VON Procedures



Figure 1: Voronoi diagram

(a) Dots indicate *sites*, and lines define boundaries (*edges*) for *regions*. (b) Large circle is the AOI boundary for the center node. Squares (\blacksquare) are *enclosing neighbors*; triangles (\blacktriangle) are *boundary neighbors*; stars (\bigstar) are *both* enclosing and boundary neighbors; circle (\bigcirc) represents a regular *AOI-neighbor*; crosses (\leftthreetimes) represent neighbors irrelevant (i.e. outside of AOI) to the center node.

Voronoi-related definitions

Site: a point (i.e. node) on 2D plane defined by a (x, y) coordinate pair. Voronoi diagram: a geometrical method to partition a 2D plane with *n* sites into *n* areas such that each point in the area is closer to the area's site than to any other site. Region: area that belongs to a particular site after partitioning. Edge: boundary lines that define Voronoi regions.

Node definitions

Joining node: the node that is about to join VON.

Moving node: the node that is moving (i.e. sending position updates to its neighbors). Leaving node: the node that is leaving VON (whether normally or abnormally). Acceptor: the node whose Voronoi region contains the joining node's initial position. Gateway server: an authority that assigns unique ID for each node in VON.

Neighbor definitions (for a given node *n*)

AOI neighbors (AN): nodes whose coordinates are inside the AOI of *n*.Enclosing neighbors (EN): nodes that have shared edges with *n*'s Voronoi region.Boundary neighbors (BN): AOI neighbors whose ENs may be outside the AOI of *n*.

VON Procedures

JOIN procedure

- 1. Joining node contacts the gateway server for a unique ID.
- 2. *Joining node* sends a join request with its coordinates to any existing node (which can be the *gateway server*).
- 3. Join request is forwarded to the *acceptor* (i.e. the node whose region contains the joining node's coordinates) by greedy forward (see Fig. 2a).
- 4. Acceptor responds by sending a list of joining node's AOI and enclosing neighbors.
- 5. Joining node connects to each neighbor on the list*.
- 6. *Joining node* builds up a Voronoi diagram of its *AOI neighbors* while the contacted nodes update their Voronoi diagrams to accommodate the *joining node* (see Fig. 2b).

MOVE procedure

- 1. Moving node sends position updates to all connected neighbors.
- 2. Boundary neighbor checks if any of its own enclosing neighbors has entered the moving node's AOI (see Fig. 3a) or if the moving node has any new enclosing neighbor. If so then it sends a notification.
- 3. If a valid new AOI neighbor is discovered, the moving node connects to it*.
- 4. Moving node disconnects any boundary neighbor that has left its AOI (see Fig. 3b).
- 5. All nodes update their Voronoi diagrams to reflect the current topology at each step.

LEAVE procedure

- 1. *Leaving node* simply disconnects (there is no distinction between proper and abnormal departures from the overlay network, see Fig. 4a).
- 2. Affected neighboring nodes update their Voronoi. If a *boundary neighbor* leaves, replacements are learned via still-connected *boundary neighbors* (see Fig. 4b).

* When any node A initiates a connection to node B, it also sends its knowledge of *node B's enclosing neighbors* during handshakes. Node B would then verify and notify node A of any missing ones.



Figure 2: JOIN procedure (a) *Gateway server* and its ENs are the circles. *Acceptor* and its ENs are the squares. Star (\bigstar) is the intended joining spot. Join request is forwarded to the acceptor (b) Star (\bigstar) is the *joining node*, shades are neighbors affected by join. Note that the effect is localized.



Figure 3: MOVE procedure (a) Triangle (\blacktriangle) indicates the intended new position. Squares (\blacksquare) are new neighbors about to be discovered. Stars (\bigstar) are the *boundary neighbors*. (b) After the move, crosses (\bigotimes) are the neighbors no longer inside the AOI, therefore are disconnected.



Figure 4: LEAVE procedure (a) Cross (\times) is the *leaving node*. (b) After node leave, triangle (\blacktriangle) is a new *enclosing neighbor* discovered by still-connected *boundary/enclosing neighbors* (Squares \blacksquare).