DynFilter: Limiting Bandwidth of Online Games using Adaptive Pub/Sub Message Filtering

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Introduction and Background

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2 DynFilter Architecture

3 Load Analysis & Optimization

4 Experiments

5 Conclusion

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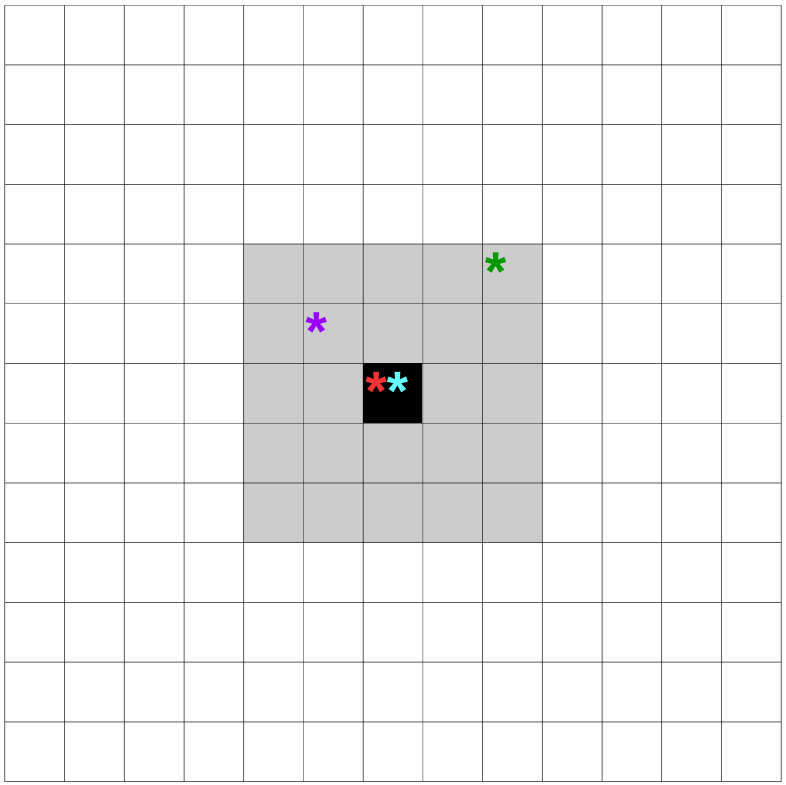

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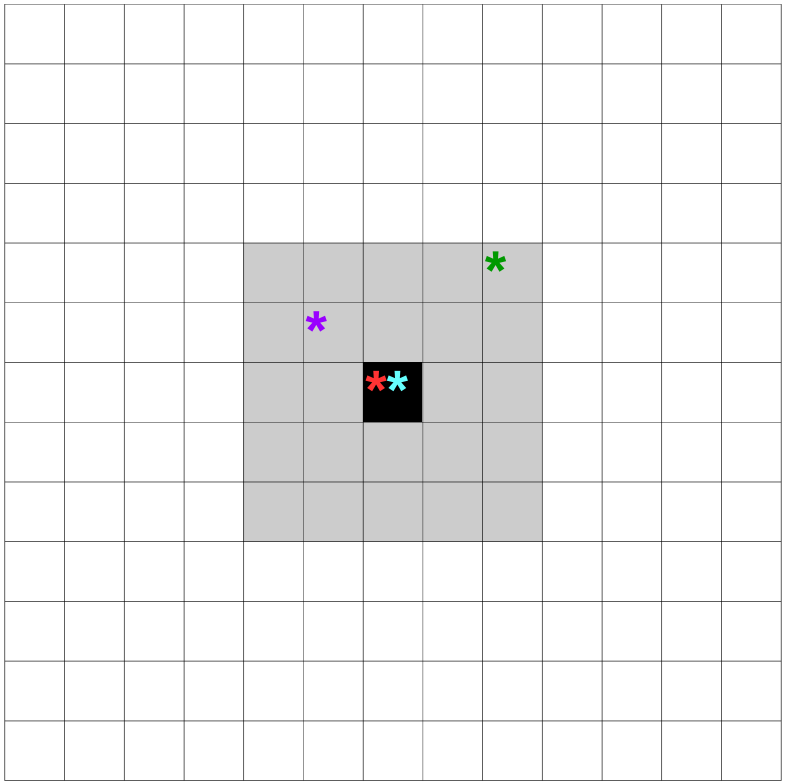

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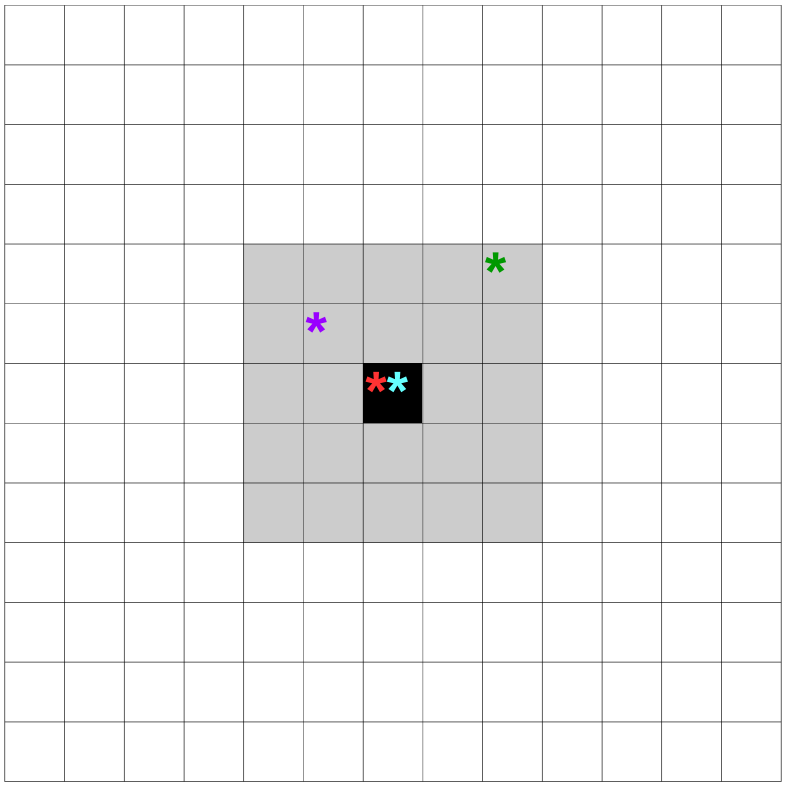

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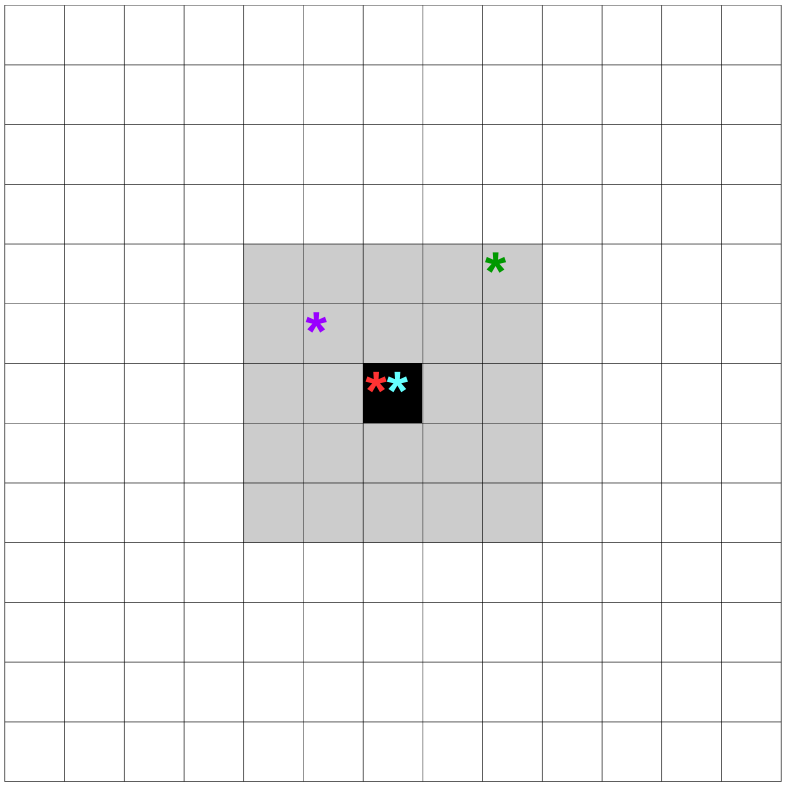

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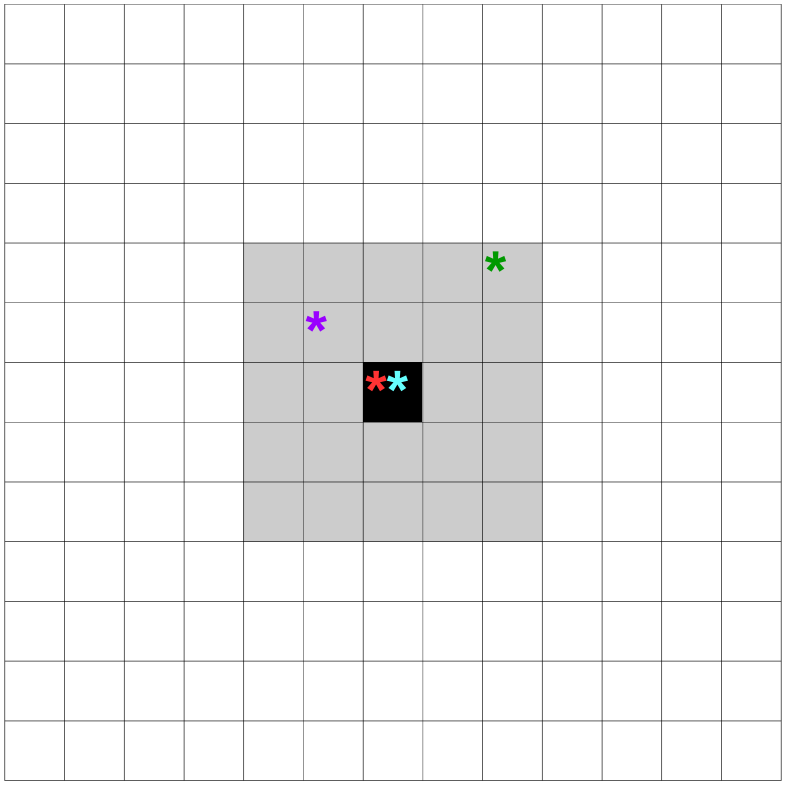

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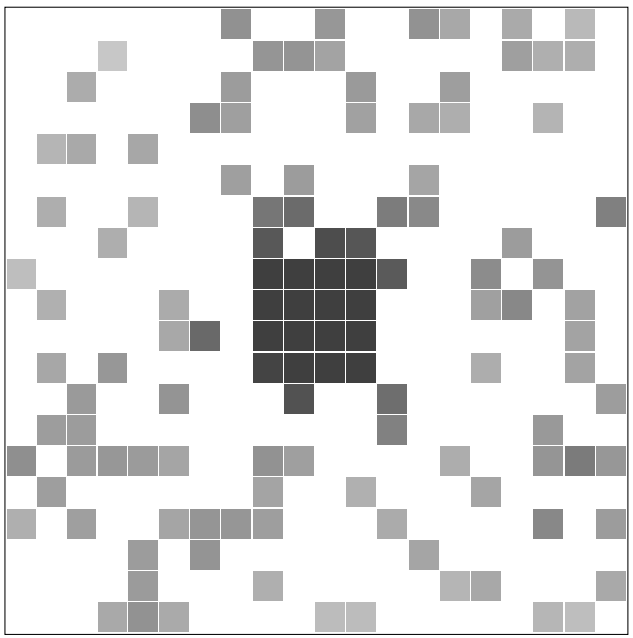

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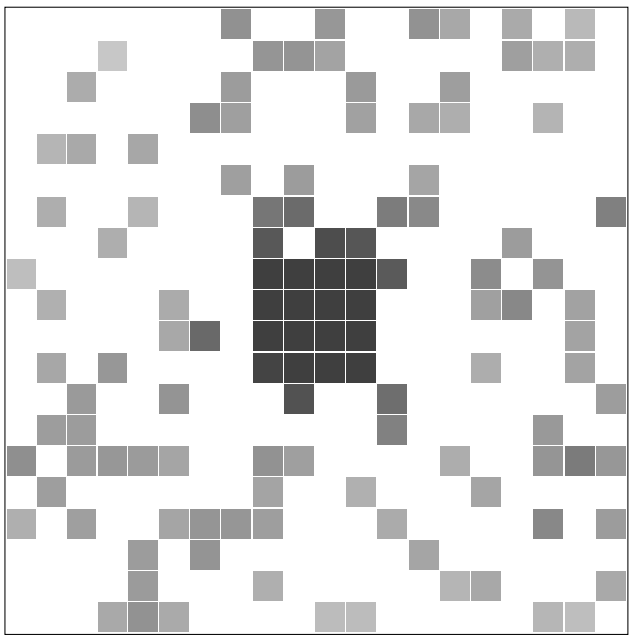

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- More players:
  - State updates of each individual player less important
  - Larger bandwidth usage

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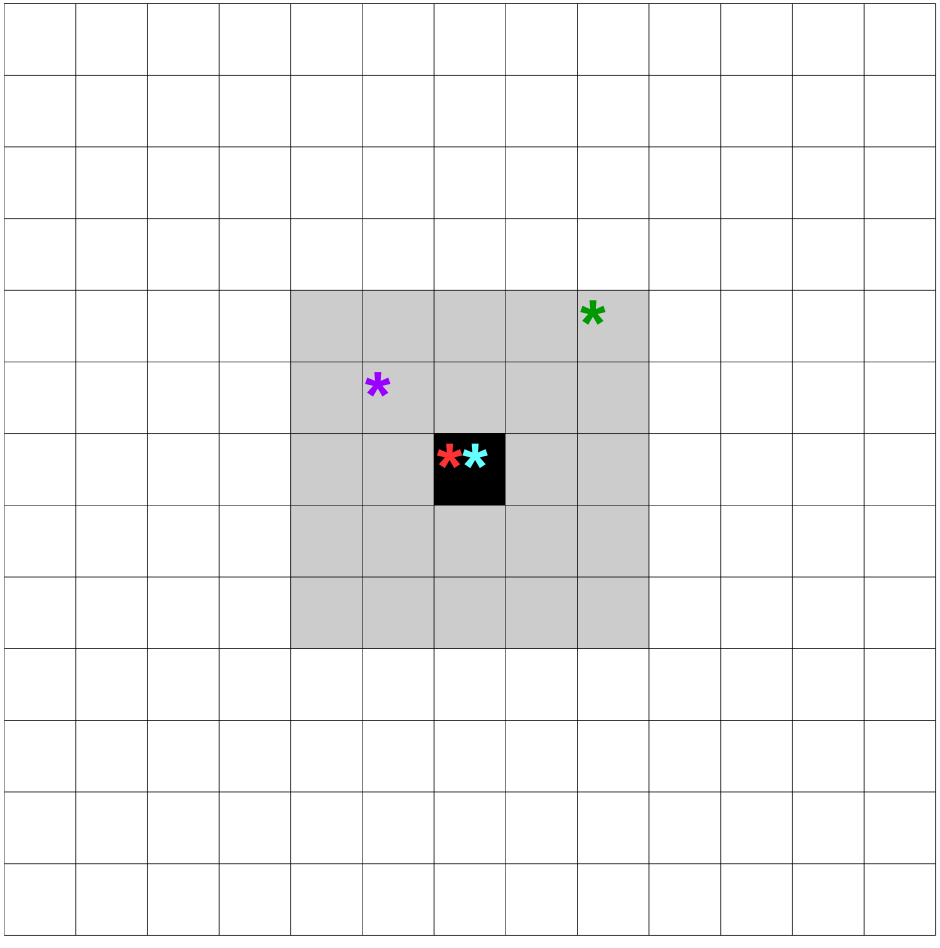
If state updates are too infrequent:

- Perception of "lag"
- Players / objects jumping
- Reduction in fun factor

Interest Management



- Goal: limiting the amount of messages that need to be transmitted
- No need to transmit state updates from all entities to all entities
- **Tile-Based Interest Management**

Motivation

- Problem: highly-variable bandwidth needs
- Popular games: lots of game servers (WoW: 250 servers[1])

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  - Large number of players, flocking

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- DynFilter: limiting bandwidth use in order to limit costs

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- **Subscribers** (in blue) subscribe to topics
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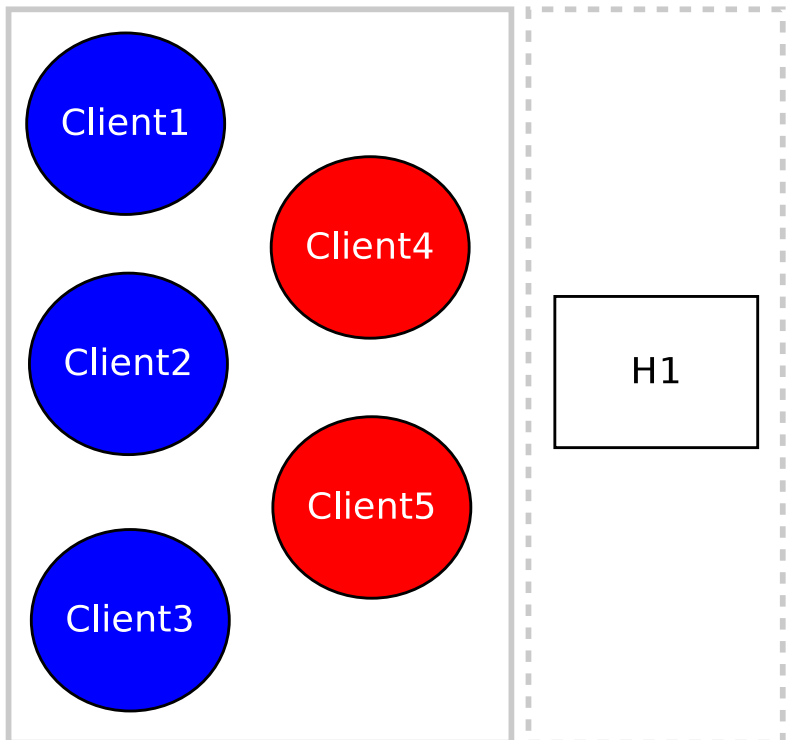
- All subscribers of a given topic c will receive all publications sent through c



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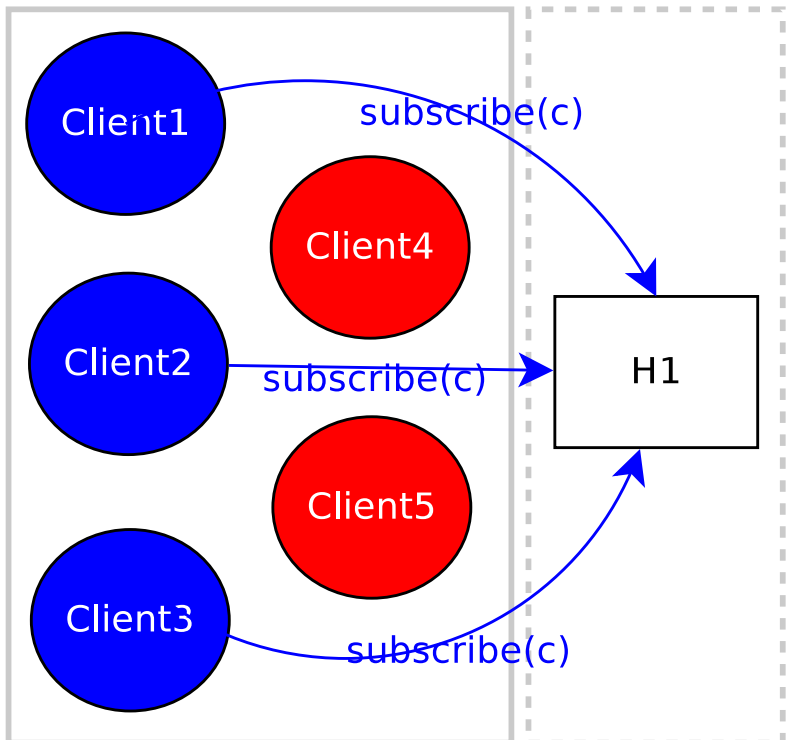

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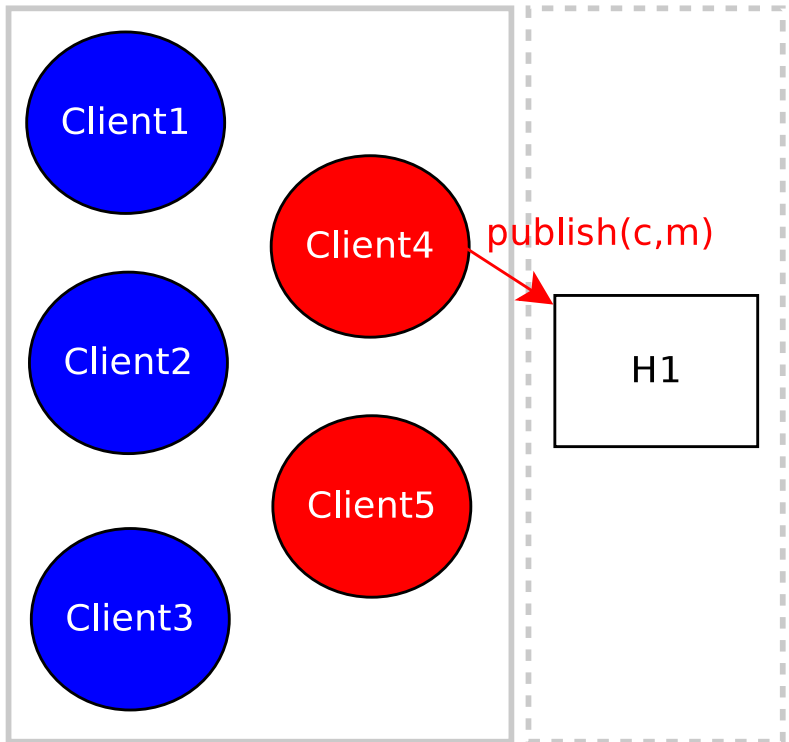

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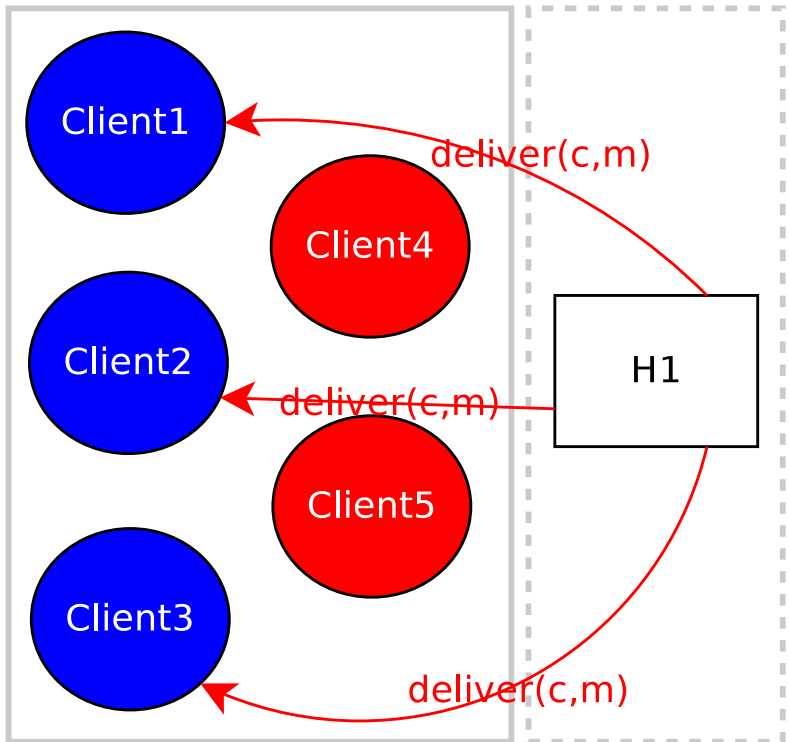

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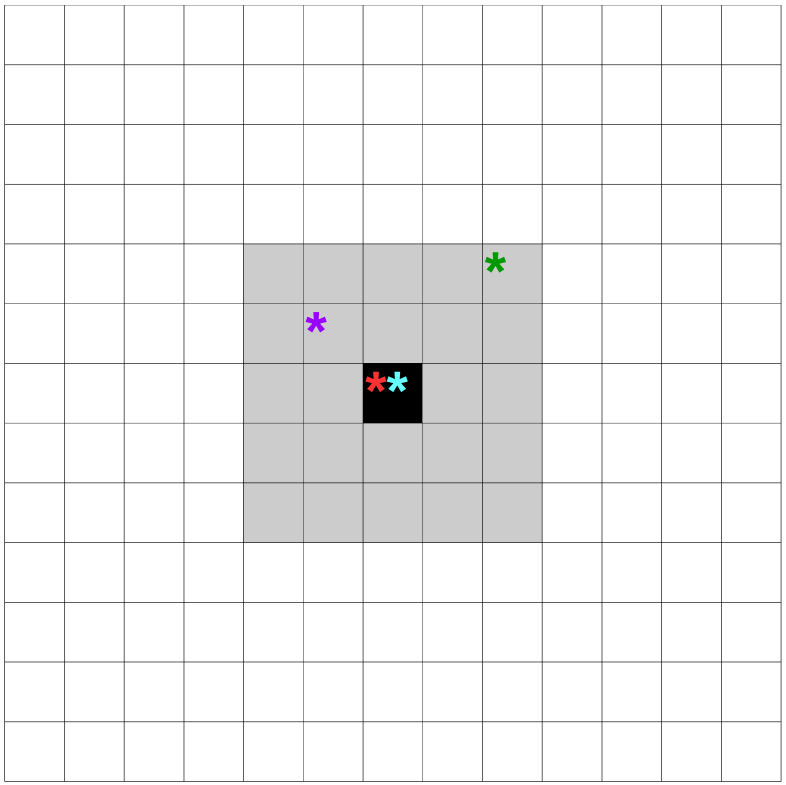
Game world divided in square tiles ($Z = 2$)



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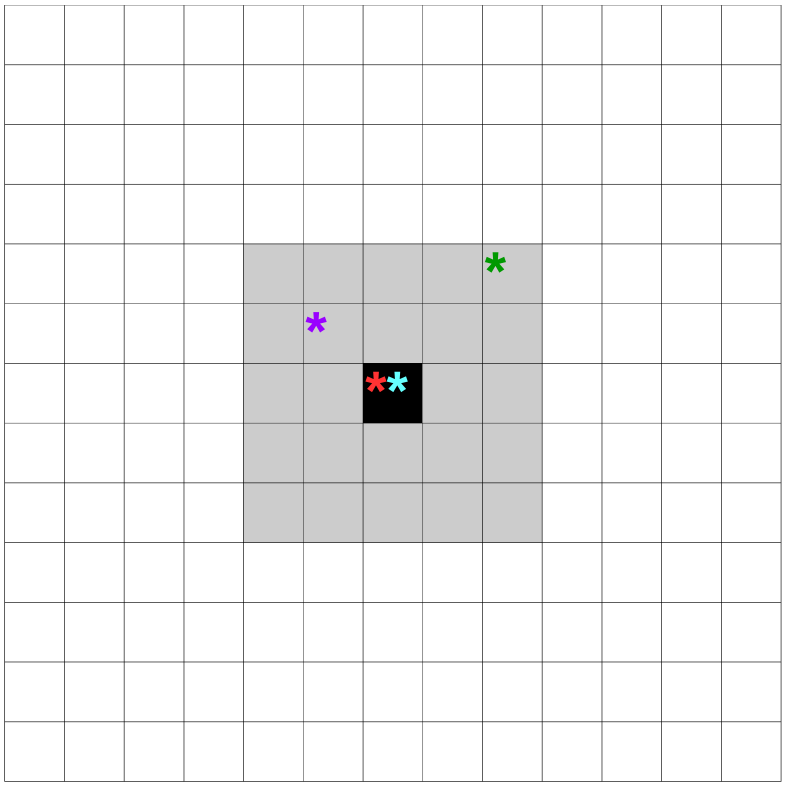

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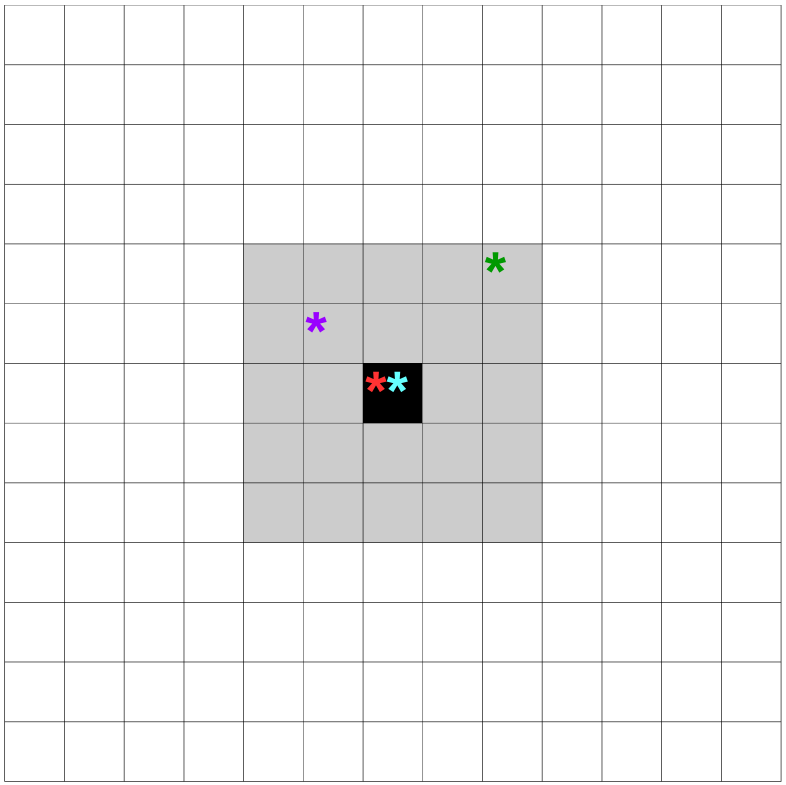

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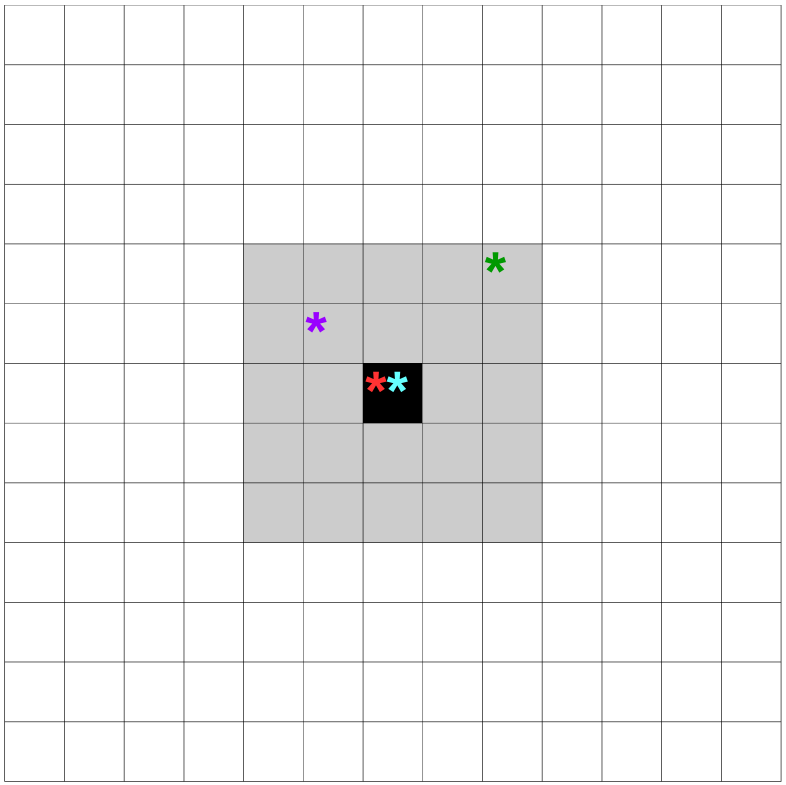

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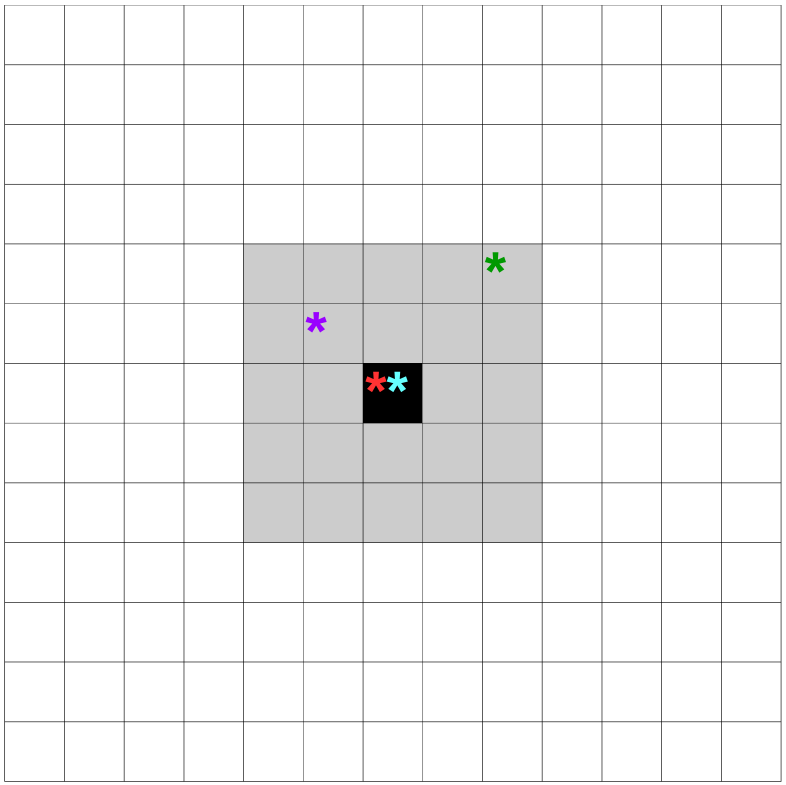

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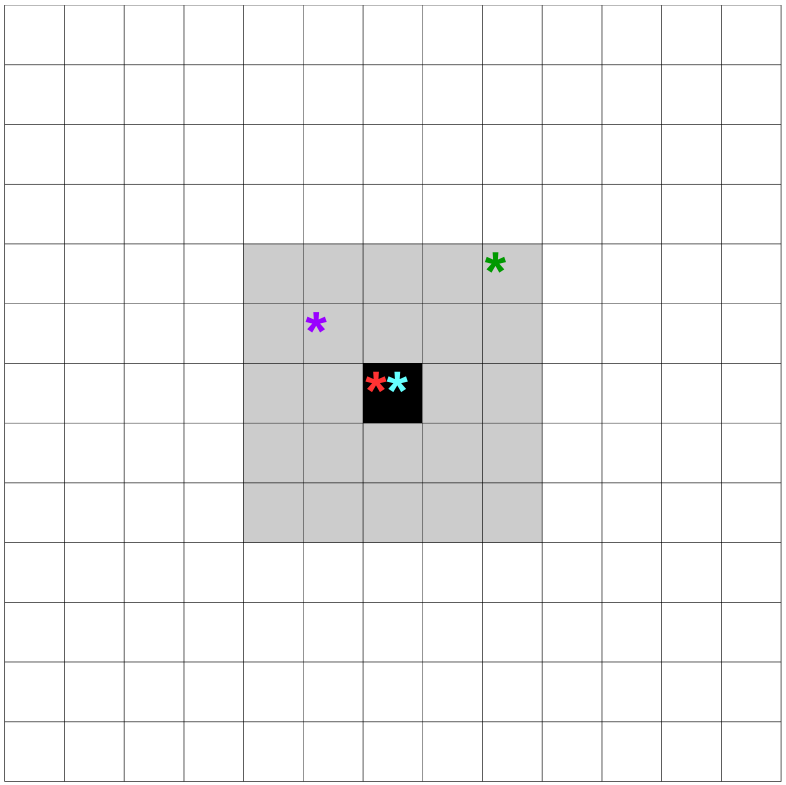

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- Players in grey area: low update frequency $\rightarrow$ filtering may apply!

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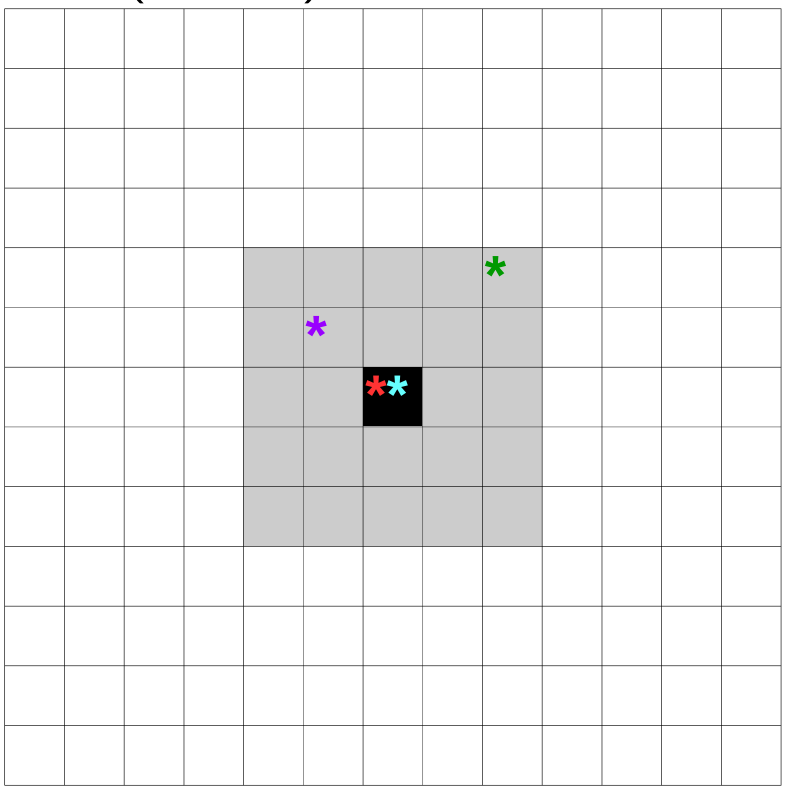

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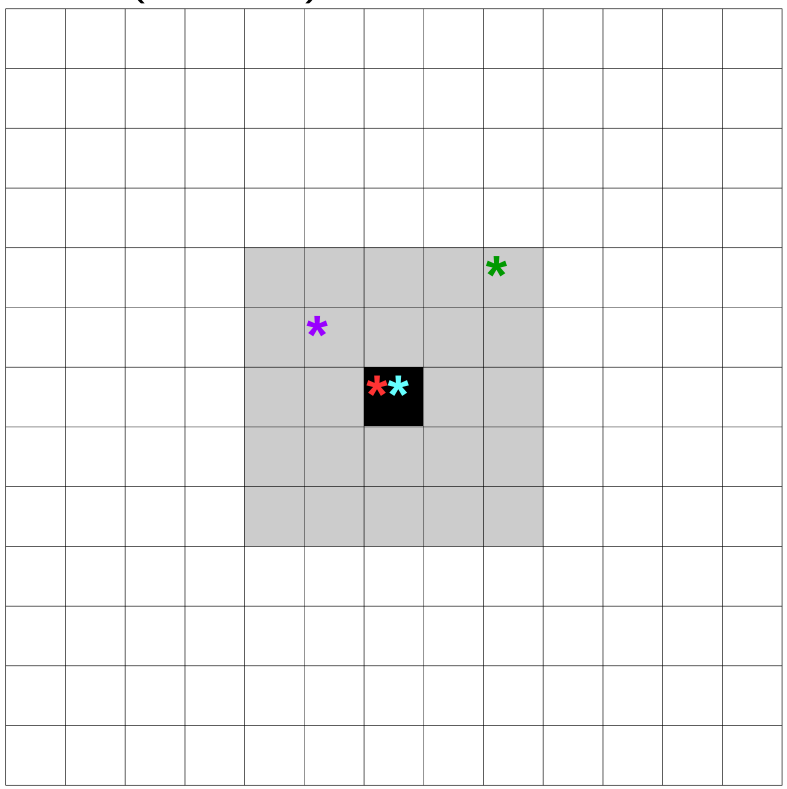

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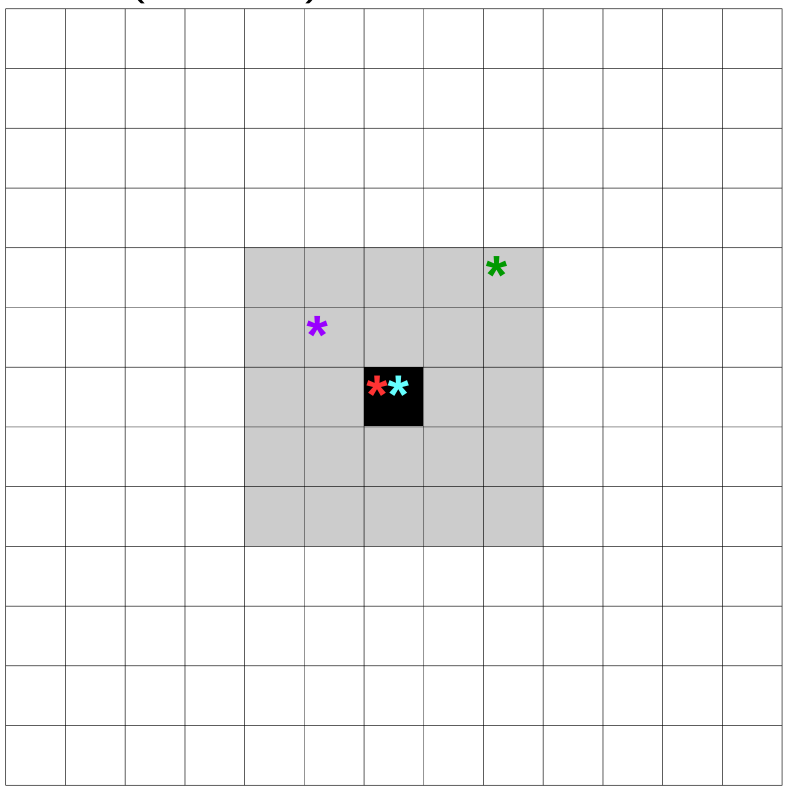

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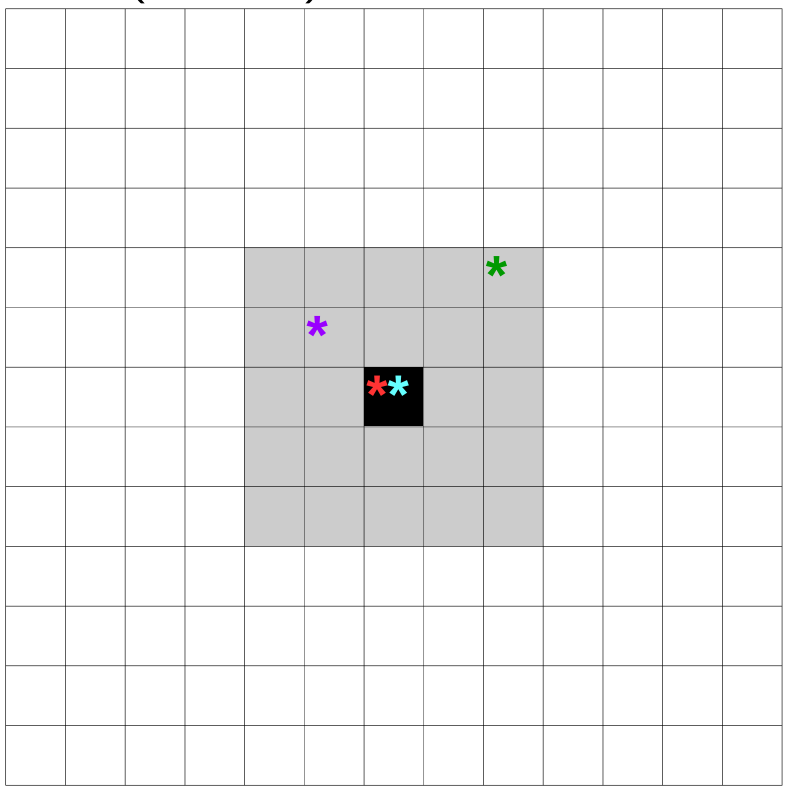

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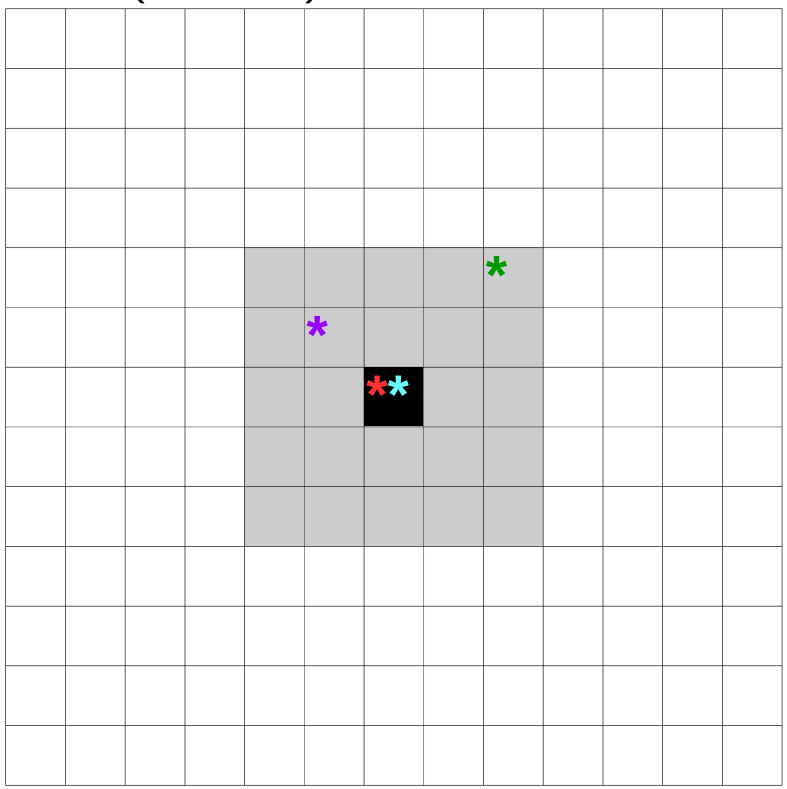

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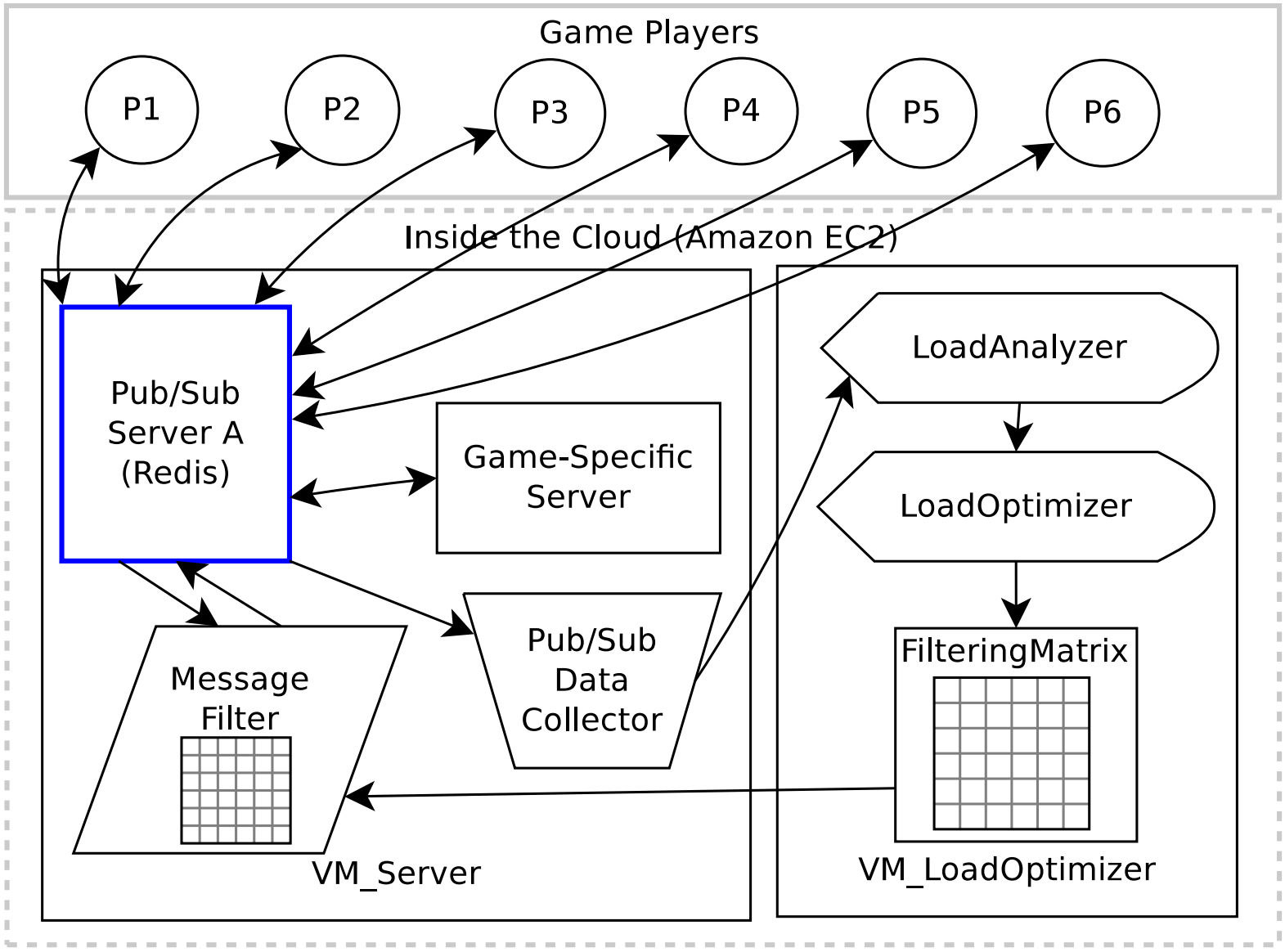
Architectural Components



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  - Else
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- If $F_{x,y} = 0 \rightarrow$ no filtering
- Otherwise, $F_{x,y}$: ratio of messages not transfered from $T^H_{x,y}$ to $T^L_{x,y}$
- Capped at a maximum value

DynFilter: Computing the Filtering Ratio

Idea: determine how many bytes we need to "save" for each $T^L_{x,y}$

Outgoing Bandwidth

- $B^H_{x,y}$, $B^L_{x,y}$: out. bandwidth over prev. unit of $T^H_{x,y}$, $T^L_{x,y}$

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Computing the Filtering Ratio

- # of bytes to "save": $Q_{x,y} = (W_{x,y}/(\sum W_{x,y})) \cdot B_{\text{remove}}$

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Experiments

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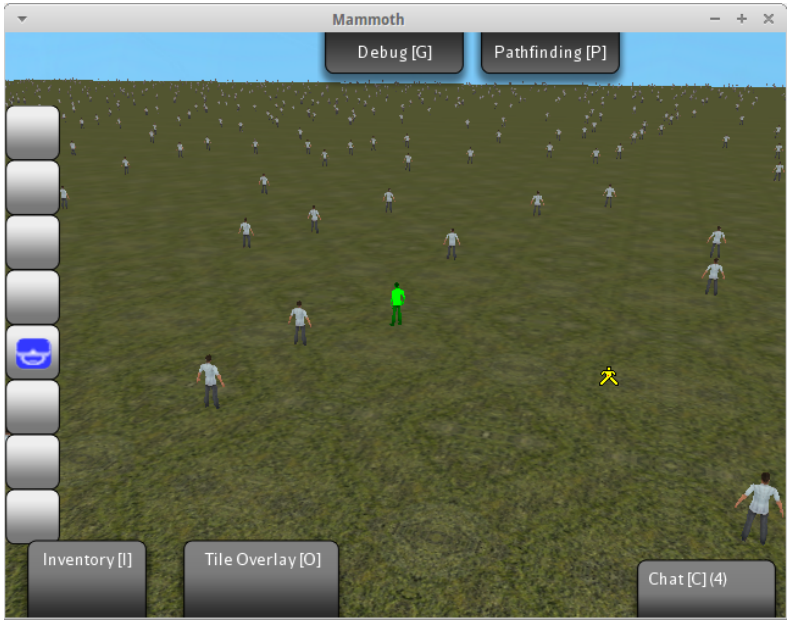
Implementation & Experimental Setup

Implementation

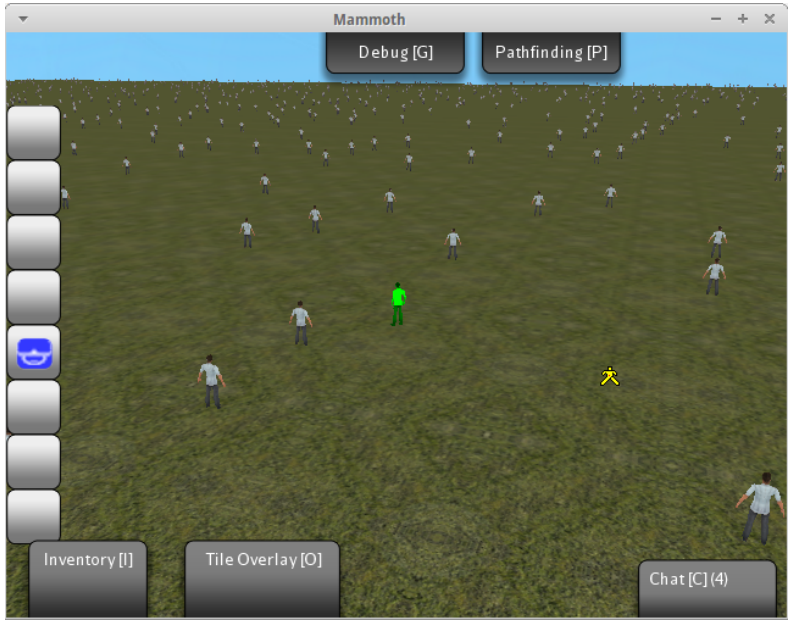
- Implemented in Java, on top of Dynamoth
- Pub/Sub: unmodified open-source Redis middleware
- Experiments run on DynGame (prototype game skeletton built on top of Mammoth)
- DynGame: large amount of AI-controlled players (random-waypoint)
- Supports flocking



Implementation & Experimental Setup

Experimental Setup

- 20 Amazon EC2 instances
- 15 players per instance (max 250)
- $Z = 2$ (subscription to up to 25 tiles)
- Period of 10 minutes
- Units of 20 seconds



Experiments

Experiment 1: FPS Game / Scalability

- Scalability in a FPS-like game with many players
- Very high frequency of updates (20 updates/sec)
- Up to 150 players (Q3=16, WatchMen=48)
- 10x10 map (100 tiles)
- Player can view up to 25% of the map ($Z = 2$)
- Bandwidth alloc.: 8000Mb

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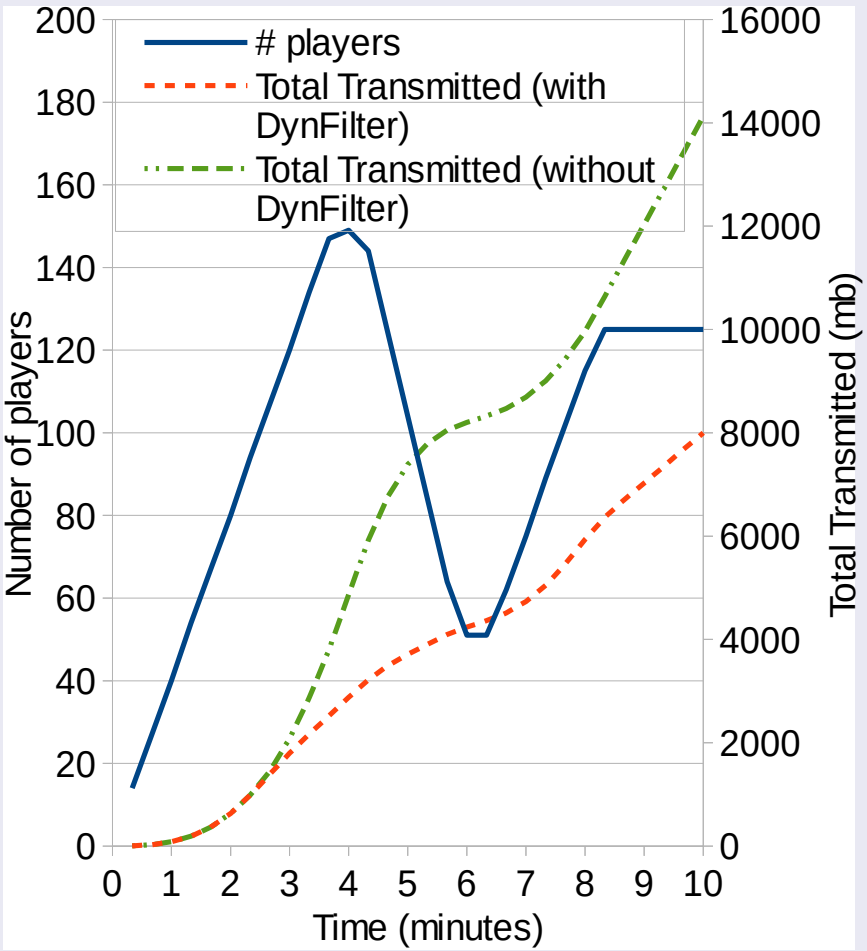
Experiment 2: MMORPG Game with Flocking

- Flocking in medium-scale MMOGs
- Flocking: quadratic growth in message delivery
- Up to 250 players
- 20x20 map (400 tiles)
- Player can view 6.2% of the map ($Z = 2$)
- Flocking ratio ψ between 0 and 0.5
- Flocking: 4x4 centric tiles
- Bandwidth alloc.:10000Mb

FPS Game - Results (1)

Number of Players and Total Outgoing Bandwidth



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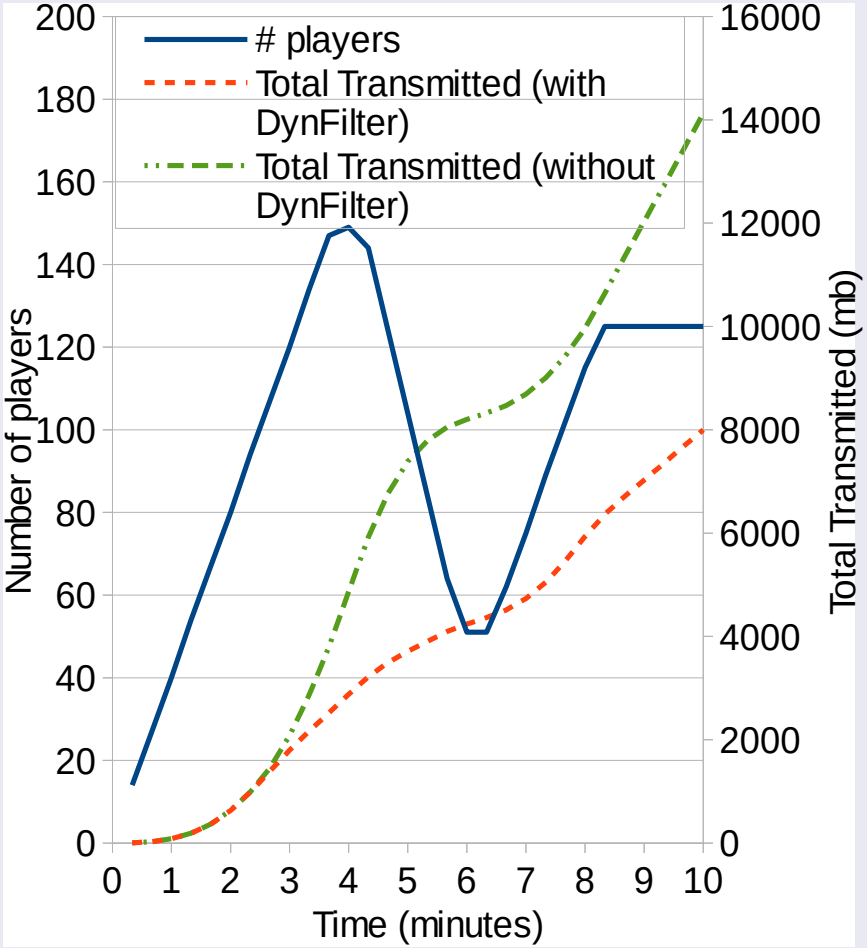
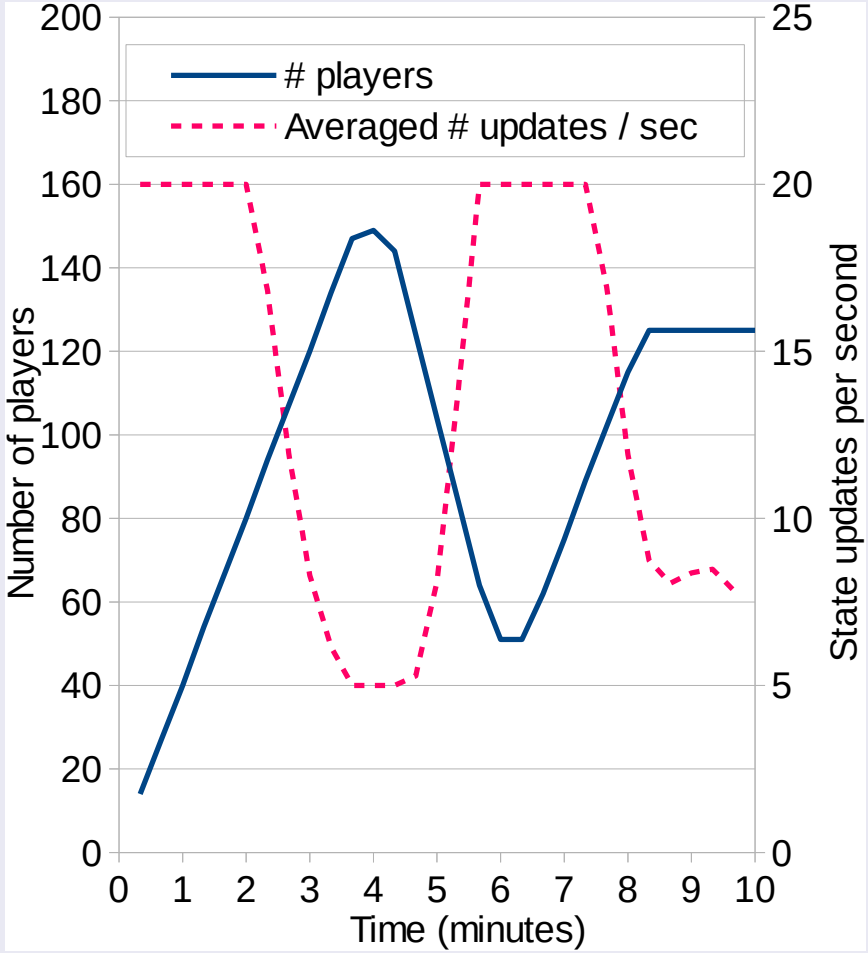


State Updates per Second

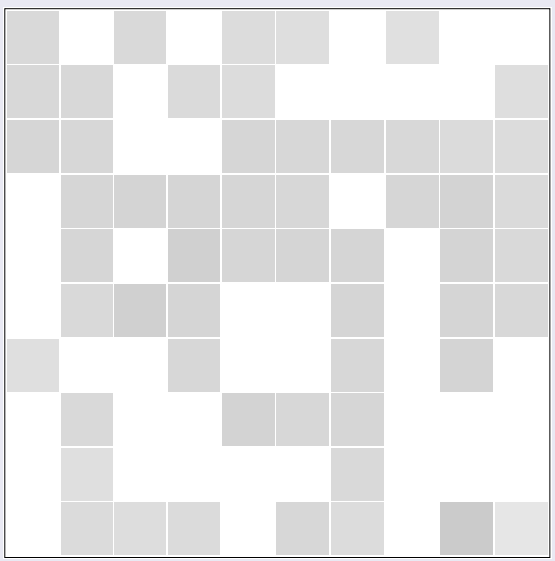


FPS Game - Results (2)

→ Bandwidth savings of 43%.

Filtering Ratio Heat Maps:

$t = 2.3$; $\hat{F} = 0.14$



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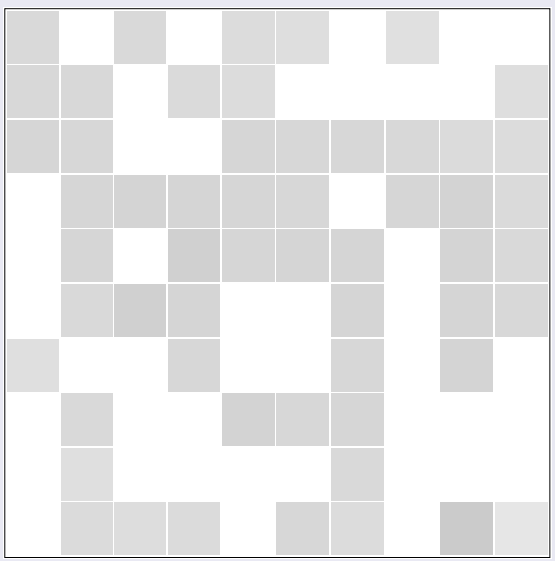

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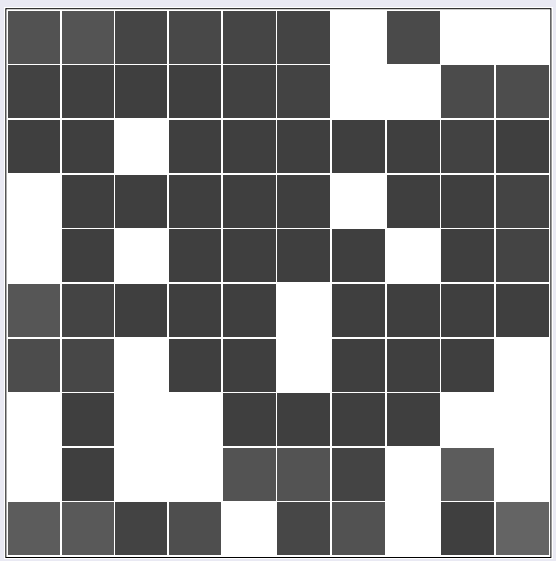

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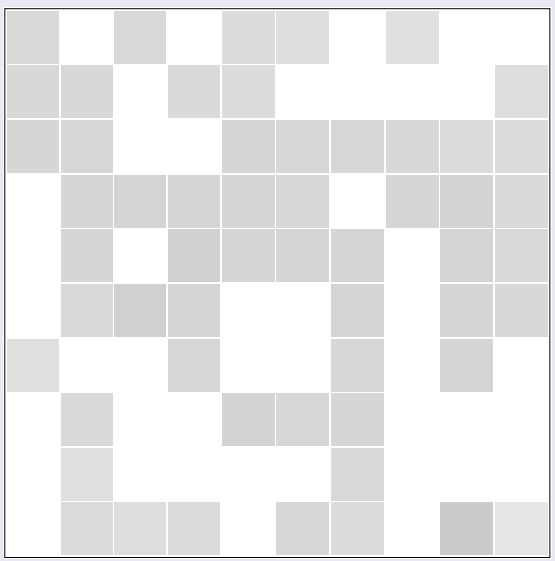

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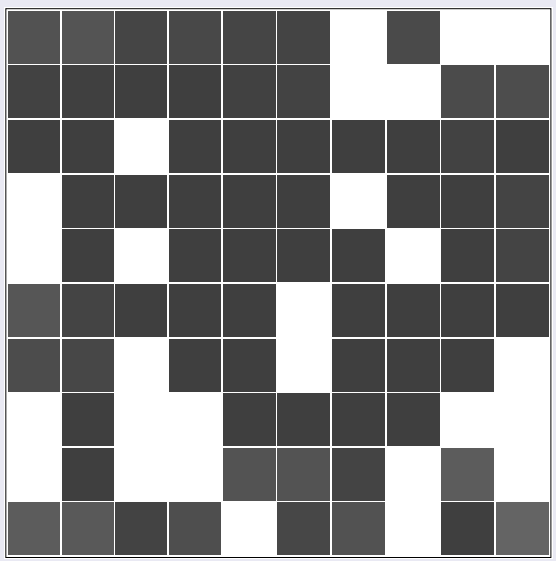
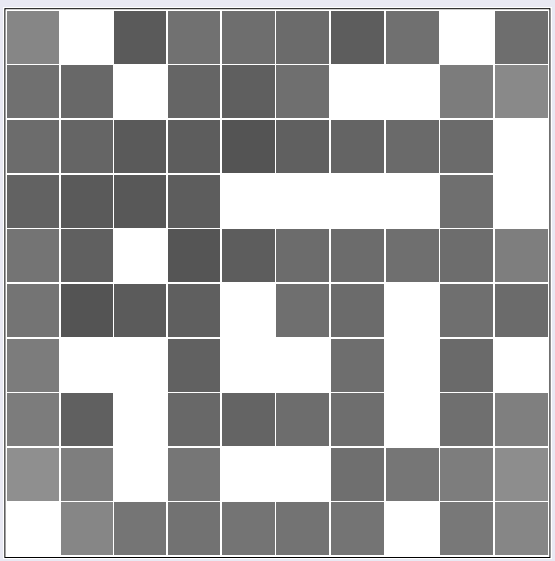
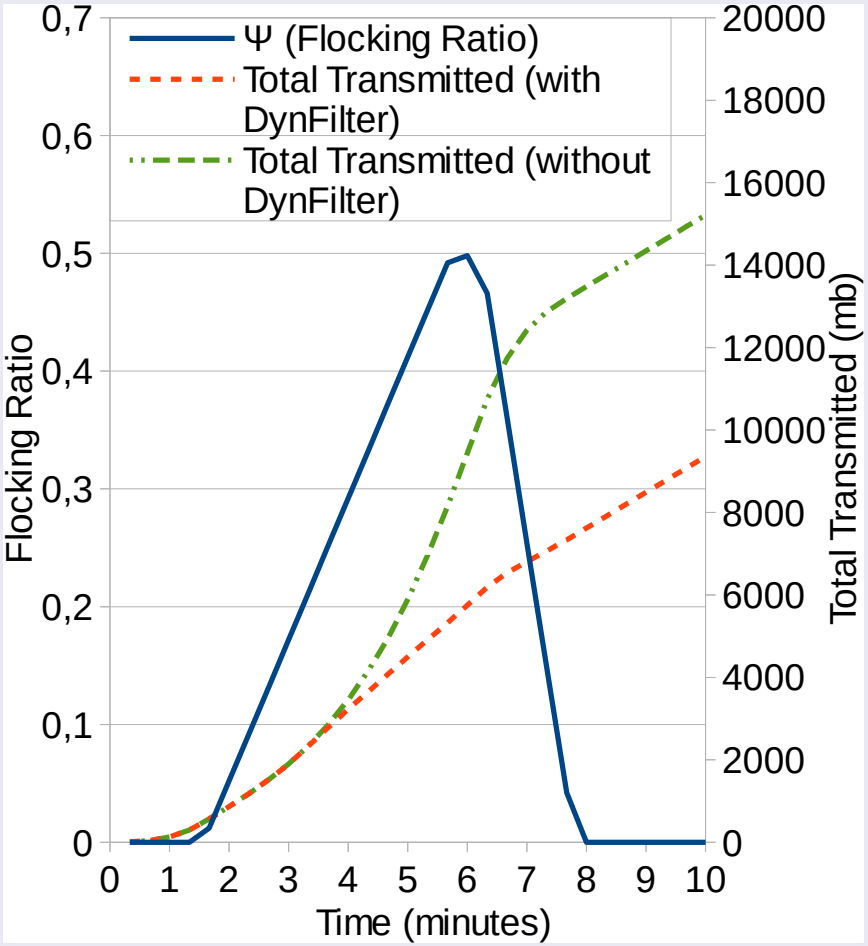


$t = 8.7$; $\hat{F} = 0.54$



MMORPG - Results (1)

Flocking Ratio and Total Outgoing Bandwidth



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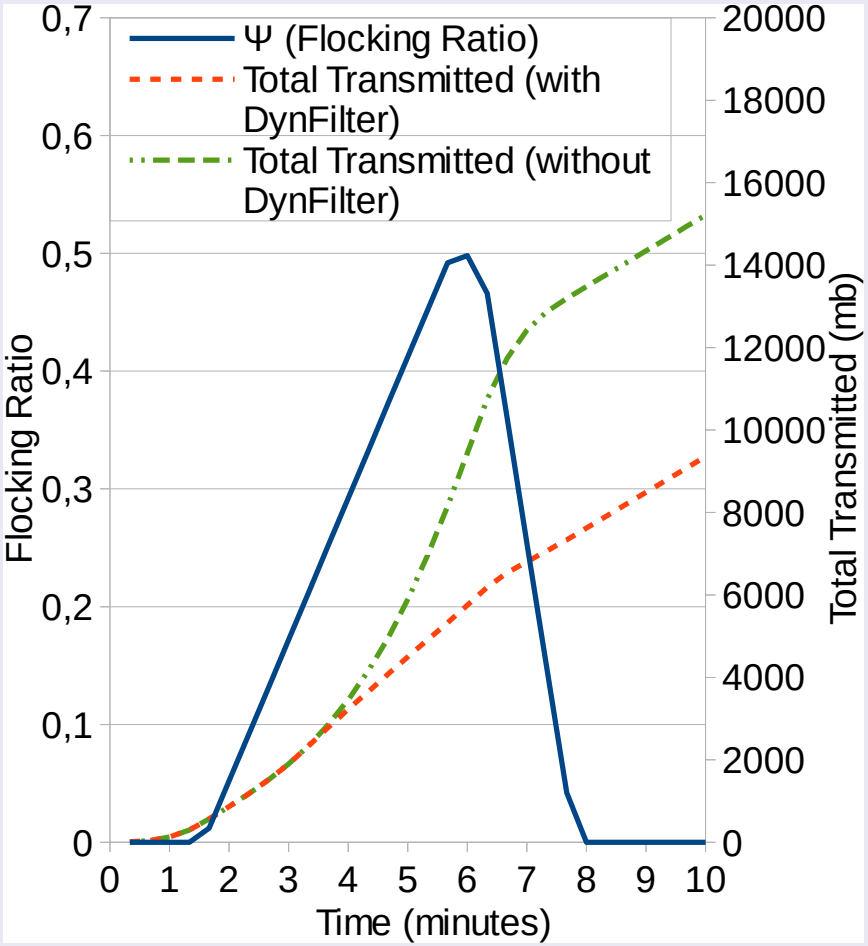

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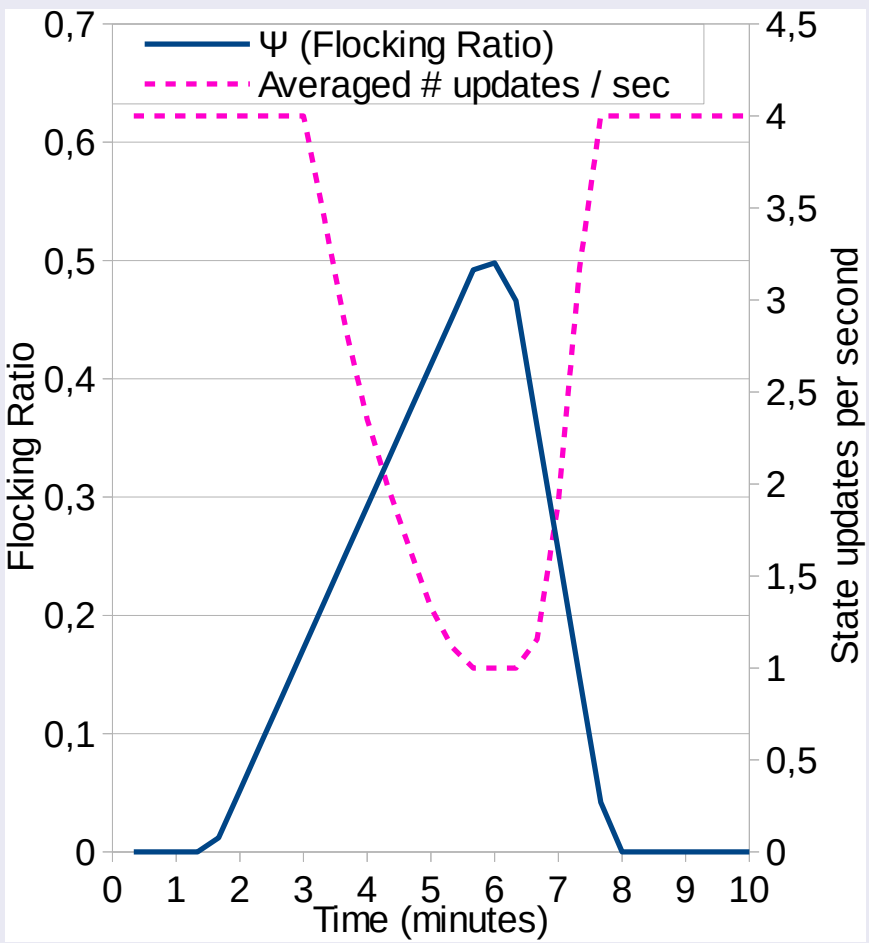

MMORPG - Results (2)

→ Bandwidth savings of 38%.

Filtering Ratio Heat Maps:

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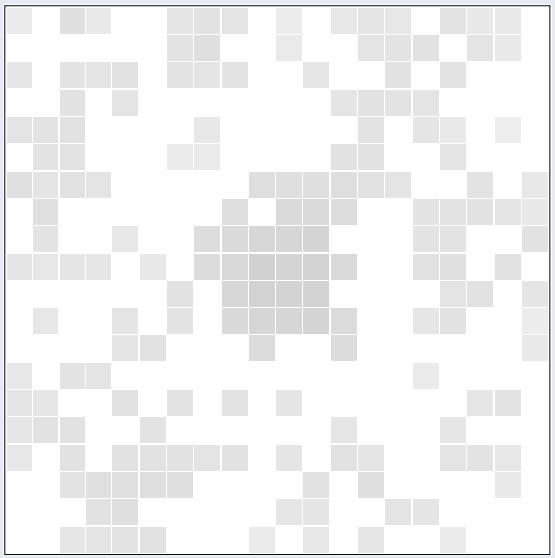

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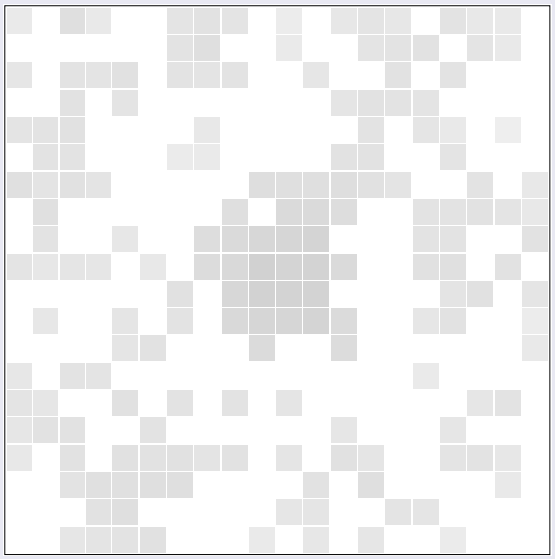

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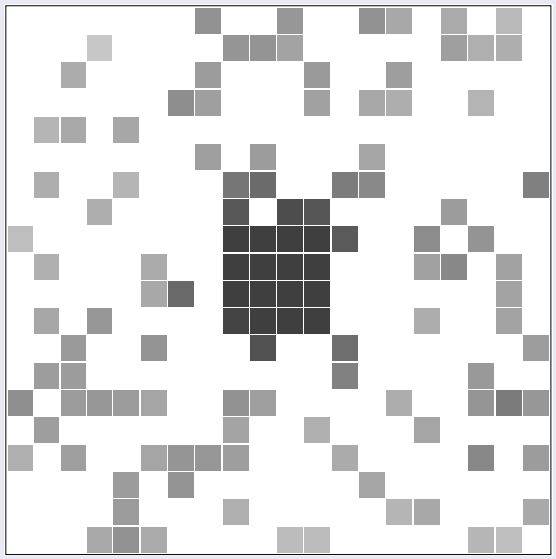

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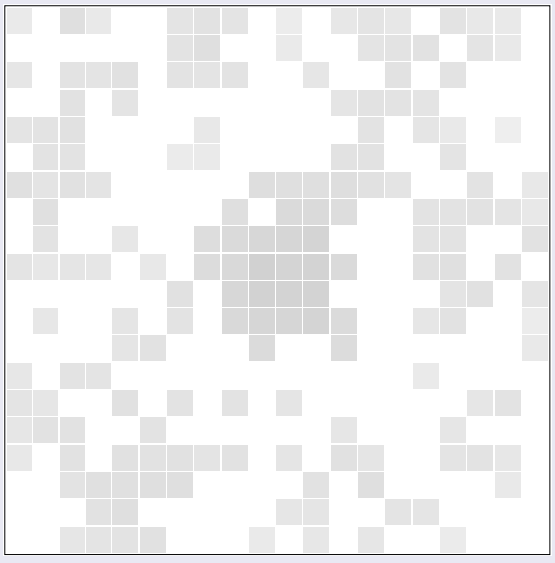

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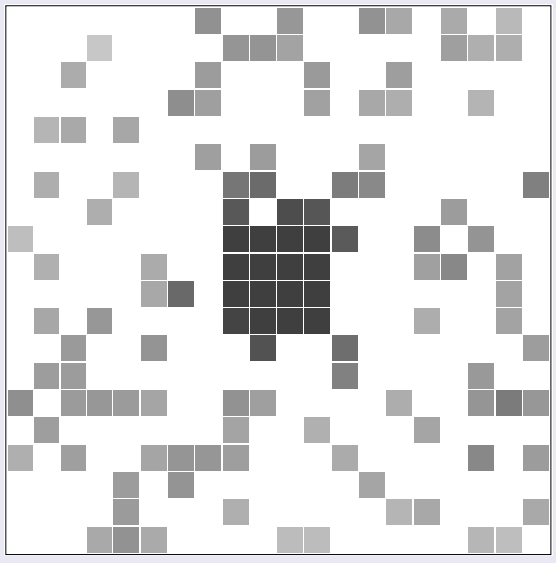
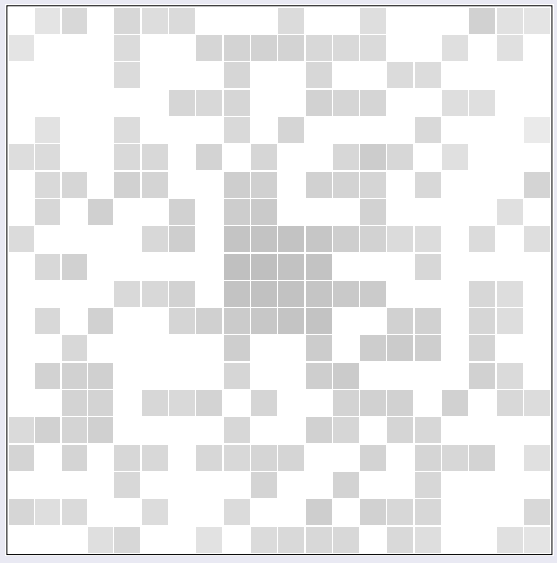


$t = 7.3$; $\psi = 0.15$



Conclusion & Future Work

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- Per-tile filtering (adapts to volume of players in tiles)
- Experiments: FPS and MMORPG
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Future Work

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- Quality of Experience evaluations

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- N-Layered Filtering
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- Classification of game messages (only some messages could be dropped)
  - Can exploit to the Pub/Sub layer for that: dropping messages from some topics only

Conclusion & Future Work

Thank you for your attention!