Spatial Publish Subscribe

IEEE Virtual Reality workshop MMVE'09

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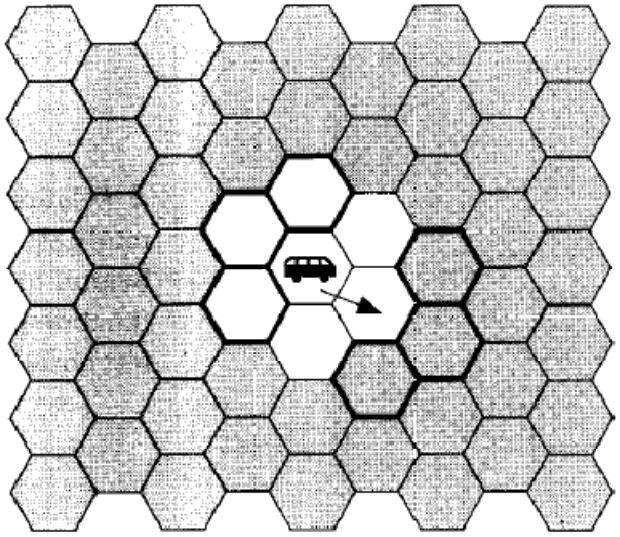
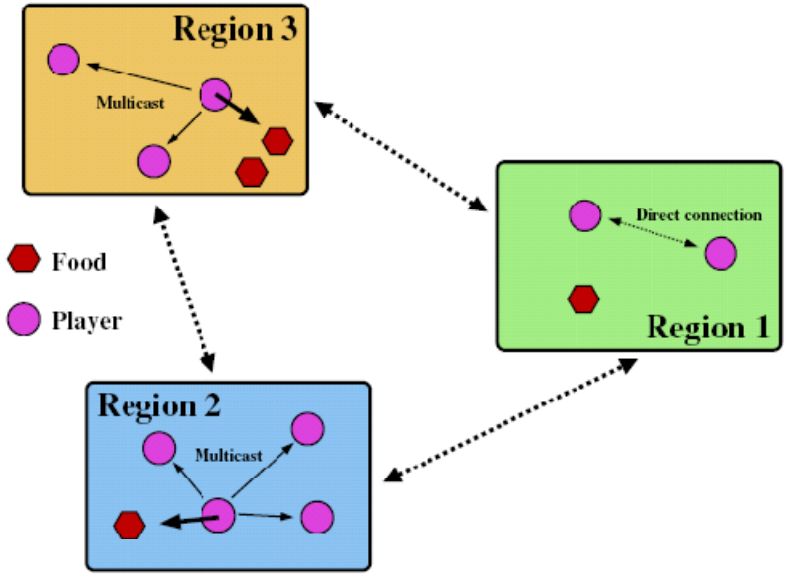
A basic primitive for virtual worlds?

- Many existing designs for building scalable virtual environments (VEs)
- Any common requirements / features?
- A common interface / API?

Spatial multicast (know thy neighbors)

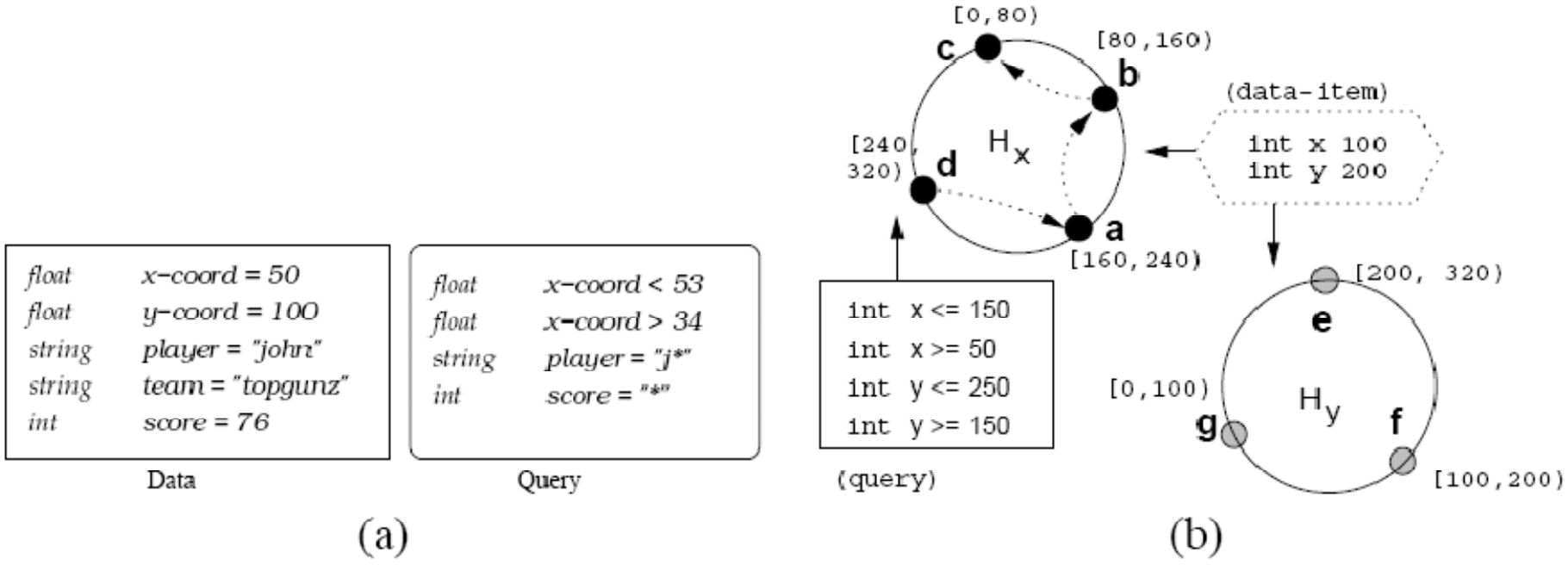
- NPSNet (Macedonia et al. ’95)
- SimMud (Knutsson et al. ‘04), Solipsis, VON, COVER,…
- Simple to understand, easy to implement

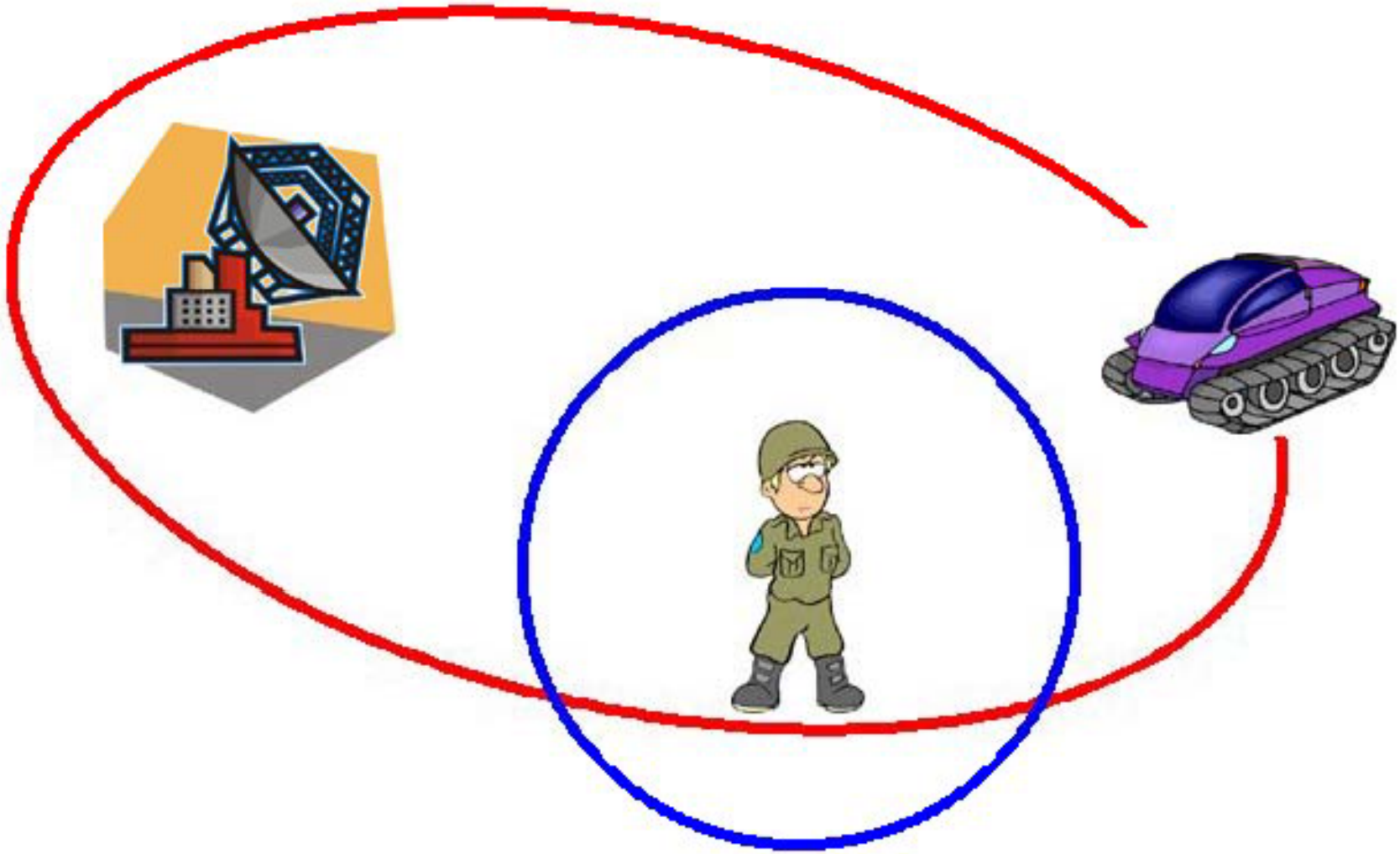




Spatial query (know thy neighbors' goods)

- OpEN (Tanin et al., '04)
- Colyseus (Bharambe et al, '06), GP3, …
- Persistent states that allow multiple queries





Spatial Publish / Subscribe (SPS)

- Why not support both?
  - Spatial multicast → publications
  - Spatial query → subscriptions
- Flexibility
  - publication / subscription of any shape / size
- Advantages
  - No continuous query ← spatial query
  - Fine-grained filtering ← spatial multicast

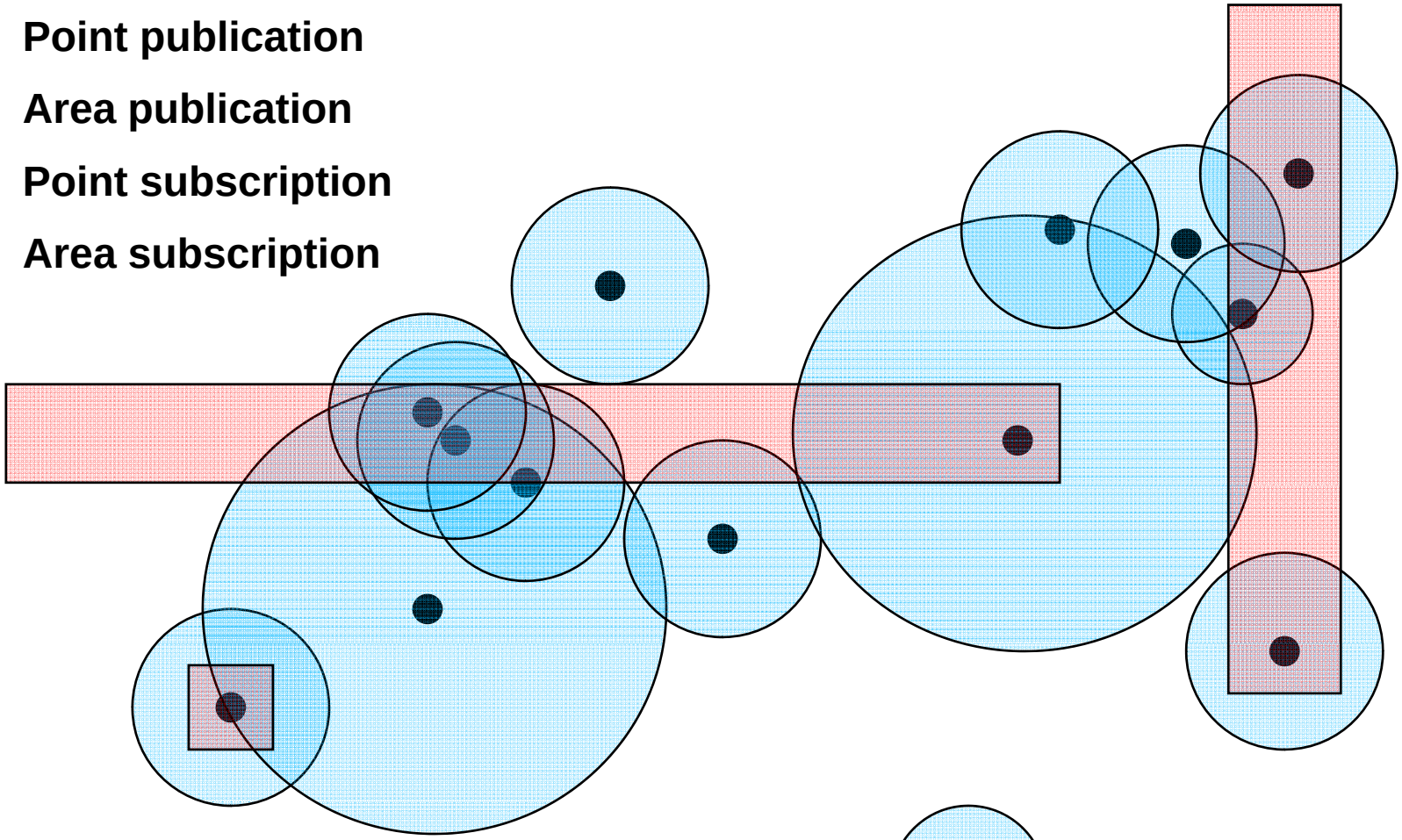
SPS: basic operations

Point publication

Area publication

Point subscription

Area subscription



pub

sub

Usage scenario

- Existing research (in the P2P space)
  - Overlay management
    - How do peers connect?
    - Solipsis, VON, N-tree, COVER, OPeN, APOLO, VoroCast
  - State management
    - How to manage objects?
    - SimMud, HYMS, Colyseus, VSM, Hydra
  - Content management
    - How to deliver content?
    - Voice (QuadCast, PartyPeer), 3D (FLoD, LoDDT, HyperVerse)

Overlay management

- Goal: provide a list of AOI neighbors
- SPS approach
  - Area subscriptions + point publications
  - Point subscriptions + area publications
  - State managers for late joiners

State management

- Goal: arbitrators to update & distribute states
- SPS approach:
  - Arbitrators (i.e., servers):
    - Area subscription in *event layer*
    - Point publications in *update layer*
  - Actors (i.e., clients):
    - Point publications in *event layer*
    - Area subscriptions in *update layer*
  - Arbitrators to update late joiners

Content management

- Goal: content delivery for same-view users
- SPS approach
  - Discovery: subscription of AOI neighbors
  - Exchange: peer-exchange with AOI neighbors

Conclusion

- SPS may be a flexible primitive for VEs
- Implementation challenges
  - Scalable (low message overhead)
  - Responsive (publications → subscribers)
  - Topology-aware (considers physical proximity)
- Important research topic for VE community

Q & A

Thank you!

What's missing?

- More generic functionalities
  - Flexibility
    - Any publication / subscription areas (a 30 km gun!)
    - Any mix of direct / forward connections
  - Practicality
    - Network environment (topology / NAT-aware)
    - Client environment (capacity-matching, superpeers)

Related work

- Communication architecture (Fiedler et al. ‘02)
  - Grid partitioning + channel-based pub/sub
- Mercury (Bharambe et al, ’06)
  - Spatial query to support pub/sub
  - Too flexible (any object field can be range-queried)
- DiGAS (Bonotti et al. ’07)
  - Flood all publications to all brokers
- HLA’s Data Distribution Management (DDM) (’97)
  - Too flexible (similar to Mercury)