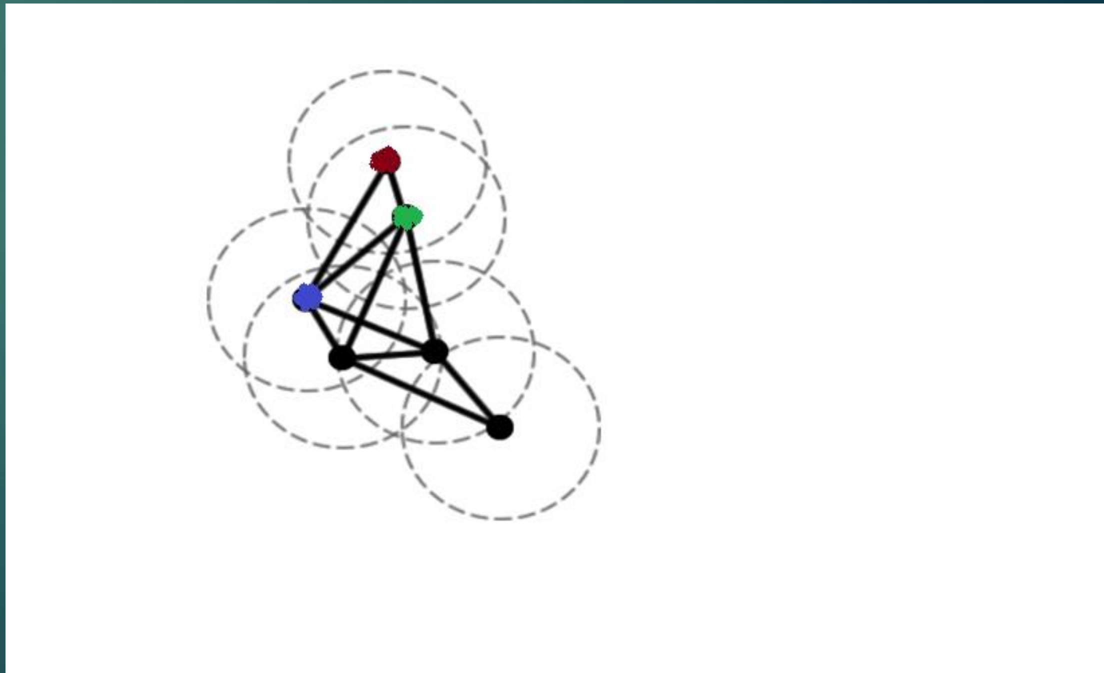
Solution to real world problem

- Now tower 1 is colored with “red” now the towers which are adjacent to the tower 1 cannot be colored with the red .
- So the next tower is to be colored with a different color.
- The tower 2 can be colored using “blue”



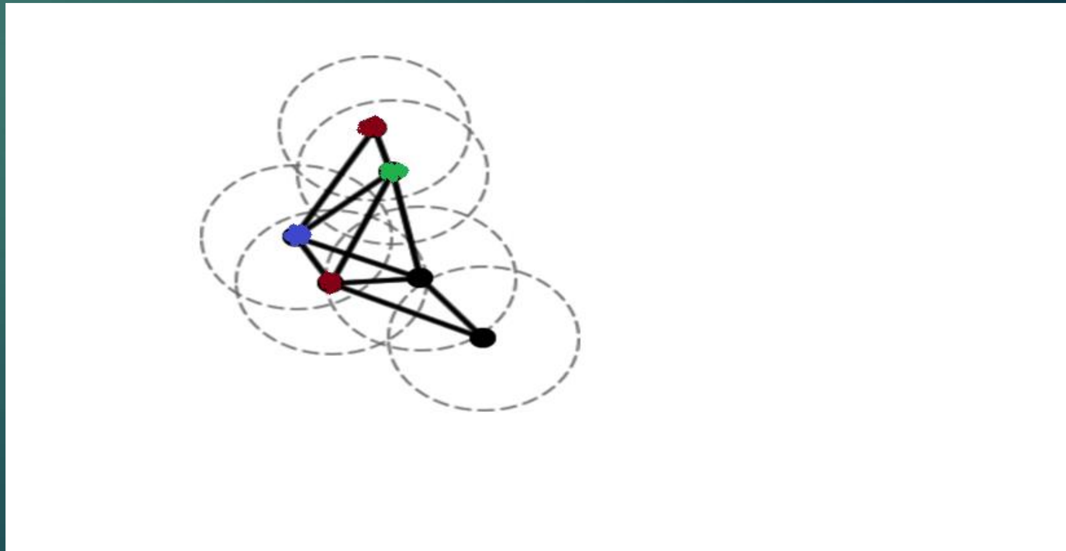
Solution to real world problem

- The tower 1 is colored with red and tower 2 is colored with blue.
- The tower 3 which is adjacent to tower1 and tower 2 so tower 3 cannot be colored with either “red” or “blue”.
- So the tower 3 should be colored with the different color. I am taking the green color for tower 3.



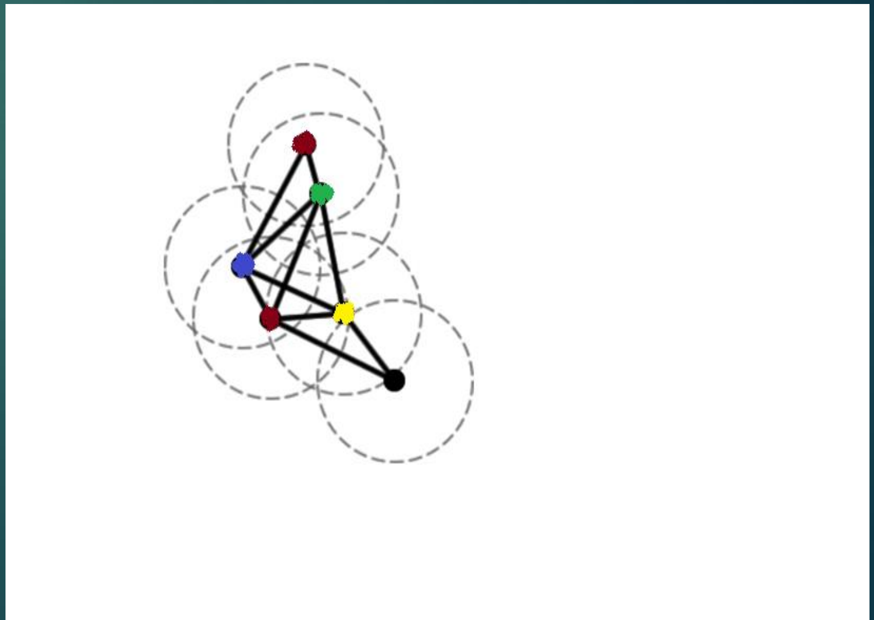
Solution to real world problem

- Now we have used three colors the tower 4 which is adjacent to tower 2 ,3,4,5.
- Here we have colored tower 2 and tower 3 so we will consider these to towers as a condition for coloring tower4.
- So we cannot use the blue or green color. We can use the red color
- The tower 4 is colored with “red”.



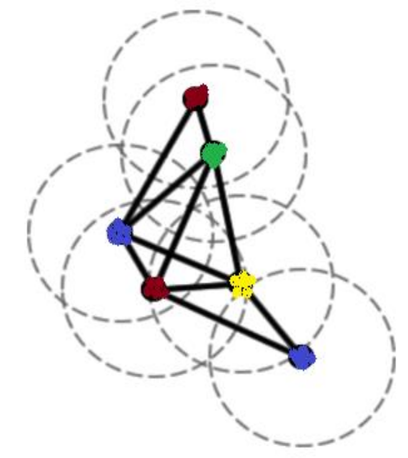
Solution to real world problem

- Now we have used three colors red, blue, and green.
- Tower 5 which is adjacent to tower 2, tower 3, and tower 4 and tower 5. tower 5 is not considered because it is not colored.
- Here we cannot assign red , blue and green so we need the another new color.
- So tower 5 can be colored using yellow.



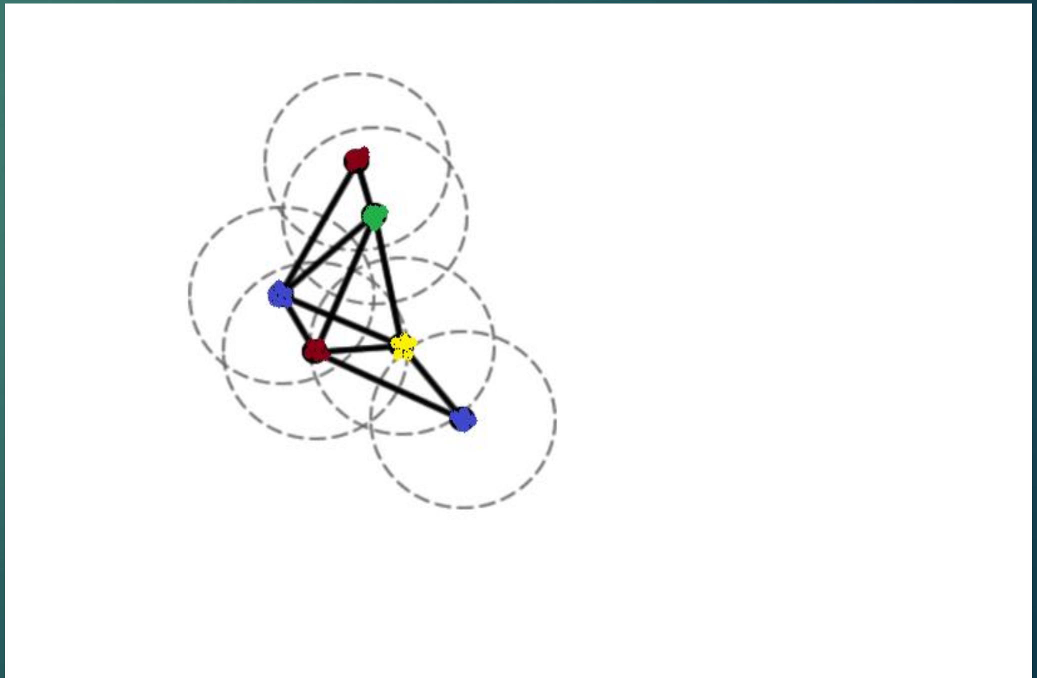
Solution to real world problem

- Now we have the last tower which is tower 6 it is adjacent to tower 4 and tower 5.
- Tower 6 cannot be colored with red or yellow so it is colored with blue.



Solution to the real world problem

- Here each color represents the radio frequencies for the towers.
- Here we have used four colors to allocate the radio frequencies to towers.
- So the chromatic number is 4.



References

Graph coloring and frequency assignment

http://www.zib.de/groetschel/teaching/SS2012/GraphCol%20and%20FrequAssignment.pdf

Graph coloring and their properties.

https://en.wikipedia.org/wiki/Graph_coloring

Thank you