Self-organizing Spatial Publish Subscribe

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Introduction

- Spatial simulations (e.g., Massively Multplayer Online Games, or MMOGs) allow entities (i.e., players) to send or receive messages from an area.
- Described as Spatial Publish Subscribe (SPS):
  - Subscribe an area
  - Publish messages to an area
  - Get publications if pub/sub areas overlap
  - Move a subscribed area
- To scale up spatial simulations, partitioning of the space is needed, but with fixed partitioning:
  - Entities may overload a partition
  - Lack of entities may underload a partition

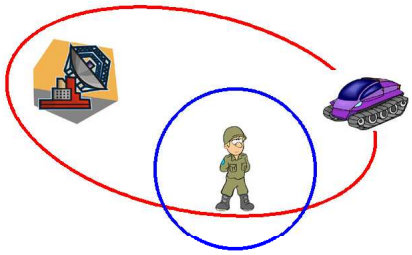

Figure 1: different entities have different interests (e.g., solder and radar have different listen scopes)

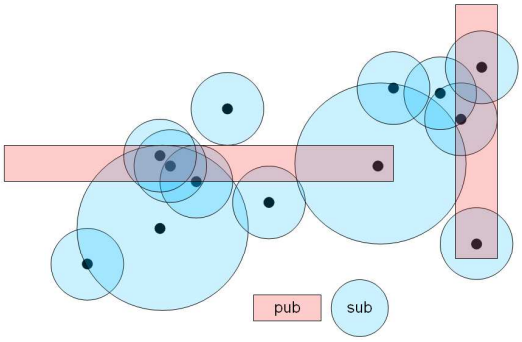

Figure 2: Spatial Publish Subscribe (SPS) is a general mechanism

Design of VSO

- Voronoi Self-organizing Overlay (VSO)
  - *Client*: an entity (e.g., a user) in the system
  - *Matcher*: a manager of a region that matches publications with subscribers
  - Matchers partition & manage the entire space into *regions*
- Basic procedure:
  - A client connects to a matcher
  - The client sends pub/sub requests to matcher (in the form of center + radius)
  - Subscription requests recorded at the *owner matcher* (who covers sub centers)
  - Matchers check if a publication should be delivered to a subscriber
- Key design elements:
  - Matchers form a fully-distributed Voronoi-based Overlay Network (VON), (Fig. 3.)
  - If a pub/sub request lies outside of region, it is forwarded via VoroCast, (Fig. 4.)
  - Scalable as matchers can be added/removed, fault-tolerant as fully-distributed.

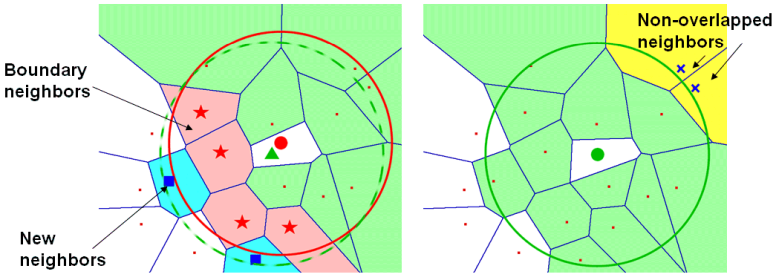

Figure 3: Neighbor discovery in VON. Boundary neighbors (stars) can notify existence of new neighbors (squares).

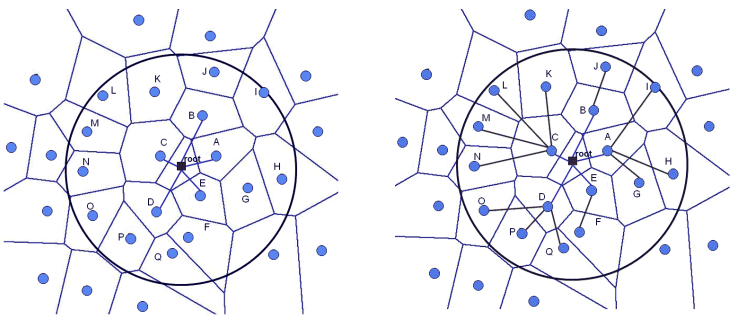

Figure 4: Non-redundant multi-cast paths in VoroCast

Self-organization of VSO

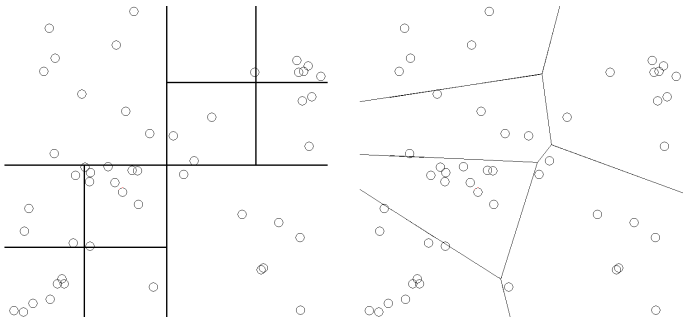

Figure 5: Quad-tree (10 regions) vs. Voronoi partitioning (6 regions)

- Advantages of Voronoi partitioning:
  - produces fewer regions for same load per region (Fig. 5)
  - can be adjusted easily for load balancing
- Adjustment rules for matcher overload:
  - shrink region sizes by asking neighbors to come closer
  - request matcher insertion (from a *gateway*), if overload persists
  - a matcher continuously moves its *site* (center) to center of entities

Summary

- SPS is a basic primitive for spatial simulations
- Voronoi diagrams provides self-organizing spatial partitioning
- VSO supports scalable & fault-tolerant SPS operations

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