Survey on Data Dissemination to Mobile sinks in Wireless Sensor Networks

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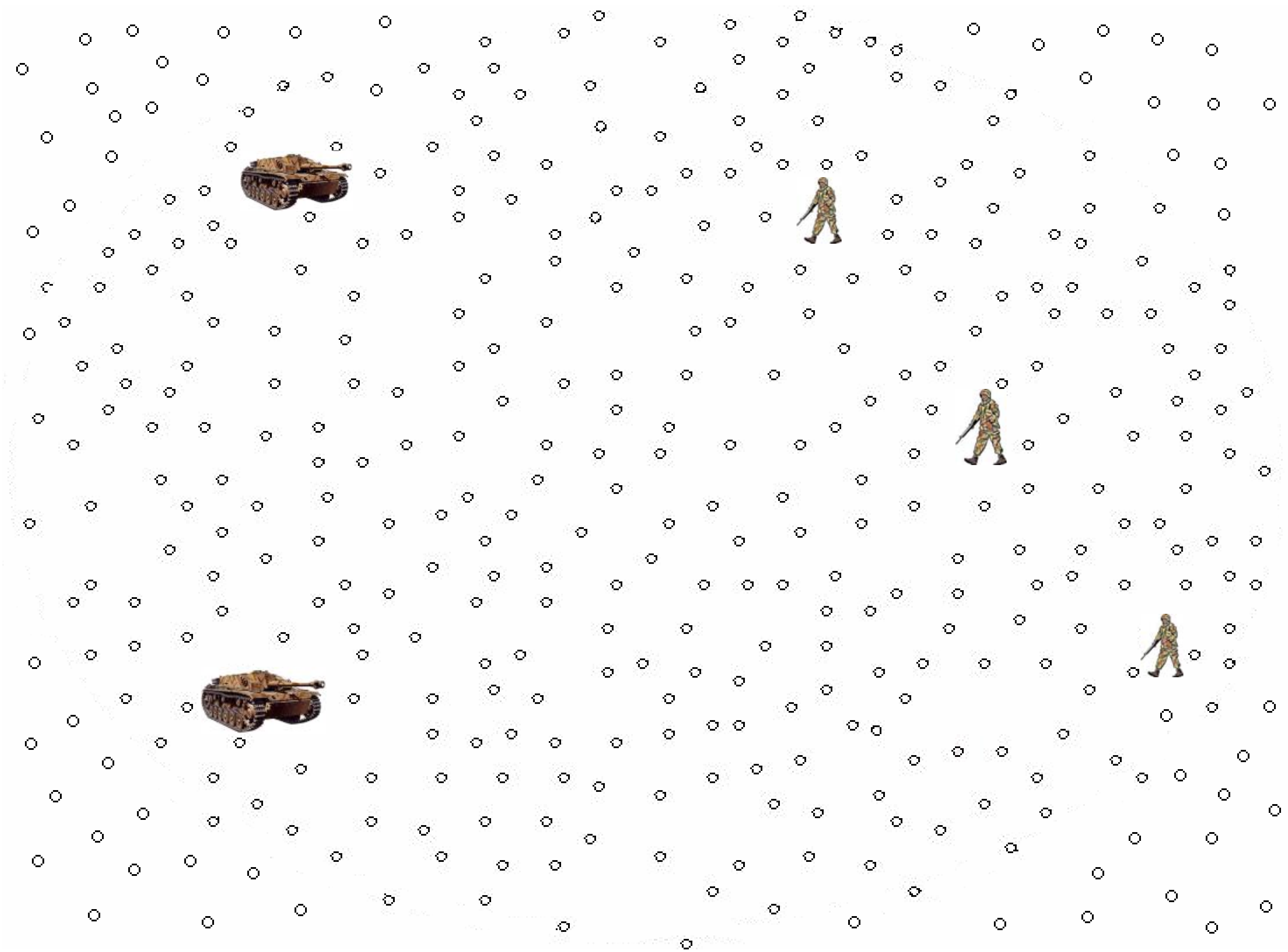
Outline

- Introduction
- Different Approaches of Data Dissemination
  - TTDD
  - SEAD
- Issues Discussion
- References

Introduction

- Wireless sensor networks
  - ☑ a large number of sensors (stationary)
  - ☑ a few data collectors ,named “sinks”
  - ☑ Restriction : energy
  - ☑ sources have to build and maintain multihop routes toward sinks to report sensory data

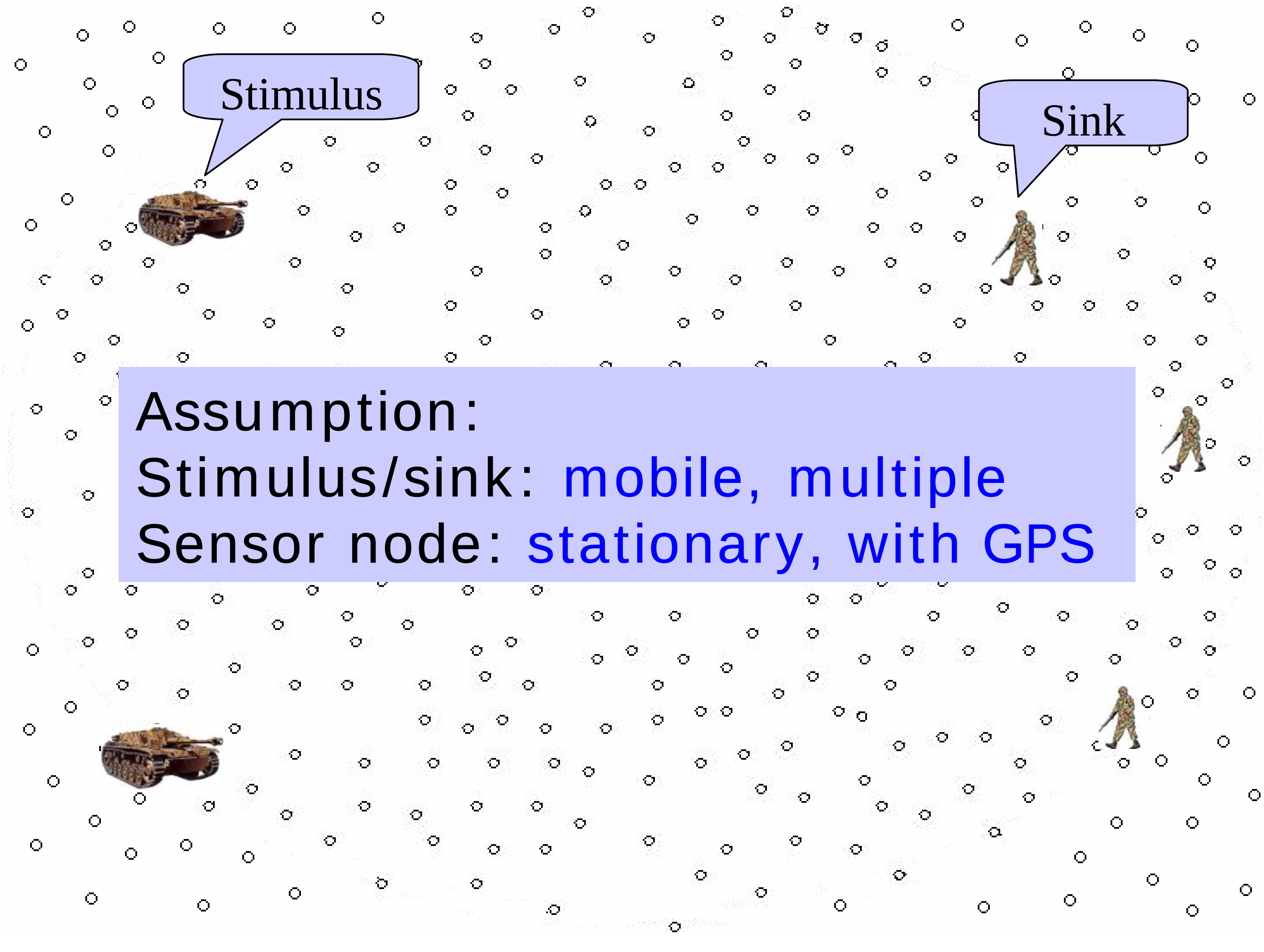
Introduction



TTDD
A Two-tier Data Dissemination Model

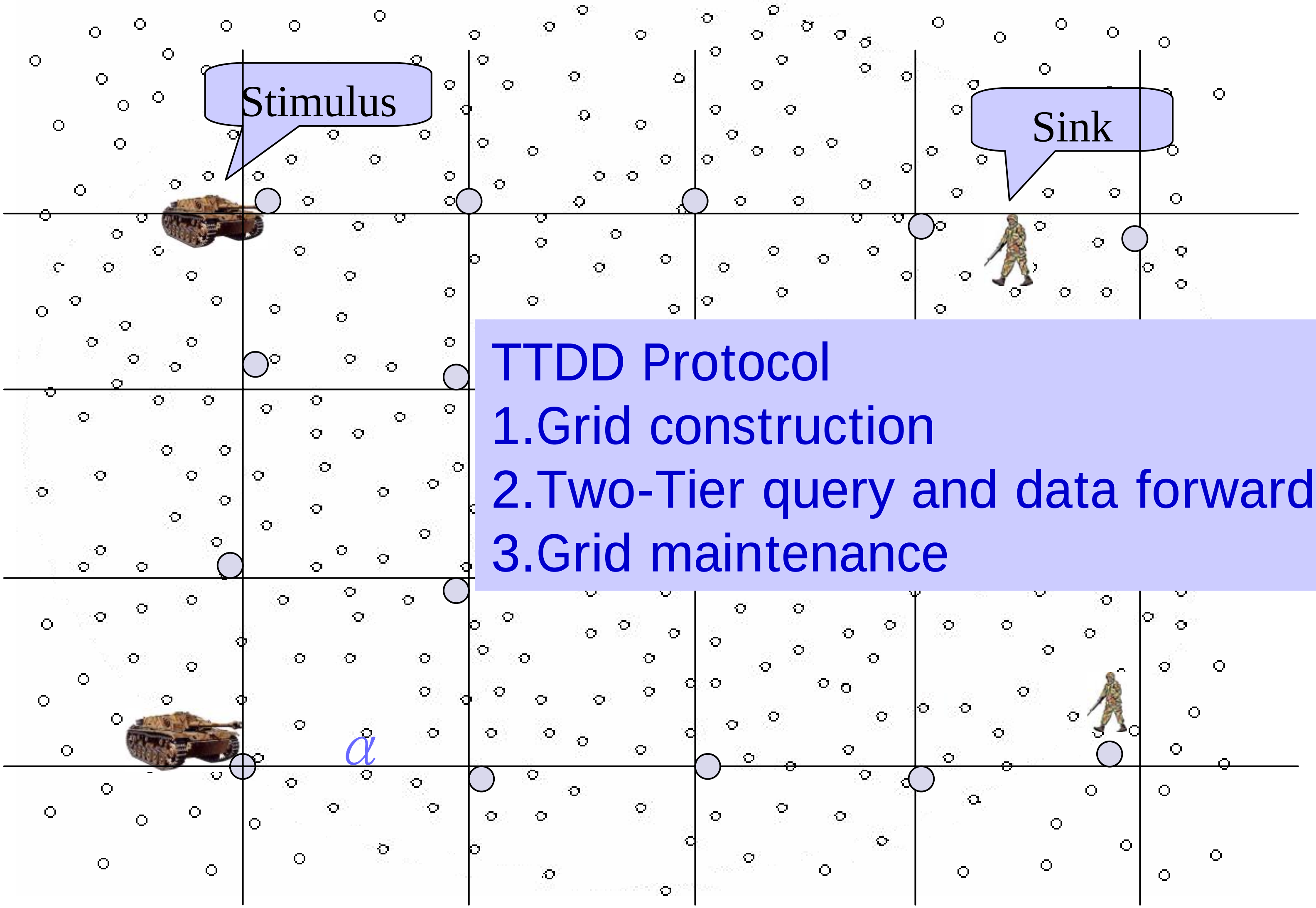
- F. Ye, H. Luo, J. Cheng, S. Lu, and L. Zhang. (UCLA) "A two-tier data dissemination model for large-scale wireless sensor networks" *Mobicom 2002*

TTDD - basic idea



Assumption:
Stimulus/sink: mobile, multiple
Sensor node: stationary, with GPS

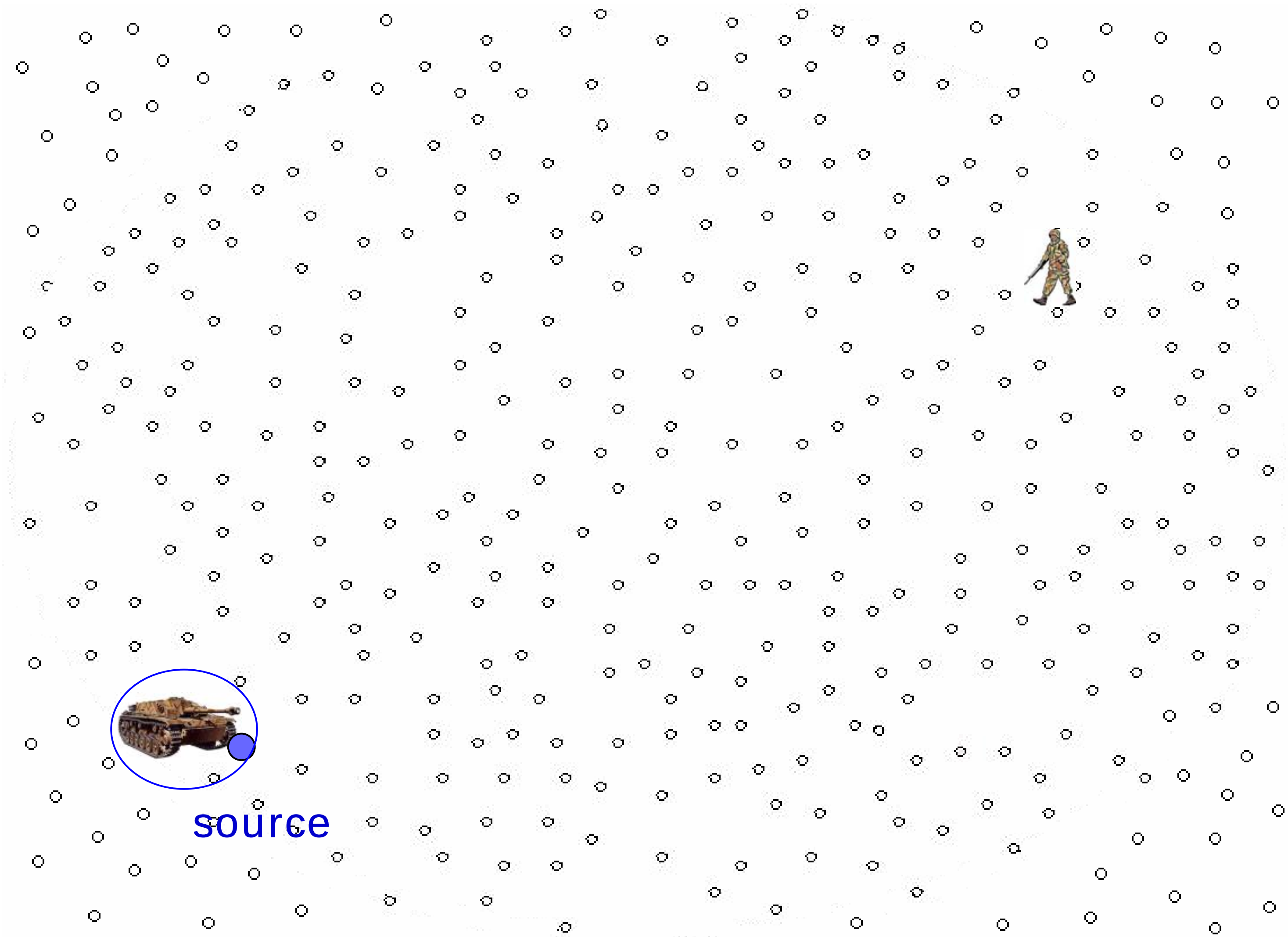
TTDD - basic idea



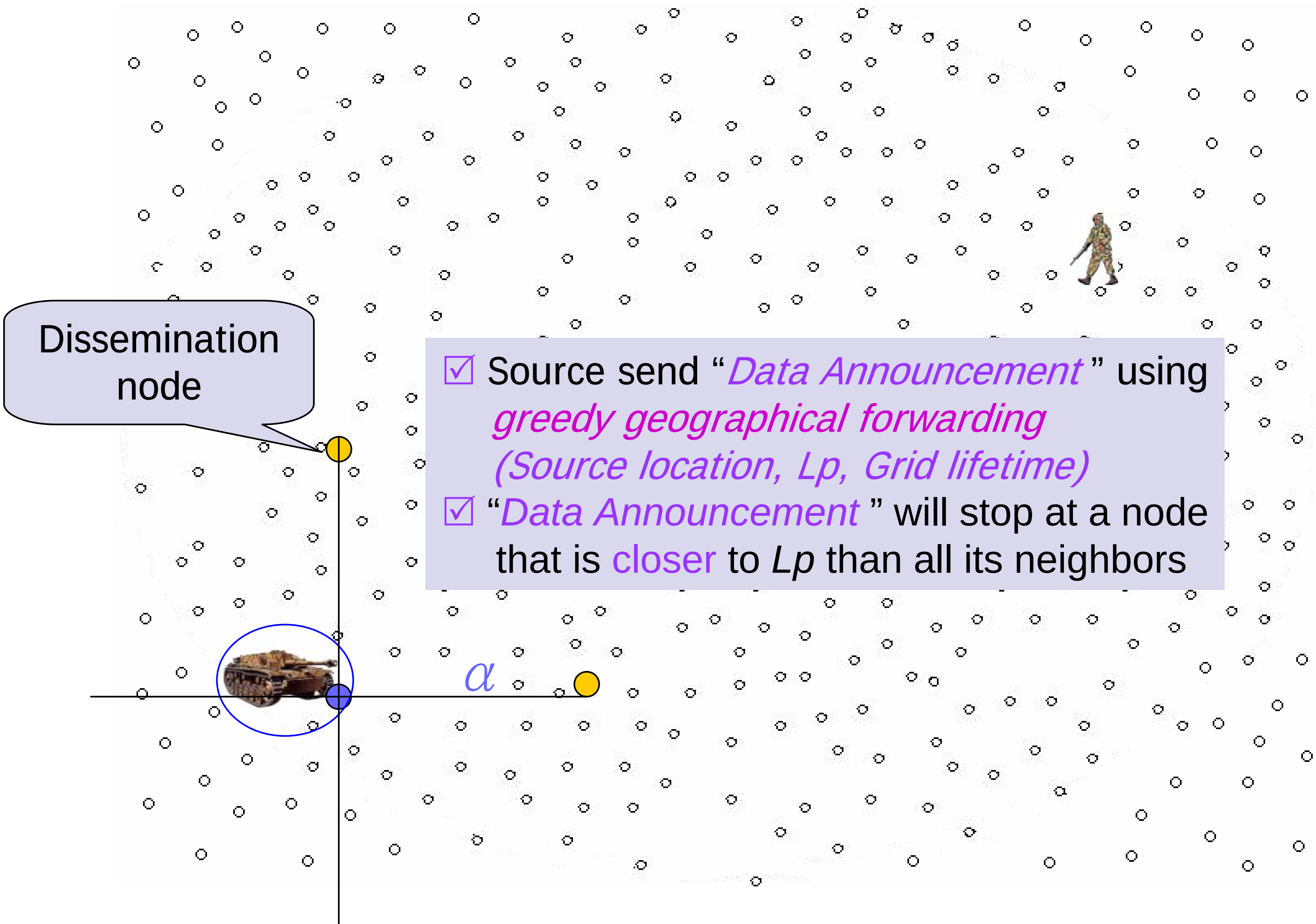
TTDD Protocol

1. Grid construction
2. Two-Tier query and data forwarding
3. Grid maintenance

TTDD - Grid construction

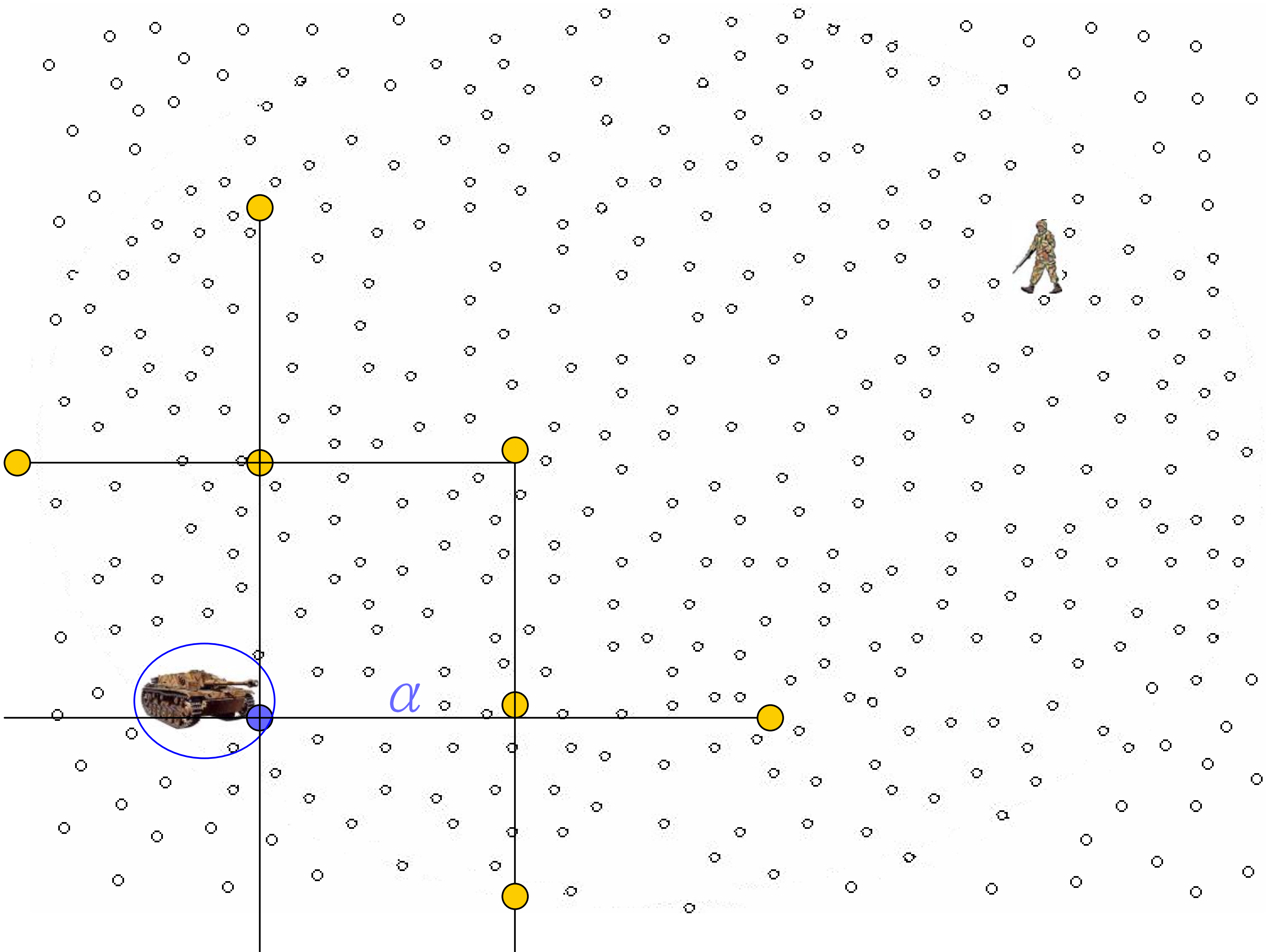


TTDD - Grid construction

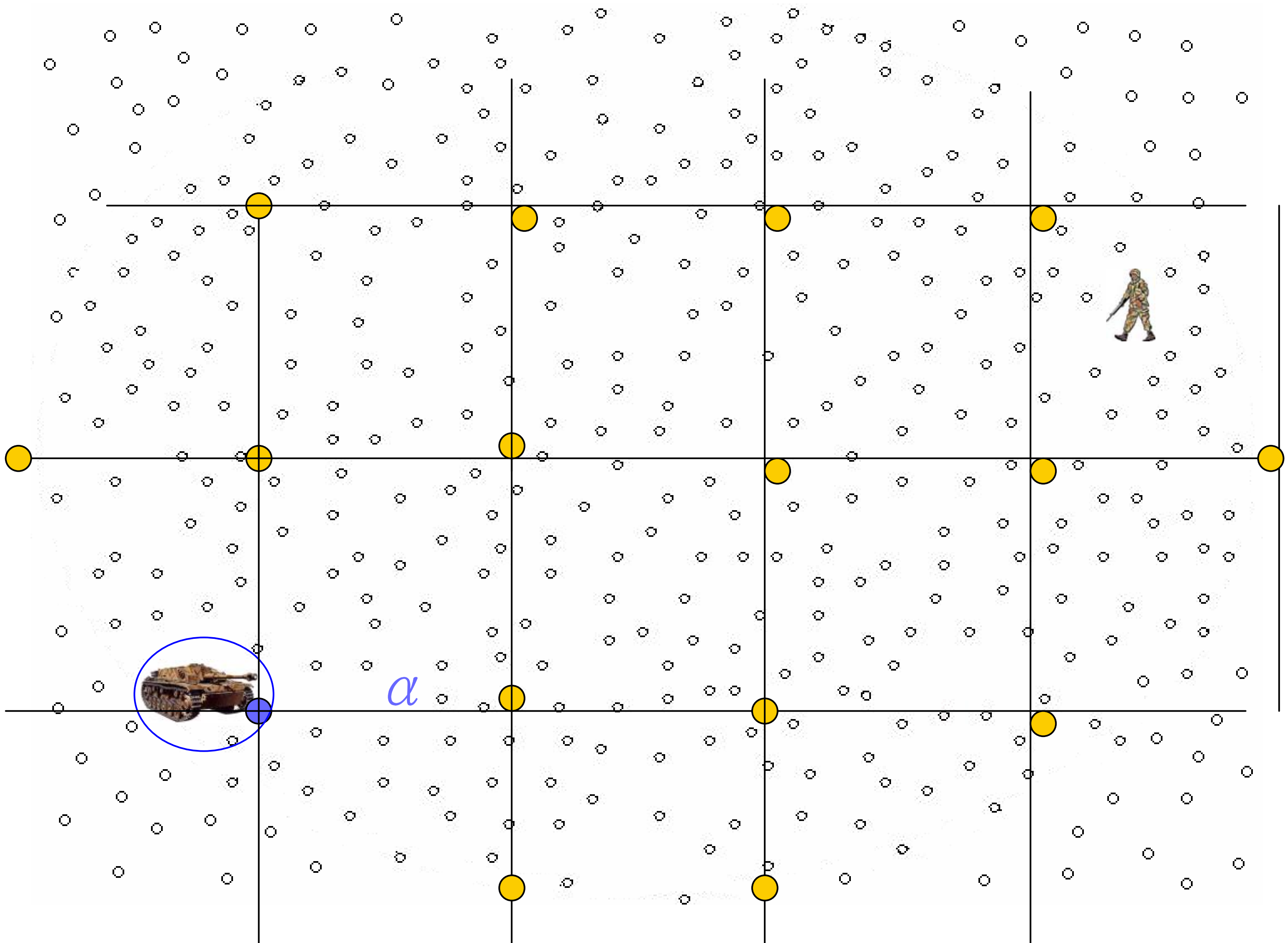


- ☑ Source send "*Data Announcement*" using *greedy geographical forwarding* *(Source location, Lp, Grid lifetime)*
- ☑ "*Data Announcement*" will stop at a node that is closer to *Lp* than all its neighbors

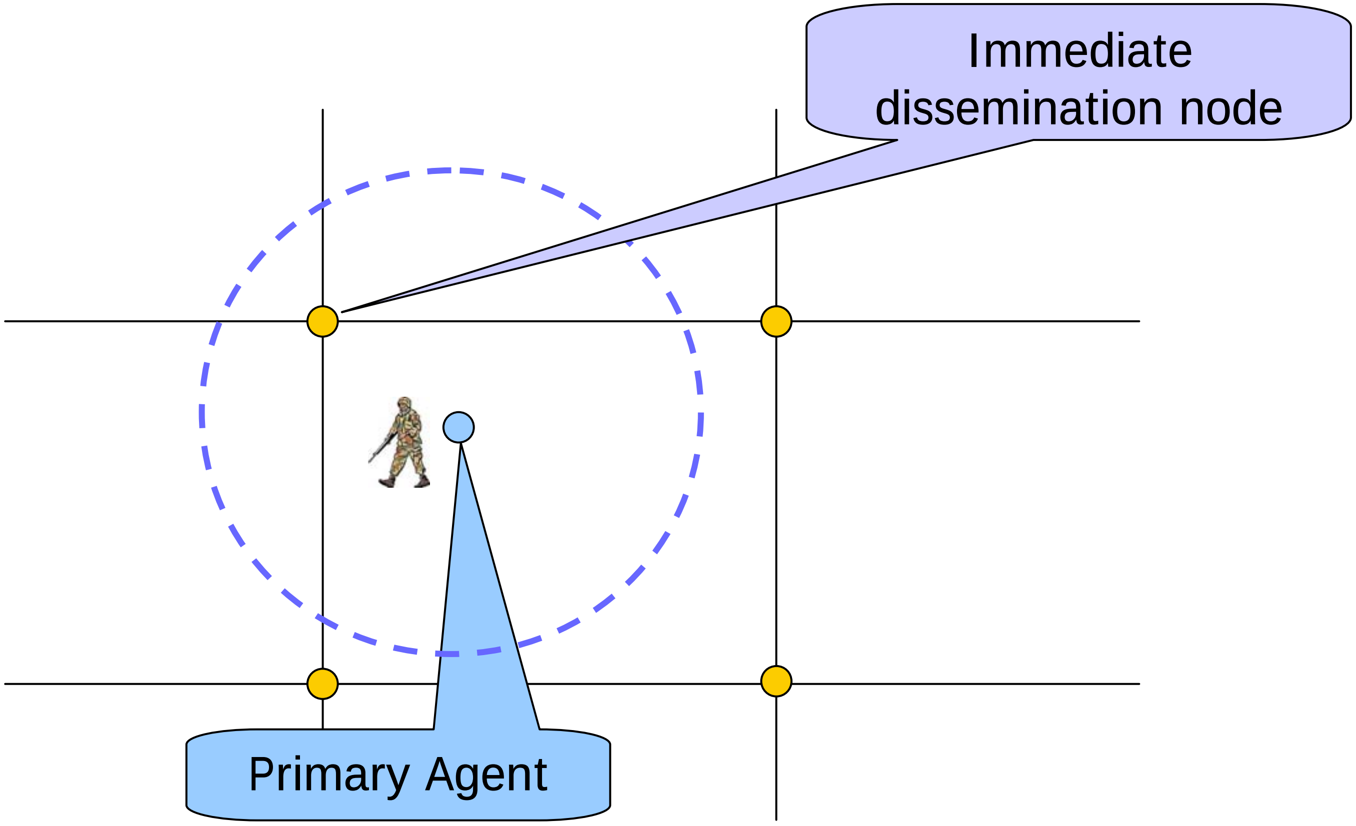
TTDD - Grid construction



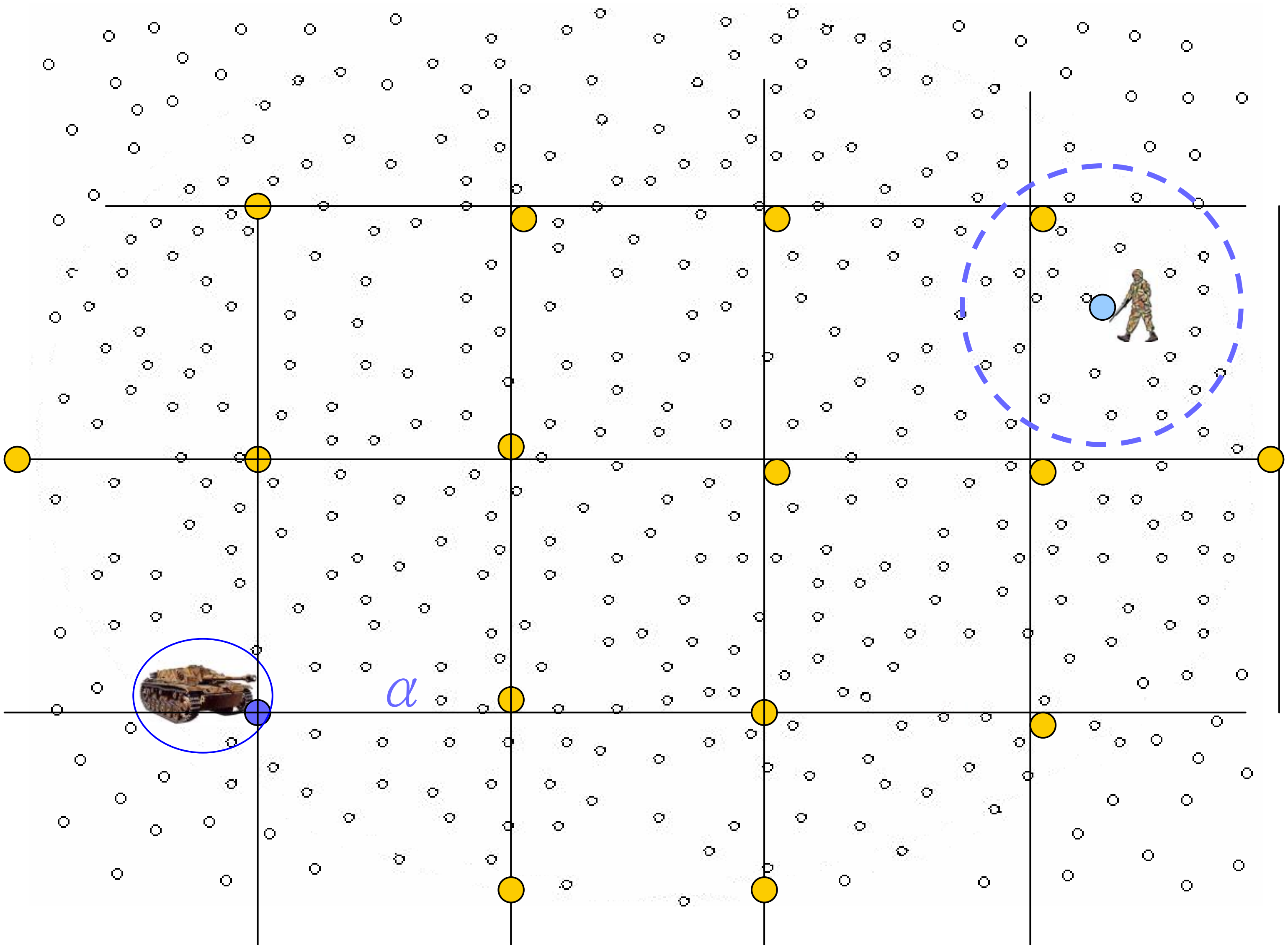
TTDD - Grid construction



TTDD - Two-Tier query and data forwarding



TTDD - Two-Tier query and data forwarding



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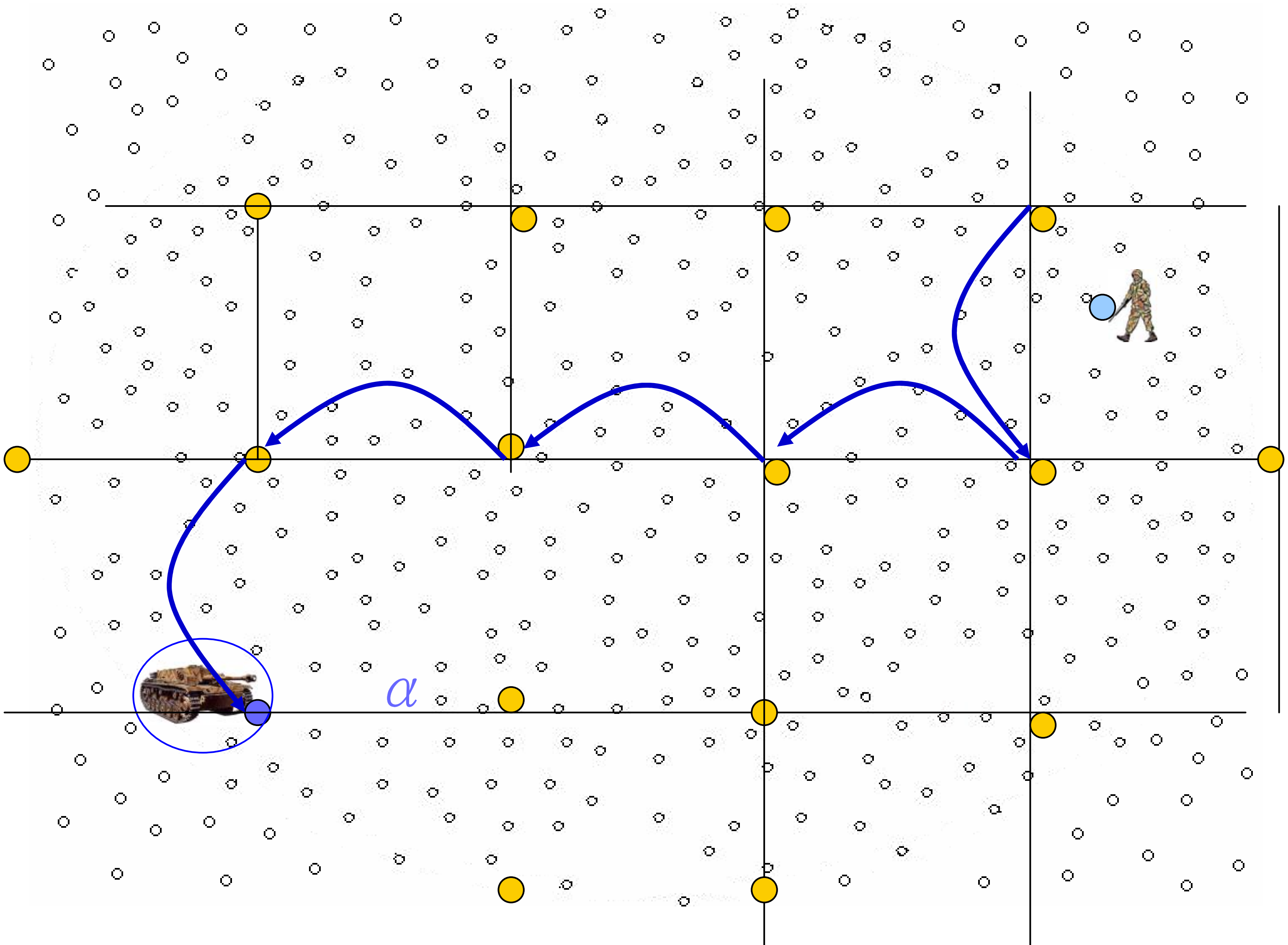
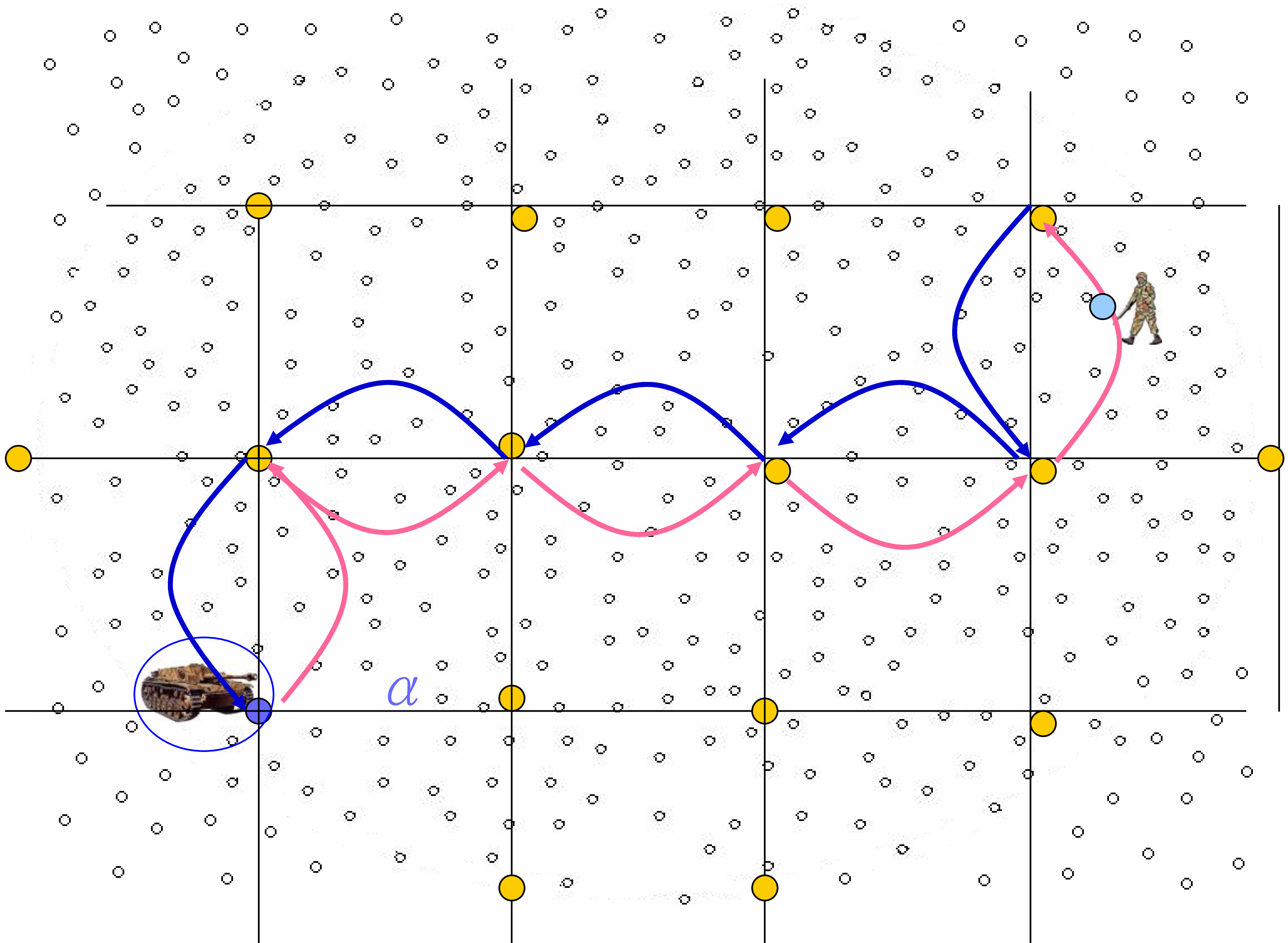
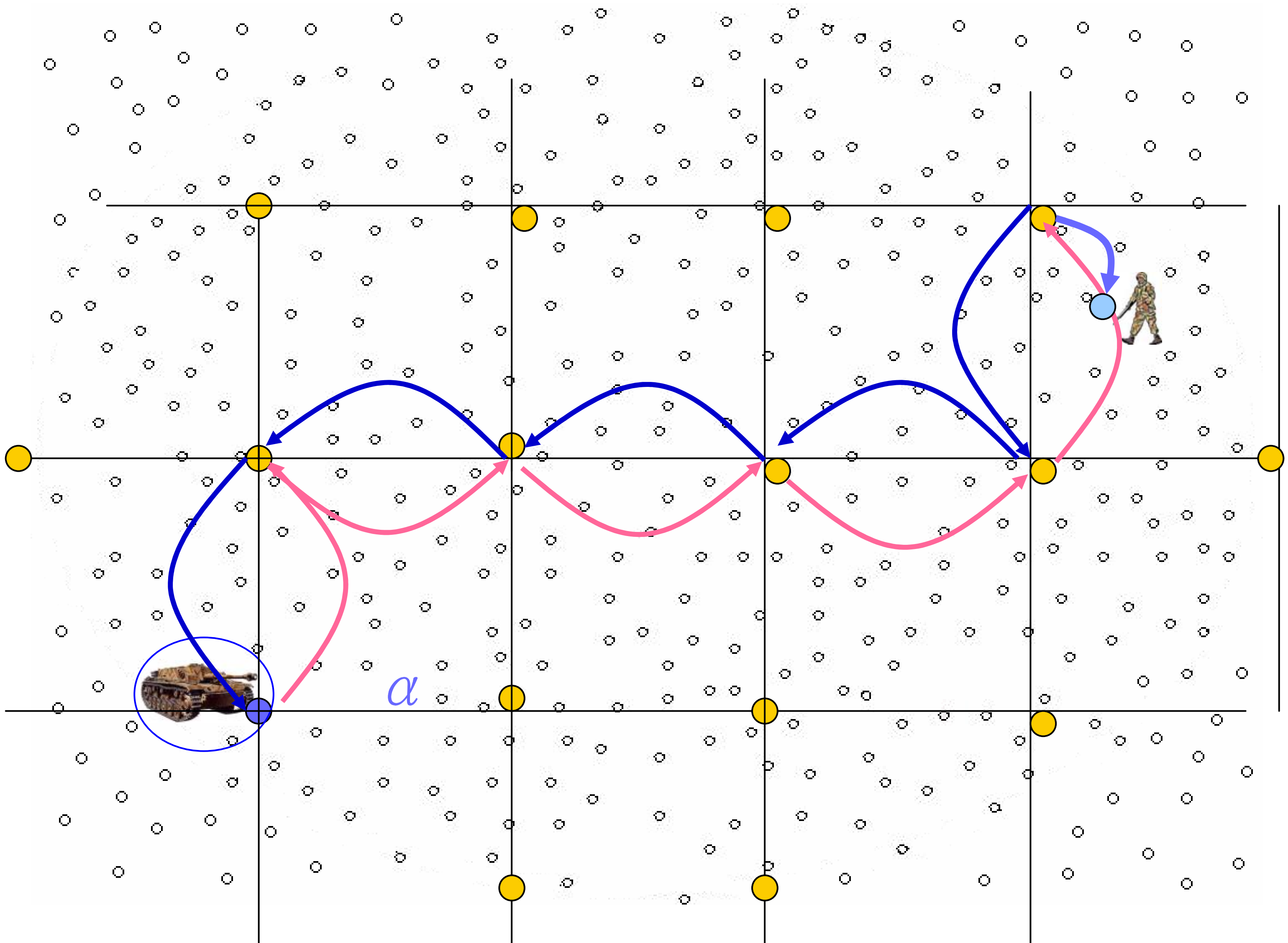


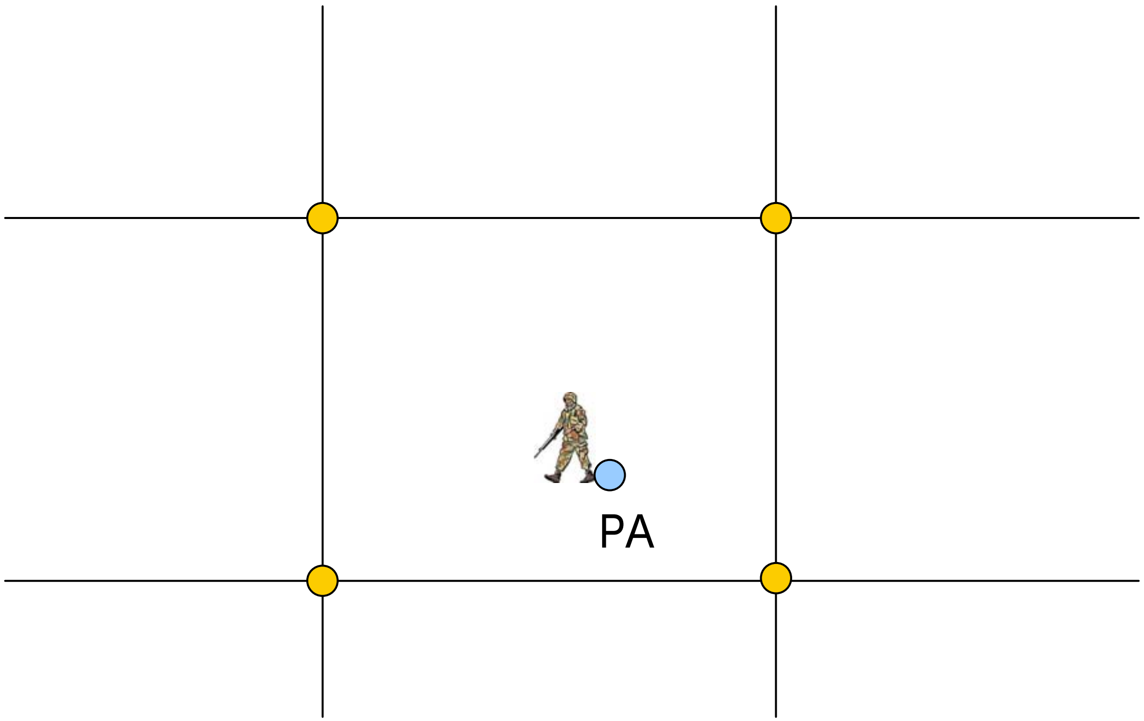
TTDD - Two-Tier query and data forwarding



TTDD - Two-Tier query and data forwarding



TTDD - Two-Tier query and data forwarding



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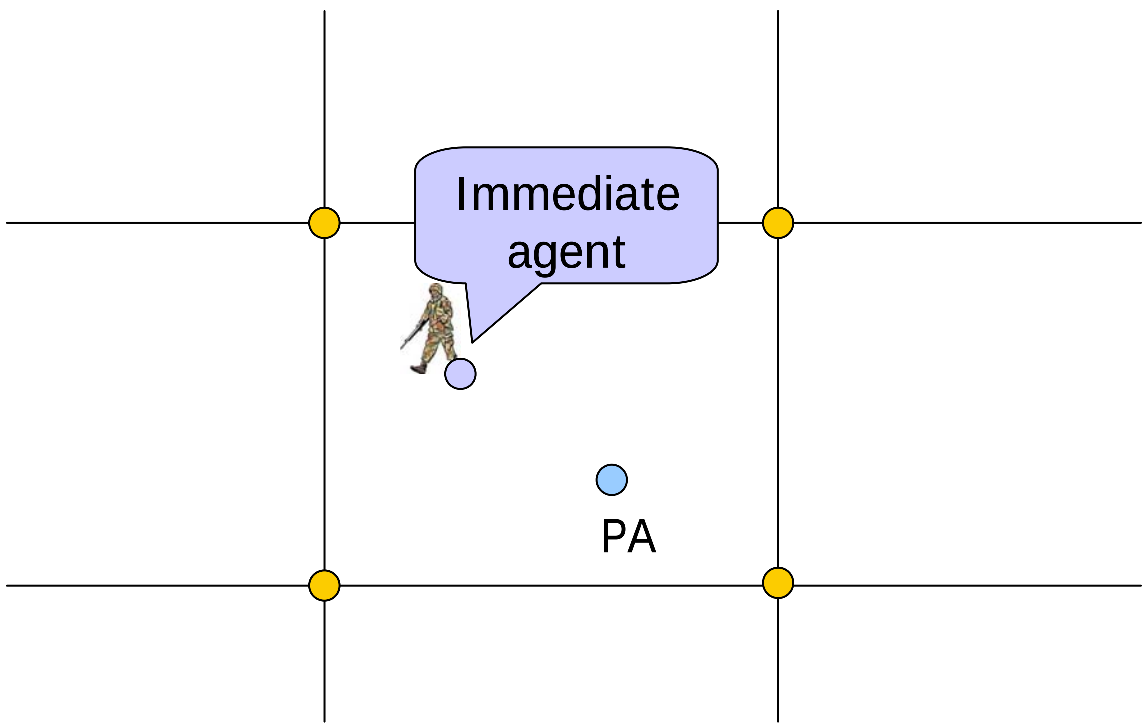
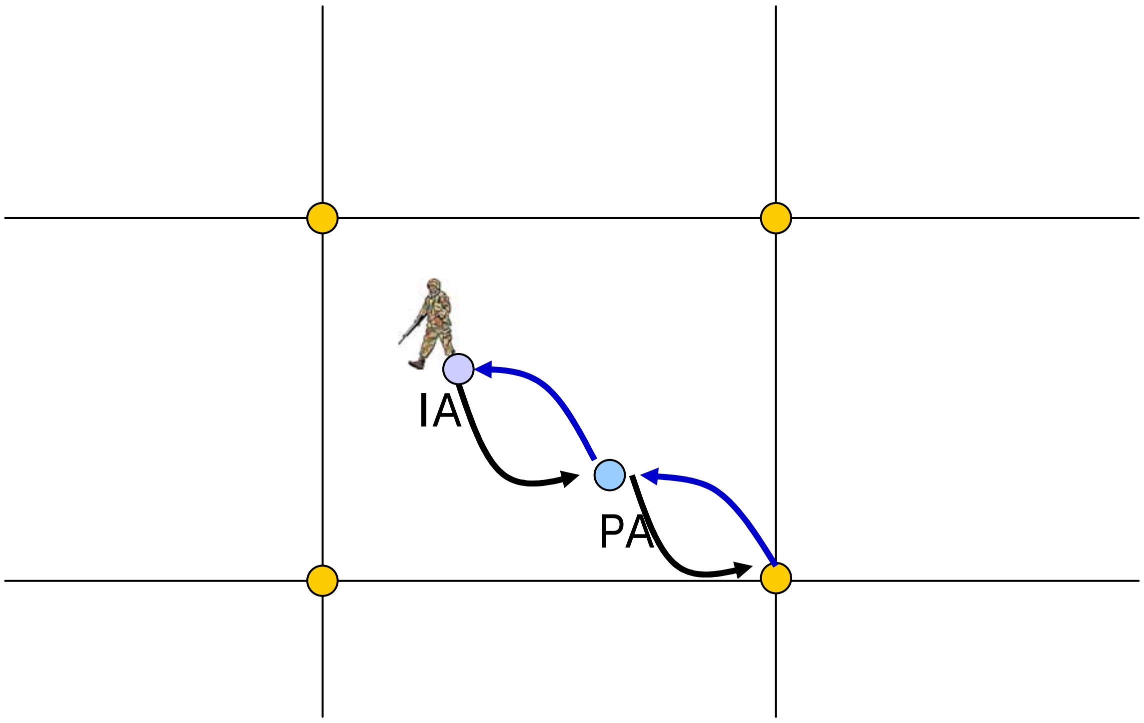


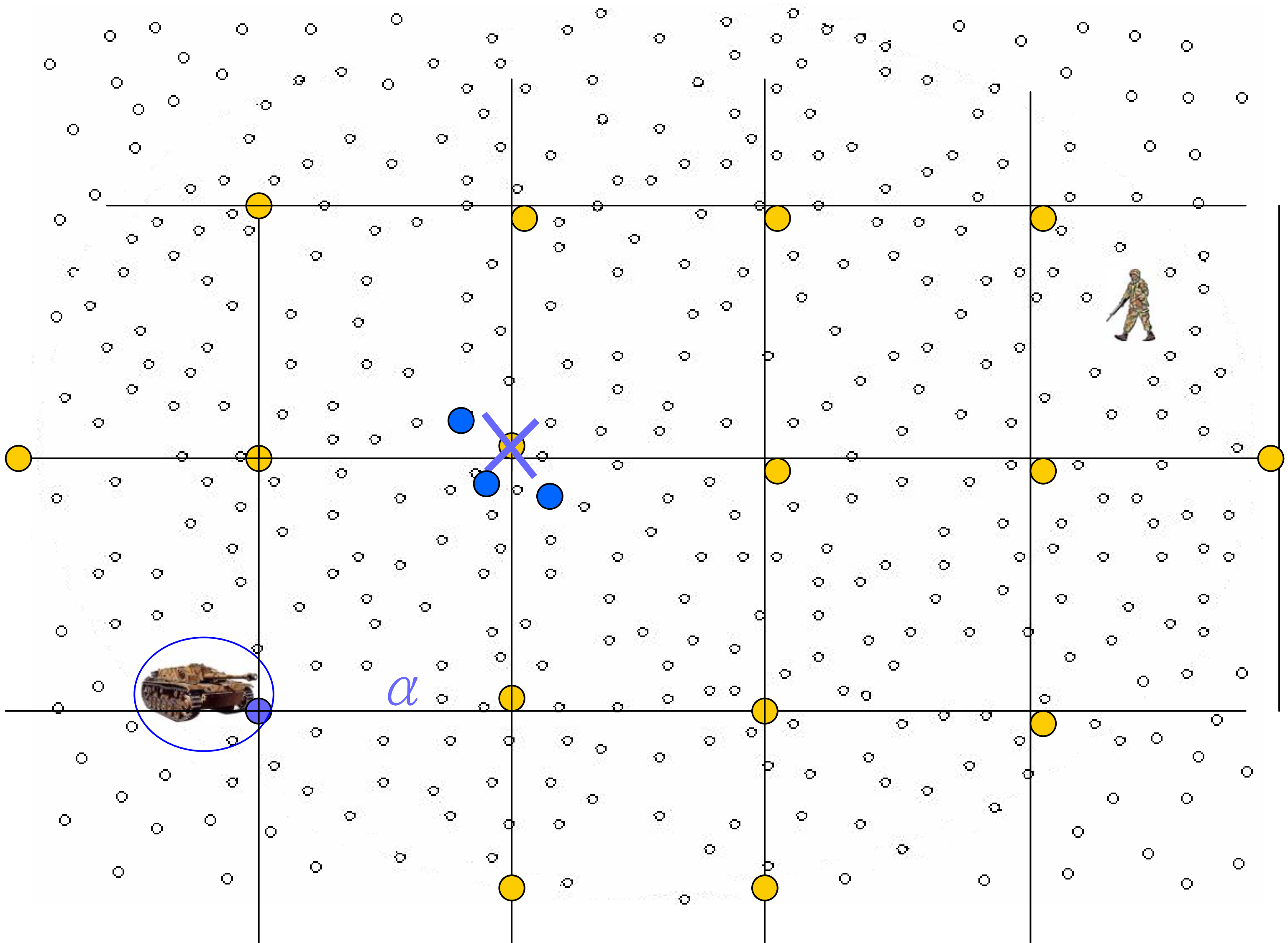
TTDD - Two-Tier query and data forwarding



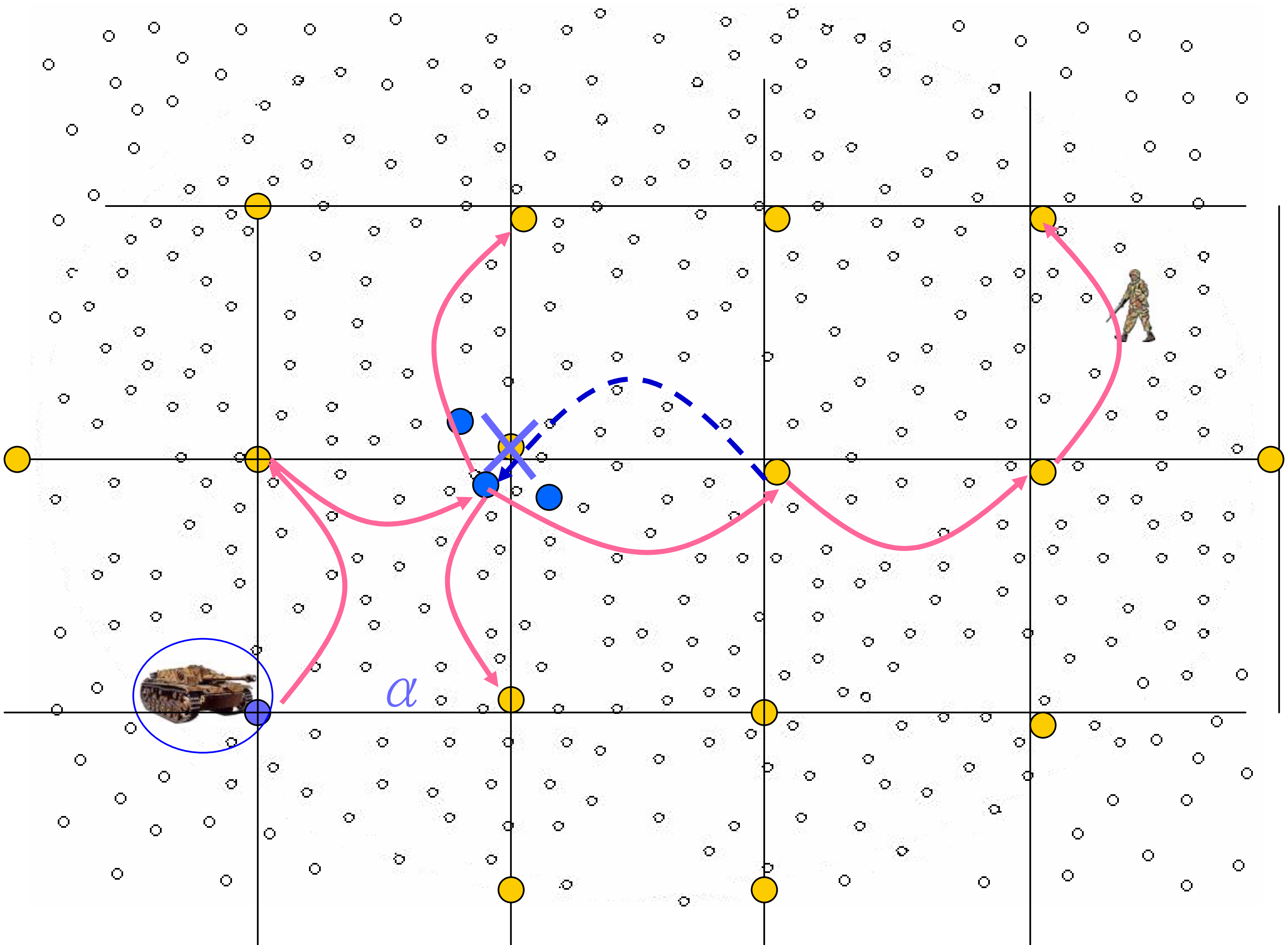
TTDD - Grid maintenance

- Two way to maintain the grid
  - “Grid lifetime” in data announcement
  - Dissemination node fails
    - “upstream information duplication” mechanism

TTDD - Grid maintenance



TTDD - Grid maintenance



TTDD - Conclusion

- Advantage
  - Construct & maintain a grid structure with low overhead
  - Can effectively deliver data from multiple sources to multiple mobile sinks
- Disadvantage
  - Each source must constructs & maintains a grid structure
  - Is it suitable for “moving target” ?

SEAD
a Scalable Energy-efficient Asynchronous Dissemination protocol

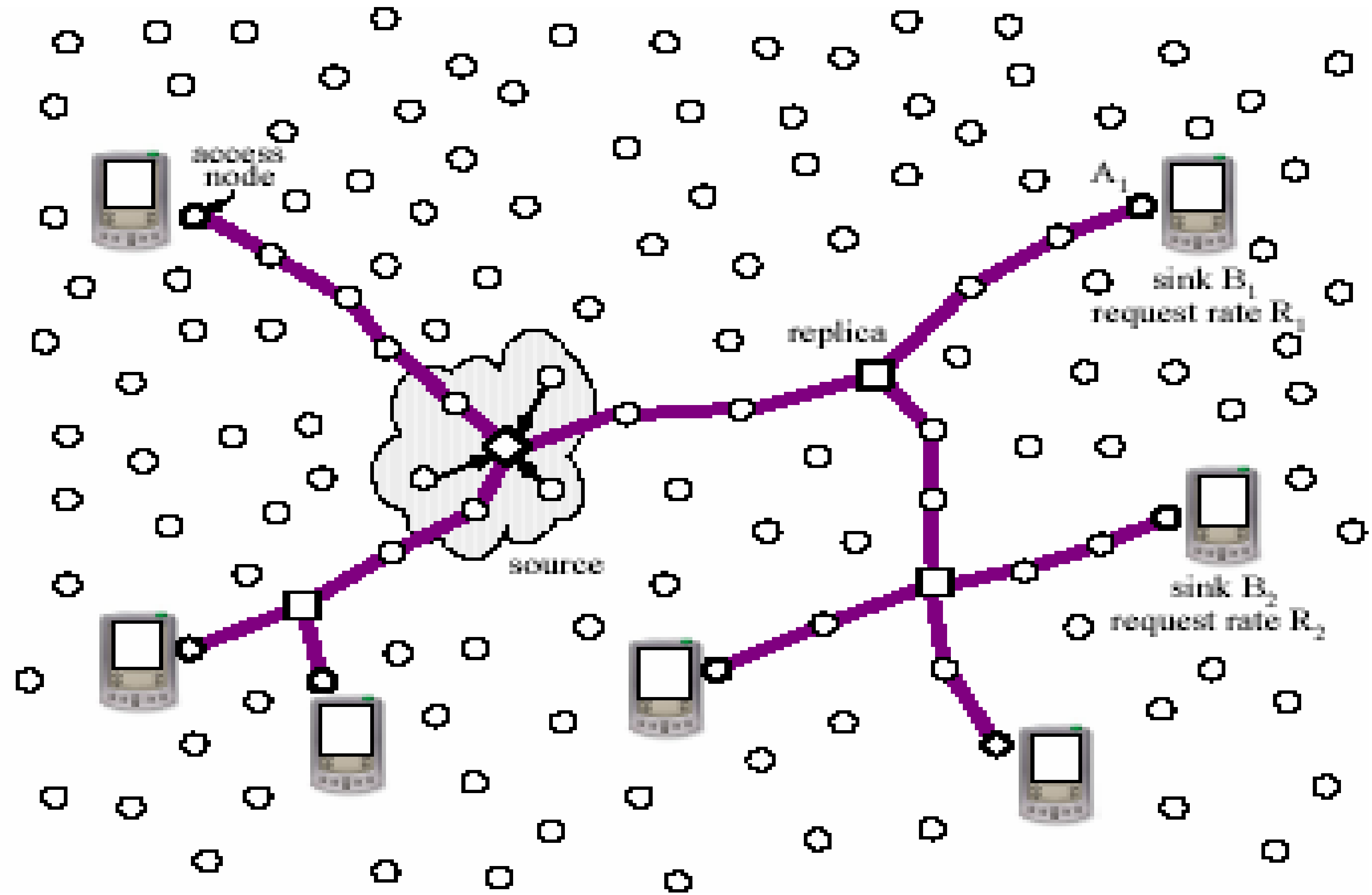
- Hyung Seok Kim, Tarek F. Abdelzaher, and Wook Hyun Kwon, "Minimum-Energy Asynchronous Dissemination to Mobile Sinks in Wireless Sensor Networks" SenSys 2003

SEAD
a Scalable Energy-efficient Asynchronous Dissemination protocol

- When sinks are mobile in sensor networks
  - Communication consists of three main parts
    - Building the dissemination tree (d-tree)
    - Disseminating data
    - Maintaining linkage to mobile sinks

SEAD

a Scalable Energy-efficient Asynchronous Dissemination protocol



SEAD
a Scalable Energy-efficient Asynchronous Dissemination protocol

- Overview of the algorithm
  - One source generates the sensory update traffic possibly on behalf of a group of local sensors
  - The data updates are disseminated along a tree to the mobile sinks in an asynchronous manner
  - Each branch of the tree may have its own update rate
    - depending on the desired refresh rate of the downstream observers

SEAD

a Scalable Energy-efficient Asynchronous Dissemination protocol

- When a mobile sink wants to join the d-tree
  - It selects one of its neighboring sensor nodes to send a *join query* to the source of the tree
  - the selected node is called the sink's *access node*
- The access node
  - is used to represent the moving sink when the optimal d-tree is built
  - Amortize the overhead in the presence of mobility

SEAD

a Scalable Energy-efficient Asynchronous Dissemination protocol

- The tree delivers data to the fixed access node. In turn, the access node delivers the data to the sink without exporting the sink’s location information to the rest of the tree
- The tree is updated only when the access node changes
- As the sink moves, no new access node is chosen until the hop count between the access node and the sink exceeds a threshold
  - Trade-off between path delay and energy spent on reconstructing the tree

SEAD
a Scalable Energy-efficient Asynchronous Dissemination protocol

- Source data is replicated at selected nodes between the source and sinks
- We define a *replica* as a sensor node that stores a copy of the source data
  - It temporarily stores the latest data incoming from the source and asynchronous disseminate it to others along the tree

SEAD

a Scalable Energy-efficient Asynchronous Dissemination protocol

- Subscription Query
  - Sink directs a join query to source via its access node
- Gate replica search
  - A gate replica is determined, which serves as the grafting point from which a branch to the new access point is extended
- Replica placement
  - locally readjusts the tree in the neighborhood of the gate replica to further reduce communication energy
- D-tree management
  - The constructed tree is managed to accommodate mobile sinks or defective regions such as a group of congested or failed nodes

SEAD – Subscription Query

- Mobile sinks beacon periodically to determine their neighbors
- A mobile sink B_i selects the nearest of its adjacent nodes as the access node A_i
  - B_i sends a *join query* to a source via A_i
  - The *join query* message contains the location of the A_i
  - and the sink's desired updated rate R_i
- The access node directly sends the *join query* to the source via the underlying routing protocol

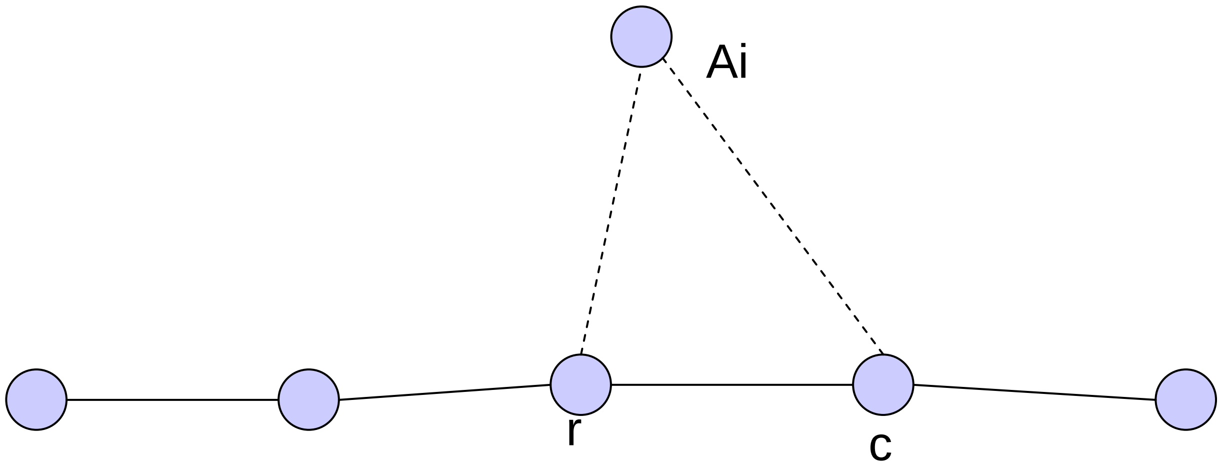
SEAD - Gate Replica Search

- Communication cost

$$Energy\_cost(a,b) \propto d(a,b)P_{ab}.$$

Pab：the packet sending rate

SEAD - Gate Replica Search



$$
\begin{aligned}
K(r) - K(c) = \\
& R_i d(r, A_i) + \sum_{m \in E_r} \| R_i - Q_m^{p(m)} \| d(p(m), m) \\
& - R_i d(c, A_i) - \sum_{m \in E_c} \| R_i - Q_m^{p(m)} \| d(p(m), m) \\
= \quad & R_i d(r, A_i) - R_i d(c, A_i) - \| R_i - Q_c^{p(c)} \| d(p(c), c) \\
= \quad & R_i d(r, A_i) - R_i d(c, A_i) - \| R_i - Q_c^{r} \| d(r, c)
\end{aligned}
$$

SEAD - Replica Placement

- Locally adjusts the tree around the gate replica to produce an optimal d-tree
- There are two ways to connect the access node to the gate replica
  - *Non-replica mode*
    - Connect it as a child of the gate replica
    - Adds no replicas to the tree
  - *Junction mode*
    - Create a child for the gate replica to feed the access node and some of the gate replica's original children
    - The new child replica is called a junction replica

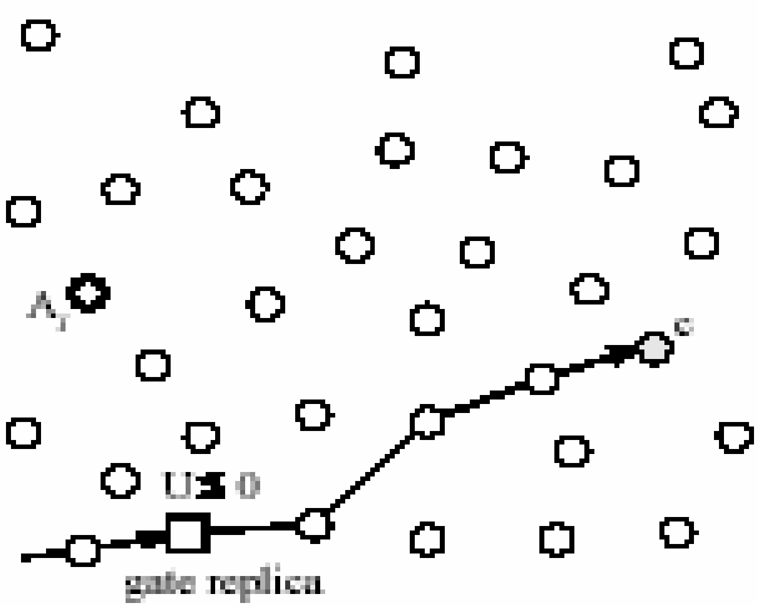
SEAD - Replica Placement

- The replica placement phase
  - compares the non-replica mode cost $U_{non\_replica}$ to a junction replica mode cost $U_{jreplica}$
  - Selects the better option so that the access node joins the tree in a way that minimizes the energy cost

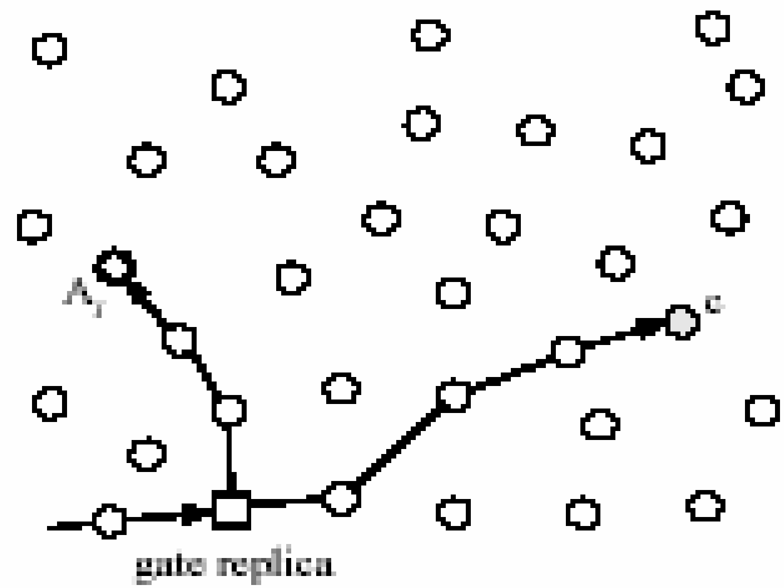
SEAD - Replica Placement

- The gate replica g calculates the cost of the non-replica mode $U_{non\_replica}(c)$ for each child $c \in C(g)$

$$U_{non\_replica}(c) = d(g, A_i)R_i + d(g, c)Q_c^g$$



(a) gate replica computing U

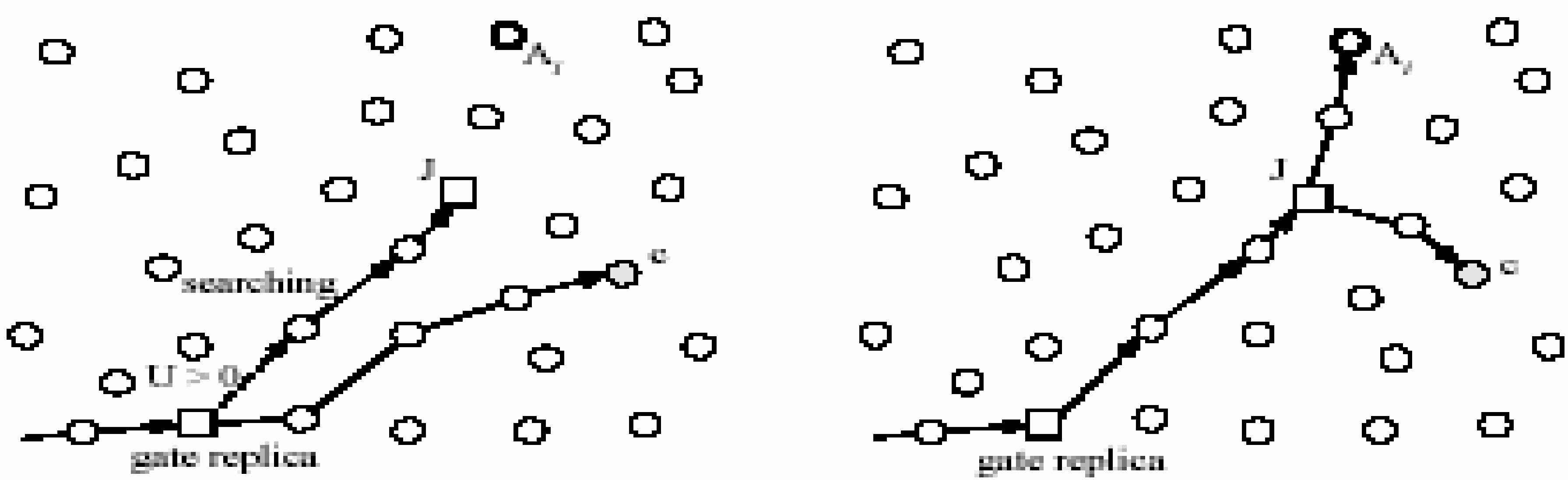


(b) non-replica mode

SEAD - Replica Placement

- The gate replica g finds the neighbor node n among its adjacent nodes within a singe hop range. Then it calculates the energy cost $U_{ireplica}(c)$ for each child c

$$U_{jreplica}(c) = \min_{n \in W} \{ d(g,n) \max(R_i, Q_c^g) + d(n, A_i) R_i + d(n,c) Q_c^g \}$$

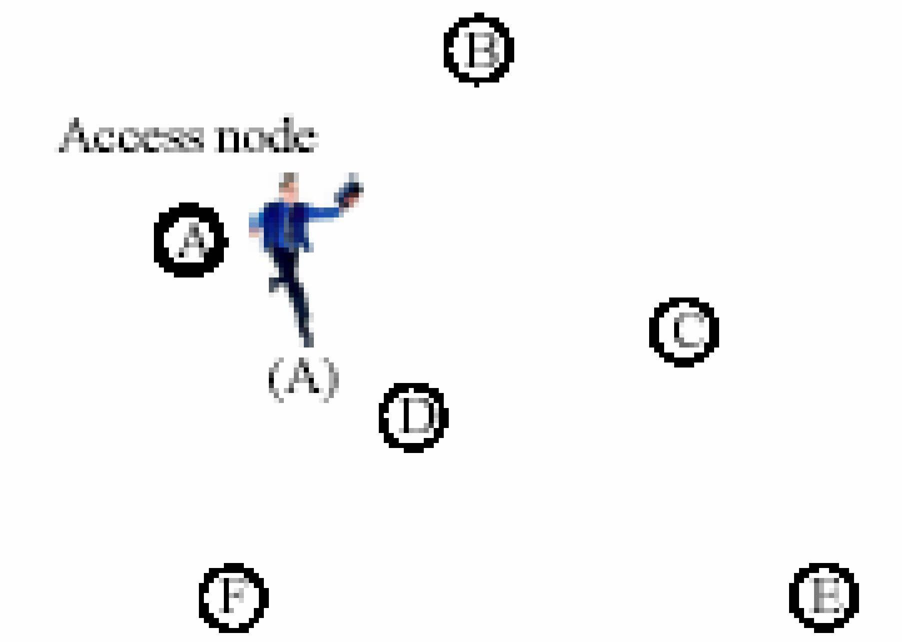


(a) searching a junction replica J

(b) juction replica mode

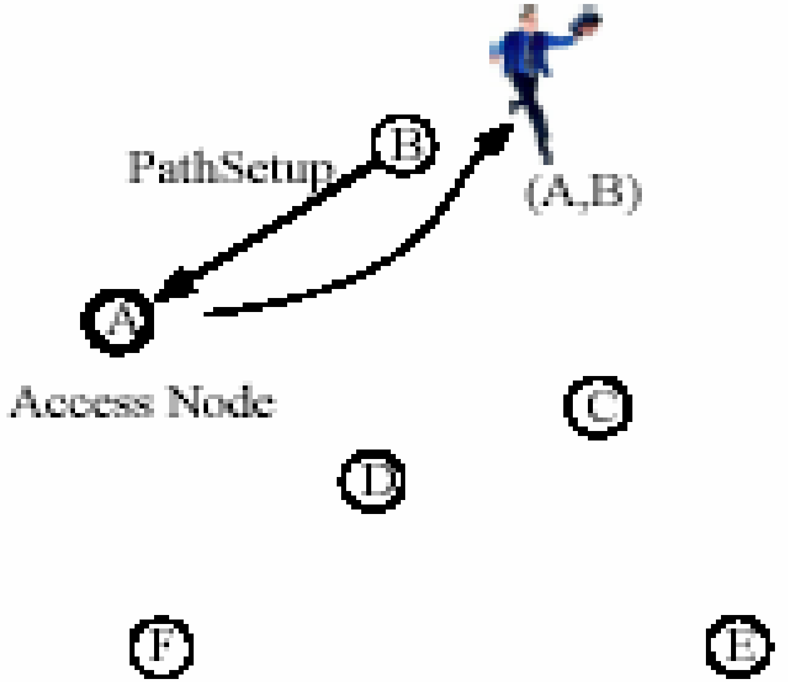
SEAD - D-tree management

- Sink mobility



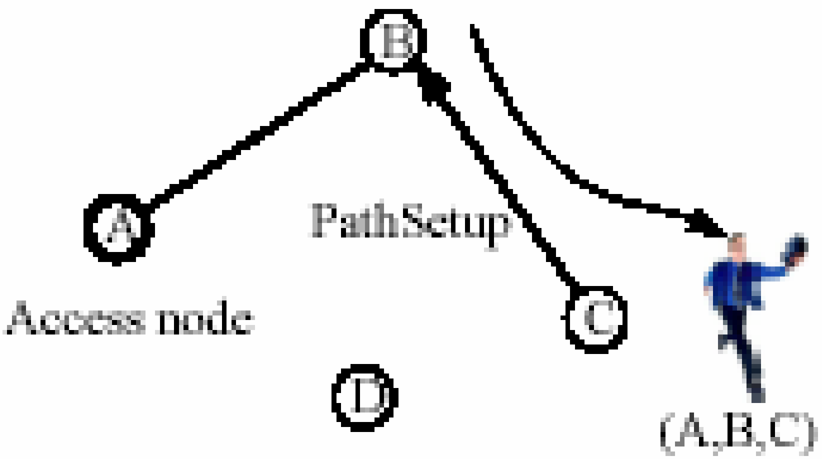
(a) initial access node setup

SEAD - D-tree management



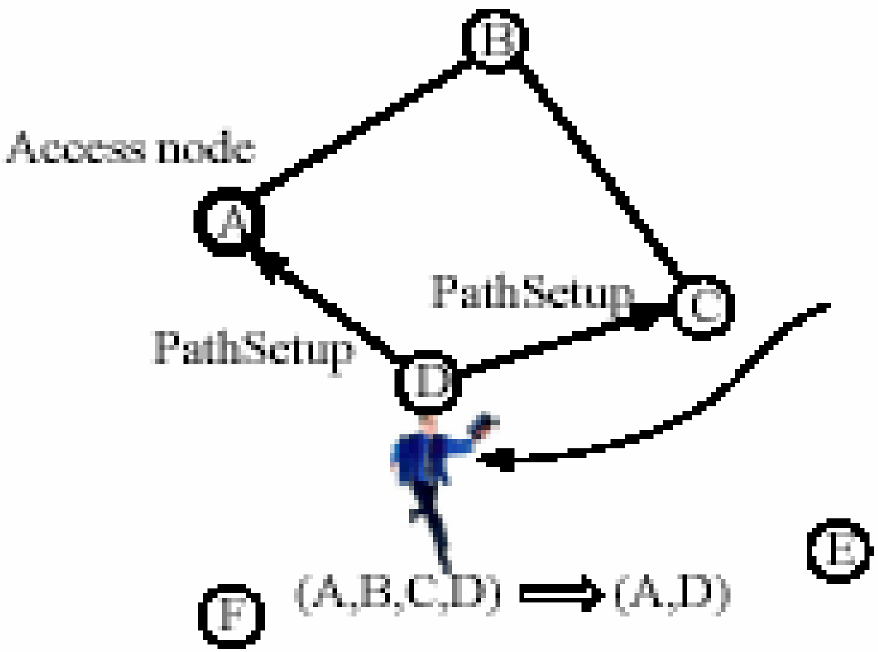
(b) path A to B setup

SEAD - D-tree management



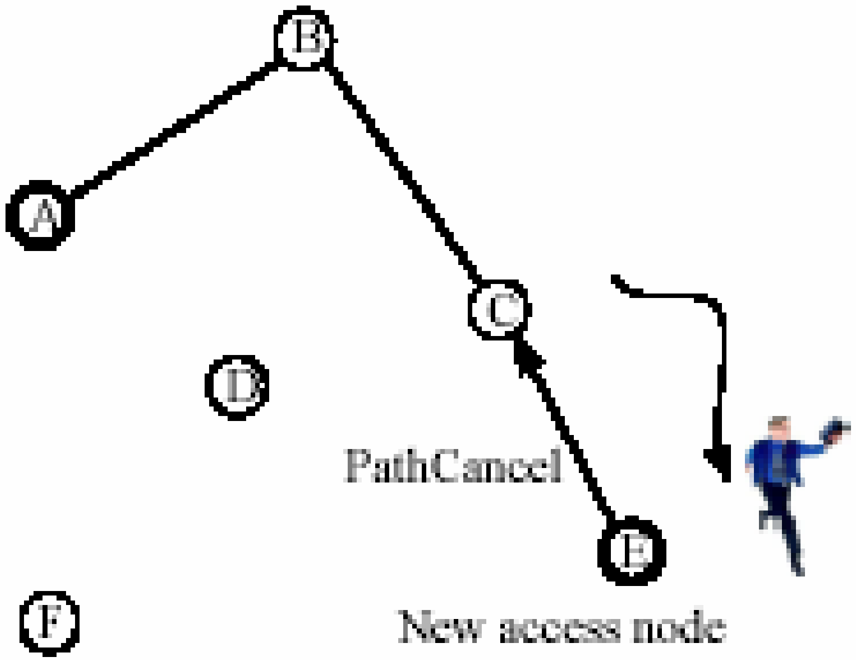
(c) path B to C setup

SEAD - D-tree management



(d) case 1: shorter path setup

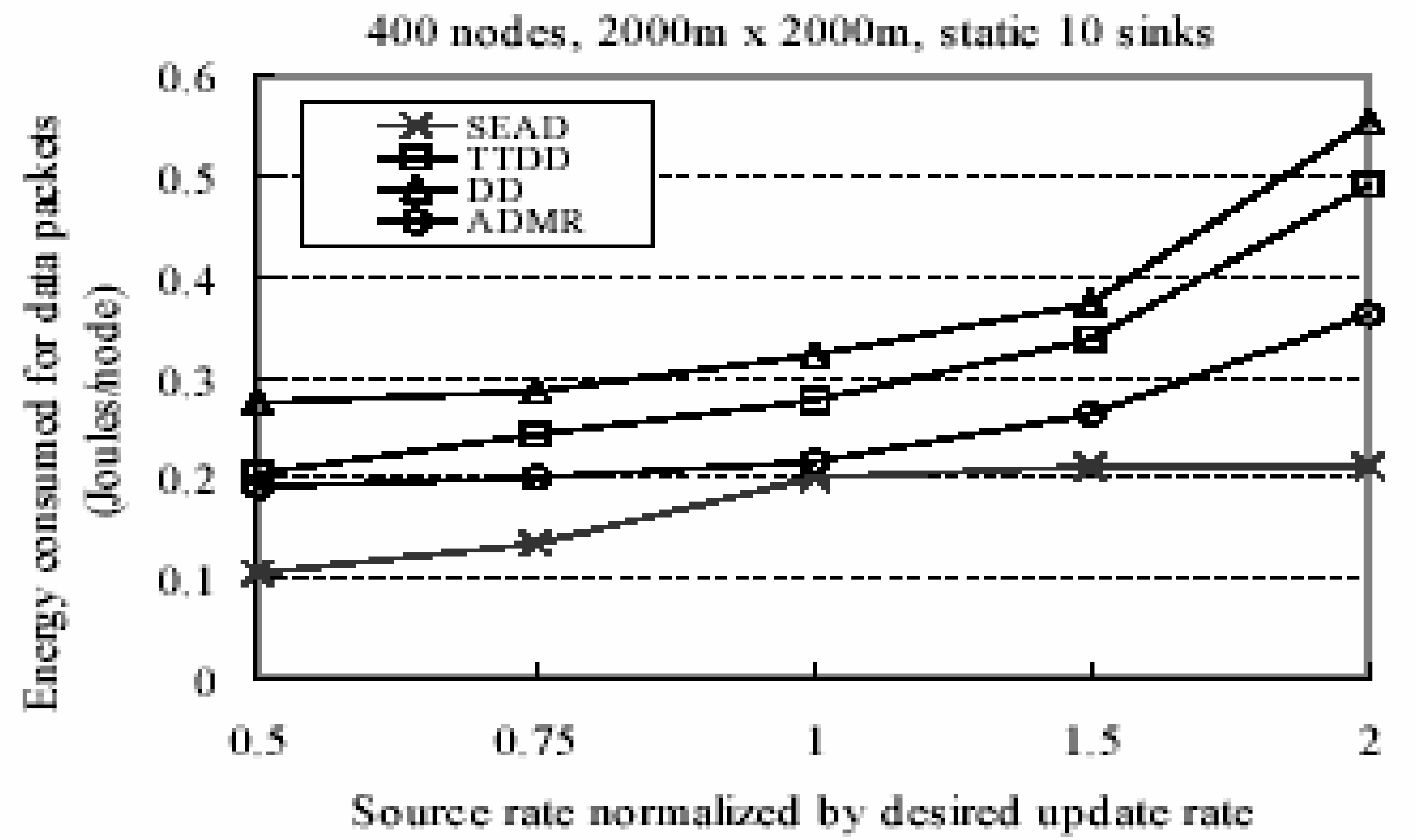
SEAD - D-tree management



(e) case 2: new access node create

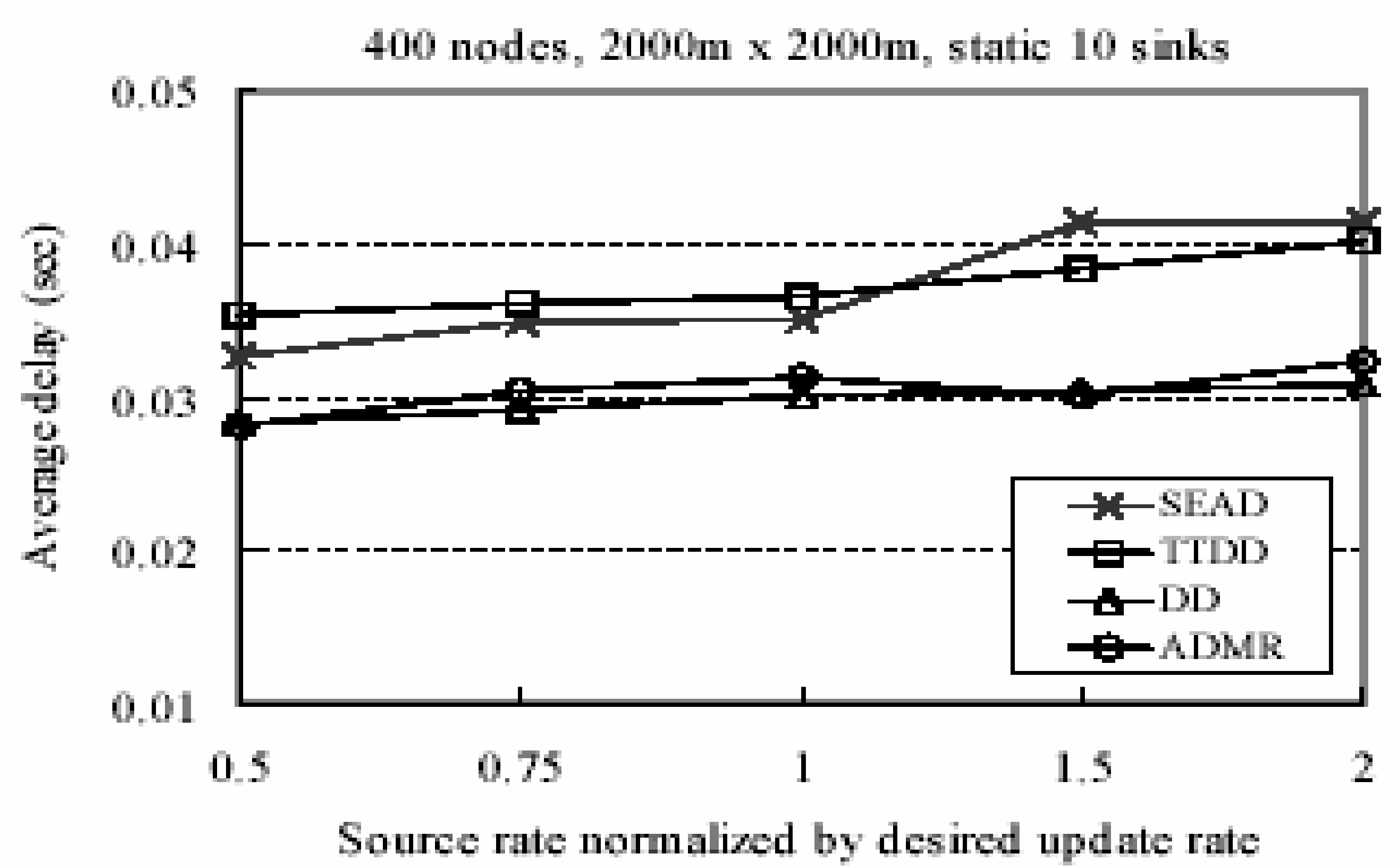
Evaluation

- Energy consumed for data packets



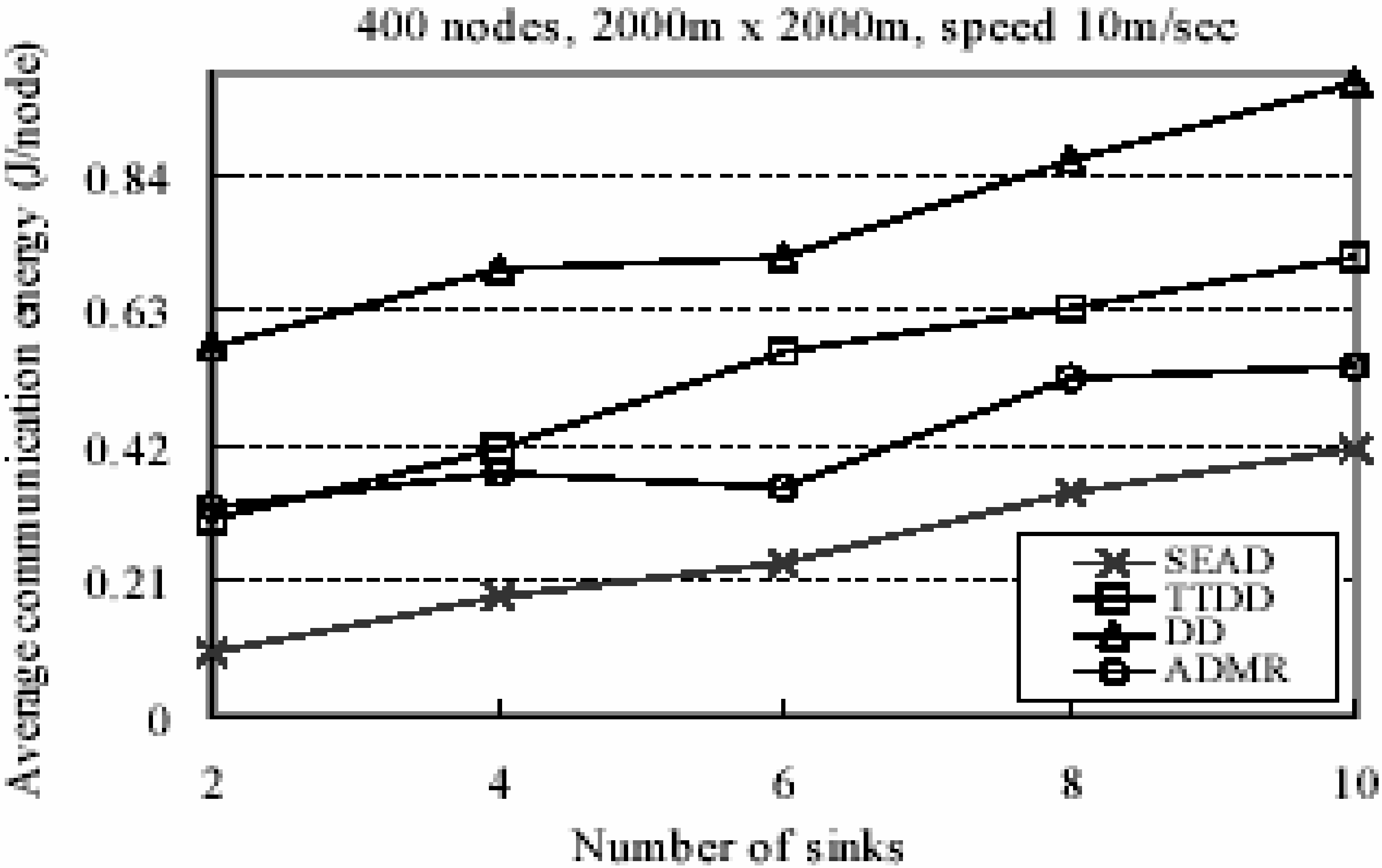
Evaluation

- Average delay



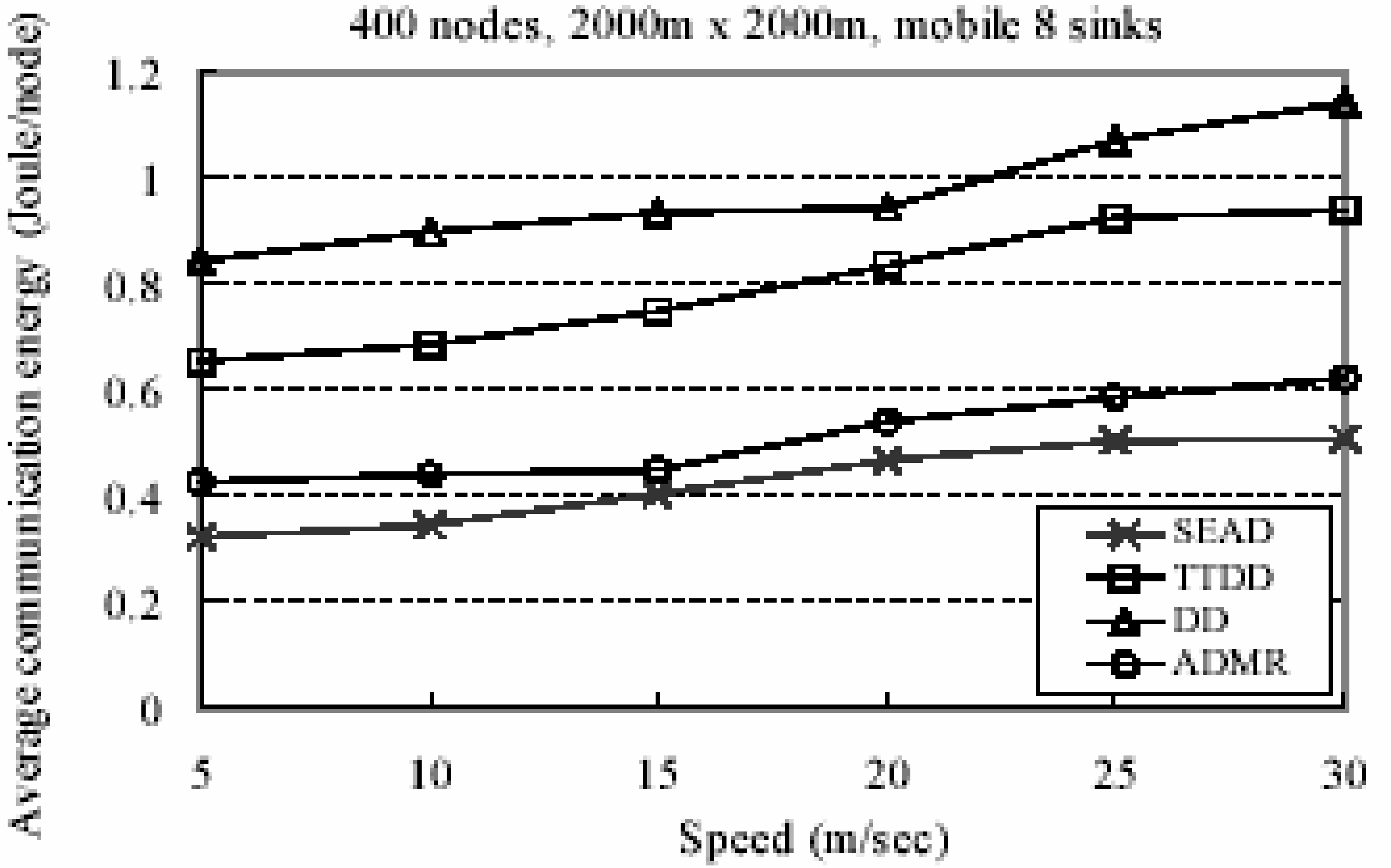
Evaluation - Sink mobility

- Energy consumption for the number of sinks



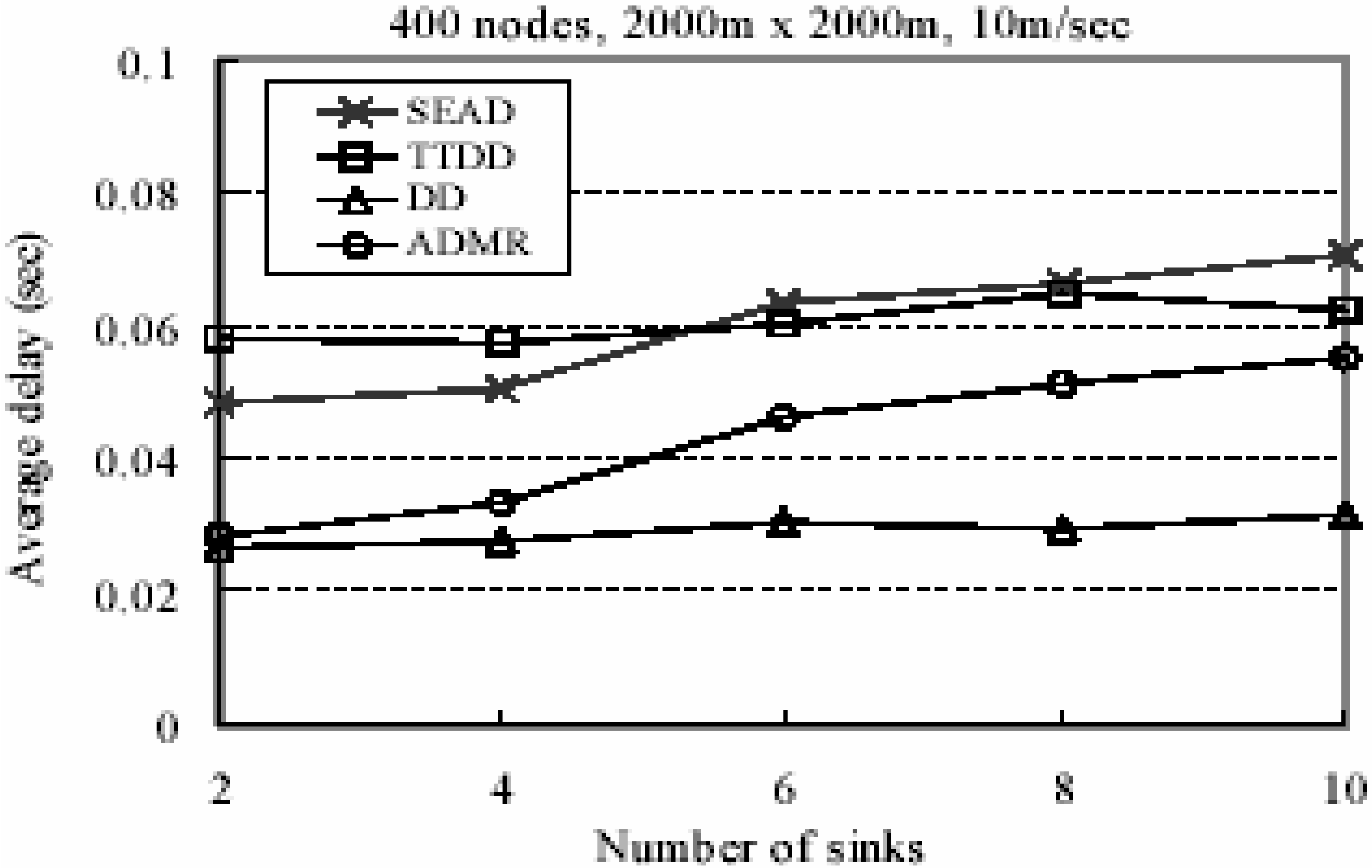
Evaluation - Sink mobility

- Energy consumption with different sink speeds



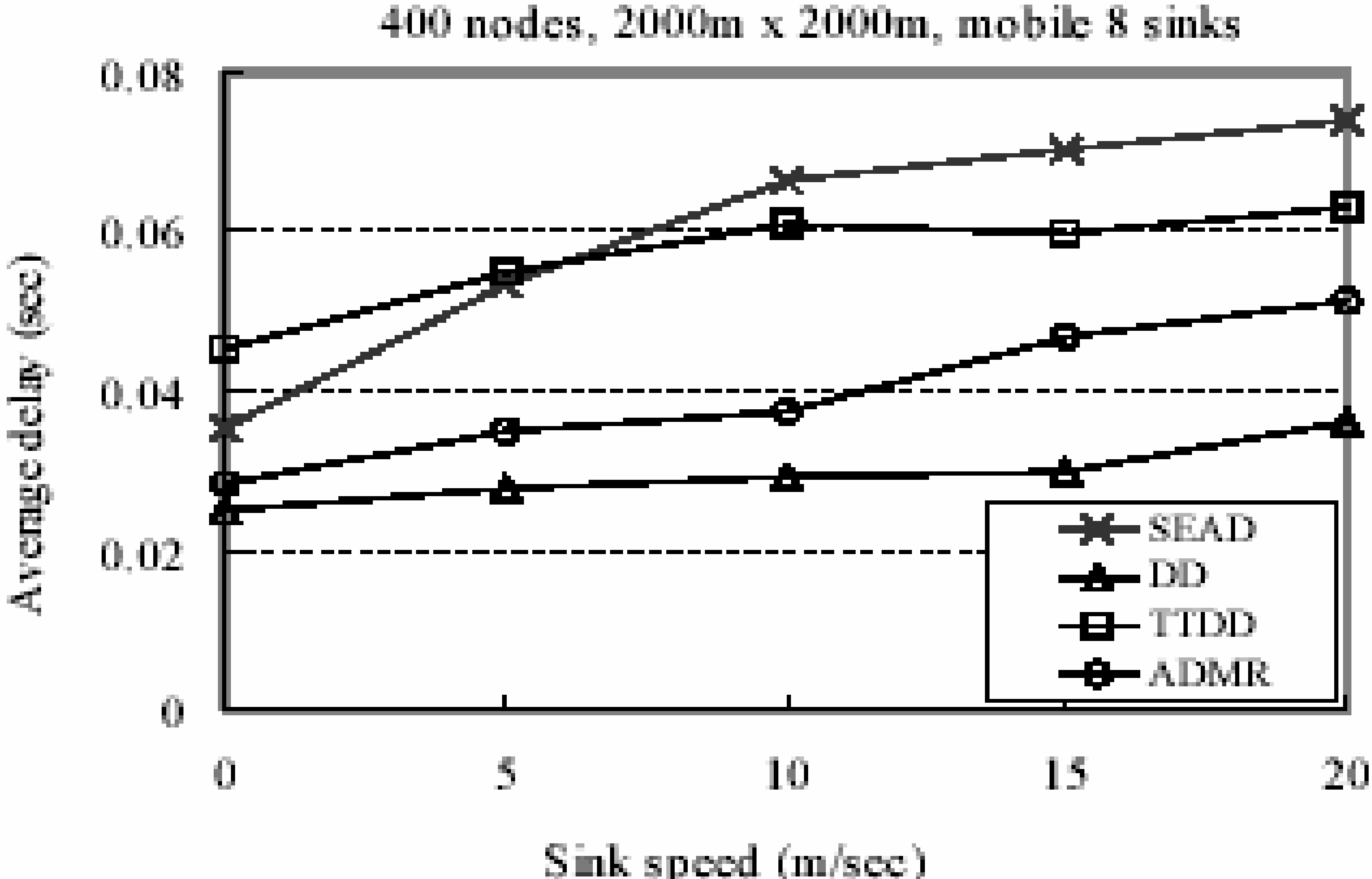
Evaluation - End-to-end delay

- Average delay with different number of sinks



Evaluation - End-to-end delay

- Average delay with different sink speeds



SEAD - Conclusion

- Advantage
  - Saves energy consumption in both building the d-tree and maintaining linkage to mobile sinks
  - Strikes a balance between end-to-end delay and power consumption that favors power savings over delay minimization
- Disadvantage

  How do access nodes know where the sources is

THANK YOU