Buffer Zone in Hotspots: Voronoi Tessellation Method

Prof. Manjesh K. Hanawal, IEOR, IIT Bombay

For a given set of Base Transceivers Stations (BTSs) in a geographical area it is hard to demarcate where the coverage area of each BTS ends due to various factors (e.g. power emitted, attenuation factors). BTSs within a hotspot can also serve users outside the hotspot area. Hence it is not possible to say if a mobile served by BTSs within a hotspot is present inside or outside the hotspot. If users' association with BTSs within a hotspot is used for such information, there will be a lot of false alarms. An example of potential false alarm is shown in the following figure where the mobiles in green color are outside the hotspot but are being served by the BTSs inside the hotspot and hence will be classified as present within the hotspot if their association with BTS within the hotspot is considered.

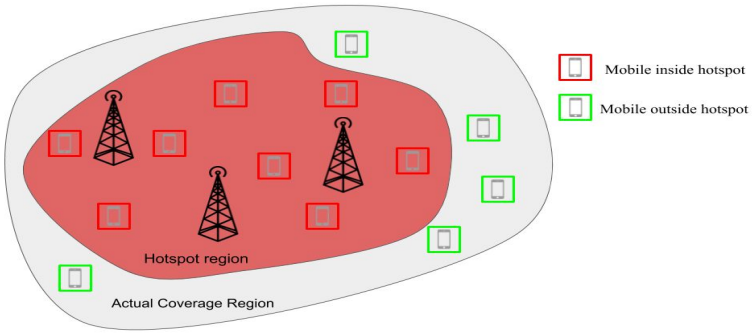

Figure: The green mobiles are served by the BTSs in the hotspot but are not in hotspot.

To minimize the false alarms we can create buffer zones around a hotspot such that all the mobiles in the buffer zones are also served by the BTSs with the hotspot as much as possible. We discuss below one possibility of creating buffer zones with Voronoi tessellation method.

Voronoi Tessellation: Given a set of BTSs in a geographical area, Voronoi Tessellation (VT) partitions the area such that there will be one partition for each BTS and all the points in a partition will be closest to the BTS associated with the partition. An example of VT is shown in the following figure:

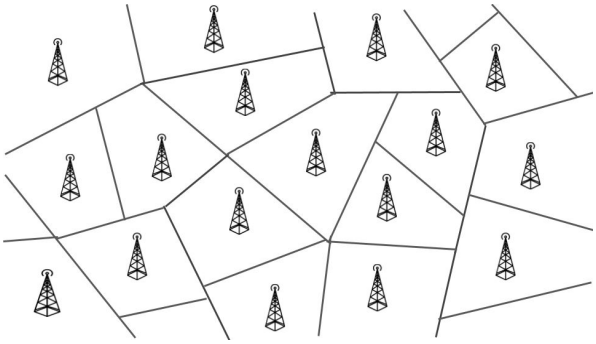

Figure 2: Voronoi Tessellation

All the mobiles that are within the partition associated with a BTS are likely to connect to that BTS only as their signal strength will be stronger there compared to other BTSs. This assumption works well in the open areas with good line of sight connectivity between mobiles and BTSs. However when there are many obstacles (walls, uneven terrain) VT method could fail. In the following we assume that the VT method largely holds for the mobile association with BTSs, i.e, mobiles connect to BTSs that are geographically nearest to it.

Buffer zone creation: Given a hotspot area, we can find the list of partitions in the VT that overlaps with it. The hotspot overlap with a partition could be partial and not necessarily complete. It is clear that the set of BTSs associated with these partitions will most likely serve the mobiles in the hotspots and not the other BTSs (associated with the non overlapping partitions). We take union of the partitions associated with these 'hotspot serving' BTSs as the new 'hotspot with buffer zone'. An hotspot and hotspot with buffer zone are shown in the figure below. Any mobile that is outside the hotspot with buffer zone will not be served by the BTSs with the hotspot with buffer zone and hence is unlikely to be wrongly classified as inside the hotspot zone thus significantly reducing the false alarms that would have arised without buffer zones. However the drawback of adding buffer zones is that it overestimates the number of mobiles in a hotspot area.

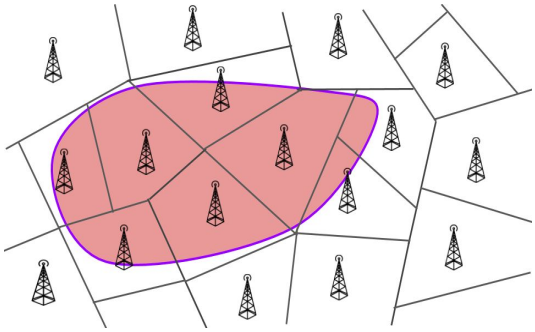

Figure: Hotspot area in blue

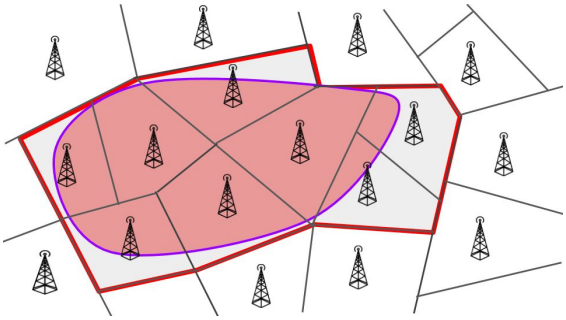

Figure: Hotspot are with buffer zone in red

Another example with a circular hotspot region.