UC SANTA CRUZ

An Interest-Driven Approach to Integrated Unicast and Multicast Routing in MANETs

PRIME: Protocol for Routing in Interest-defined Mesh Enclaves

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Motivation

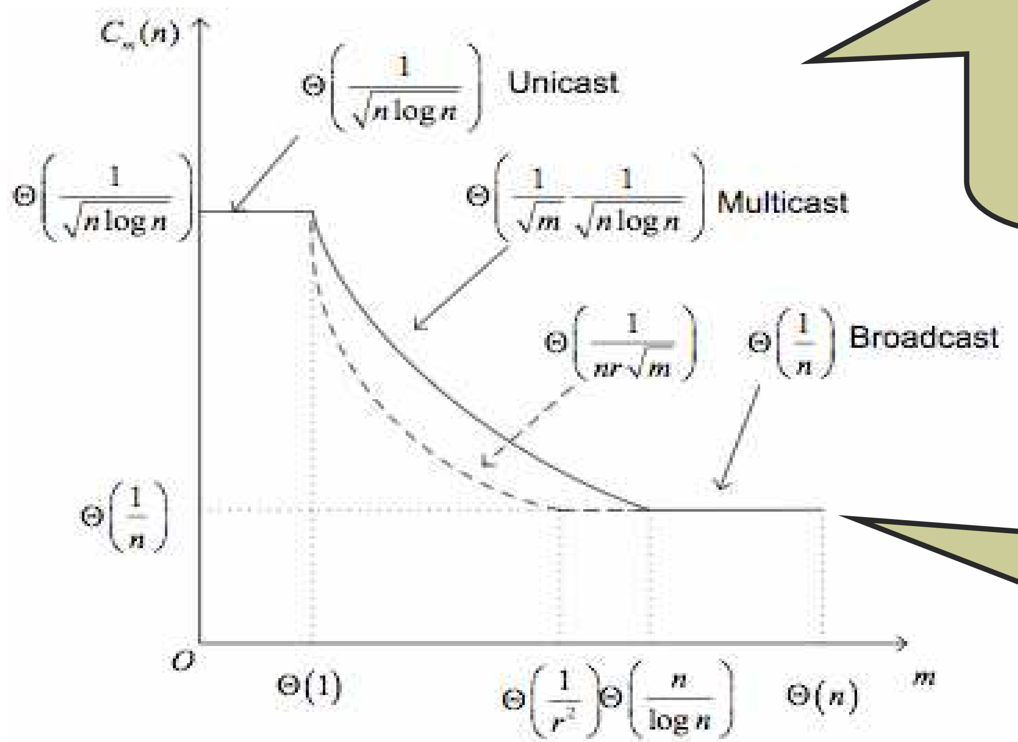
- MANET applications require point-to-point and many-to-many communication
  - very few destinations are such that a large percentage of the nodes in the network have interest in them
- These application requirements are in stark contrast with the way in which today's MANET routing protocols operate

Motivation

- Current approaches
  - Support either unicast routing or multicast routing
  - Proactive and on-demand routing protocols for unicasting and multicasting are such that the network is flooded frequently
    - This is the case even when protocols maintain routing information on demand (e.g., AODV and ODMRP)

Motivation

- What We Know from Capacity Results:



Signaling overhead of routing protocols should be close to $\Theta(1)$

*Confine signaling to “**regions of interest**” and limit floodings*

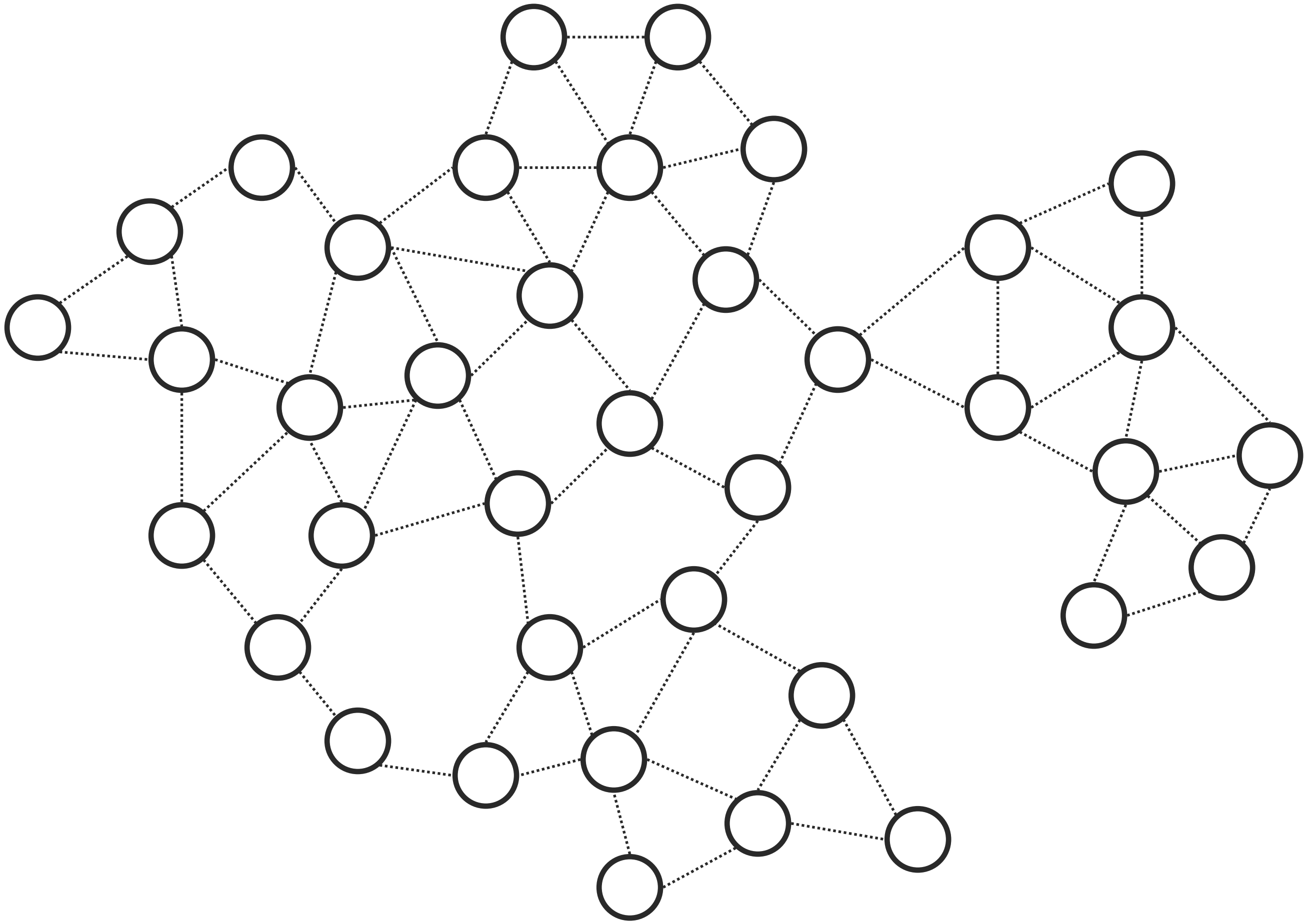
Our proposal

- Integrated routing:
  - The same control signaling to support unicast and multicast routing
  - The distinction between on-demand and proactive signaling for routing is eliminated
  - Interest-driven signaling is used instead
- Interest-defined mesh enclaves are established and maintained
  - Connected components of a MANET over which control signaling and data packets for unicast or multicast flows are disseminated

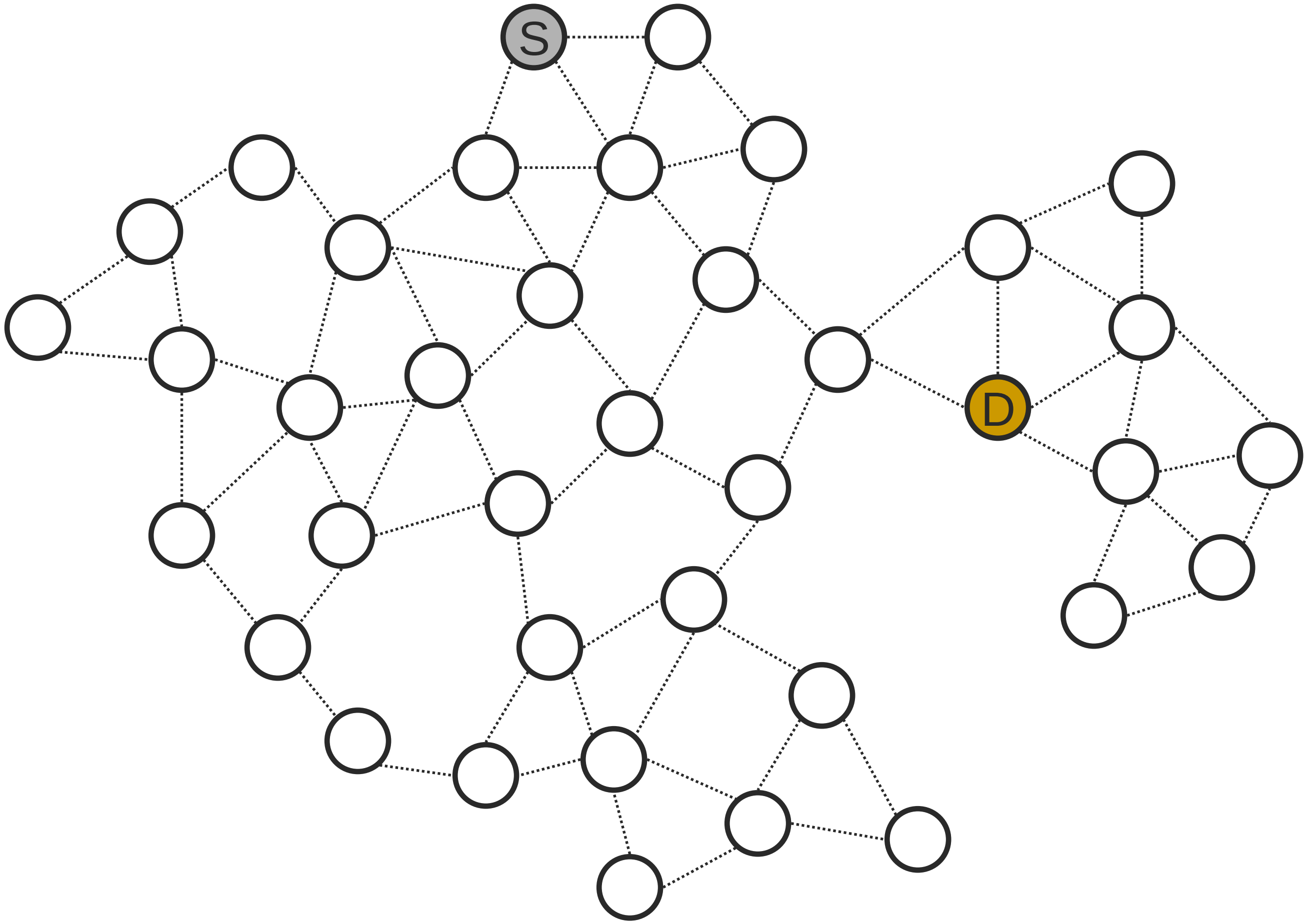
Our proposal

- The Protocol for Routing in Interest-defined Mesh Enclaves (**PRIME**)
  - Interest-defined Routing
    - Enclaves
      - Activated and Deactivated
    - Enclaves for Data Packet Forwarding
      - Local Repairs
    - Adaptive Enclaves

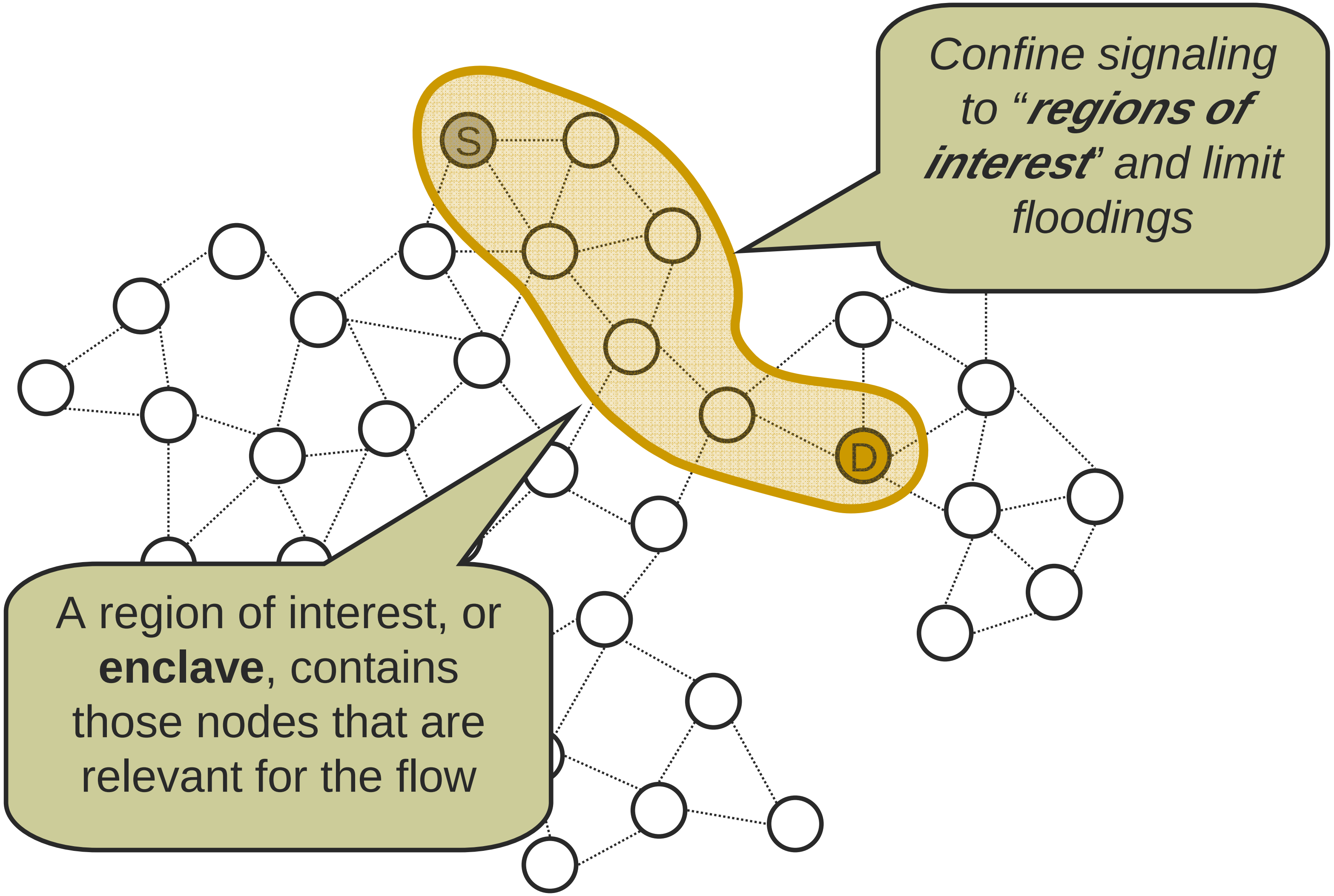
Enclaves



Enclaves



Enclaves: unicast



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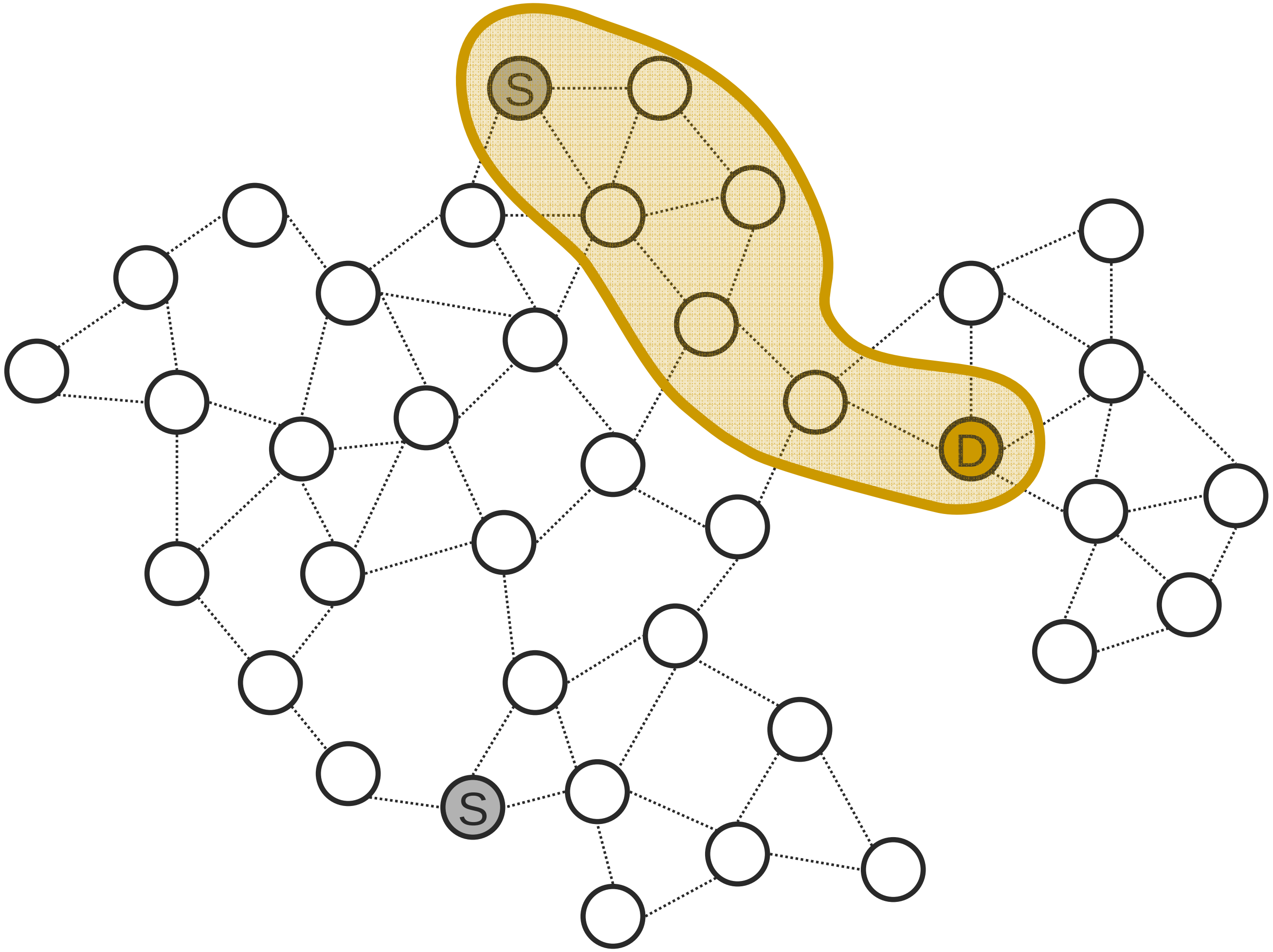

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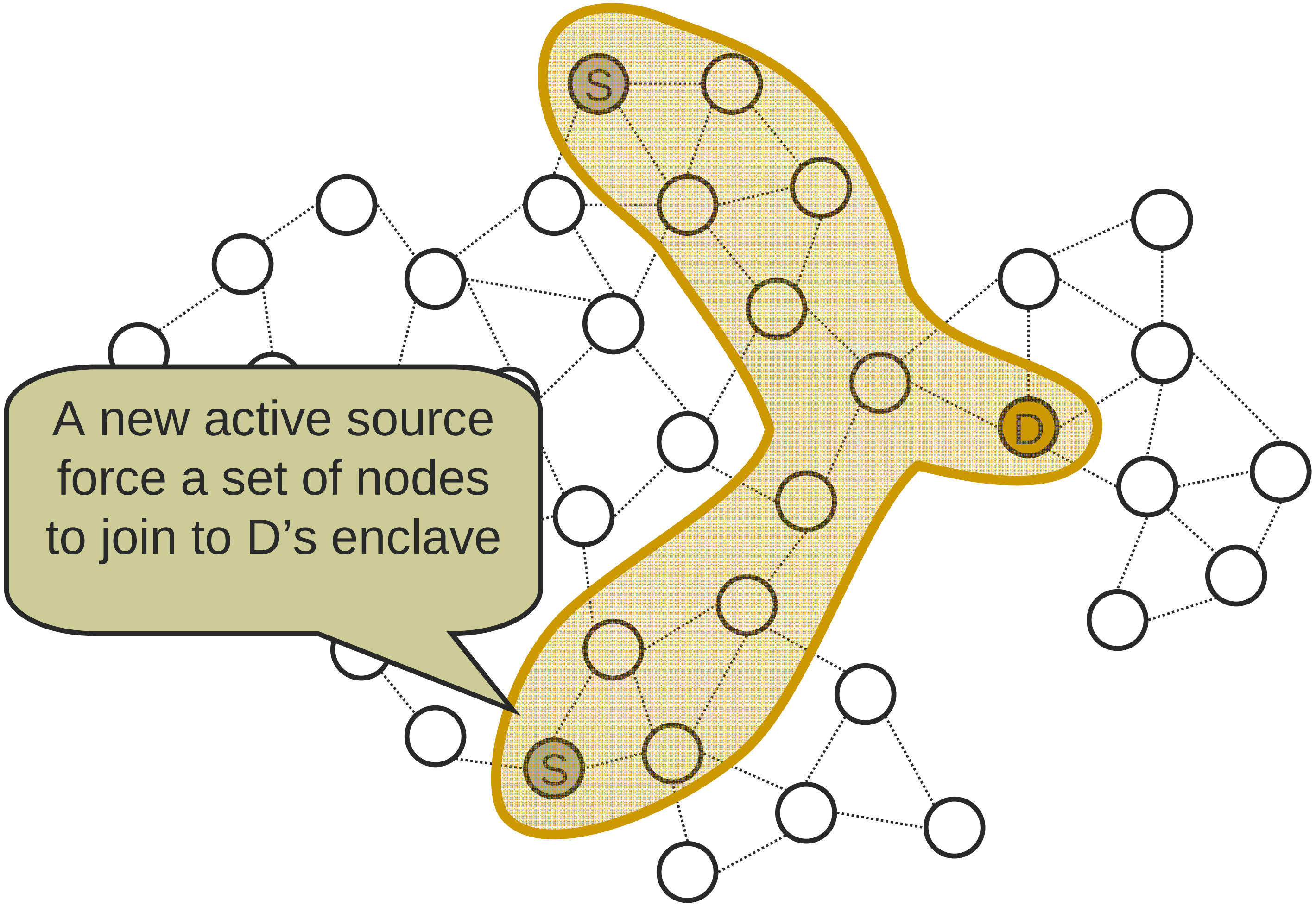

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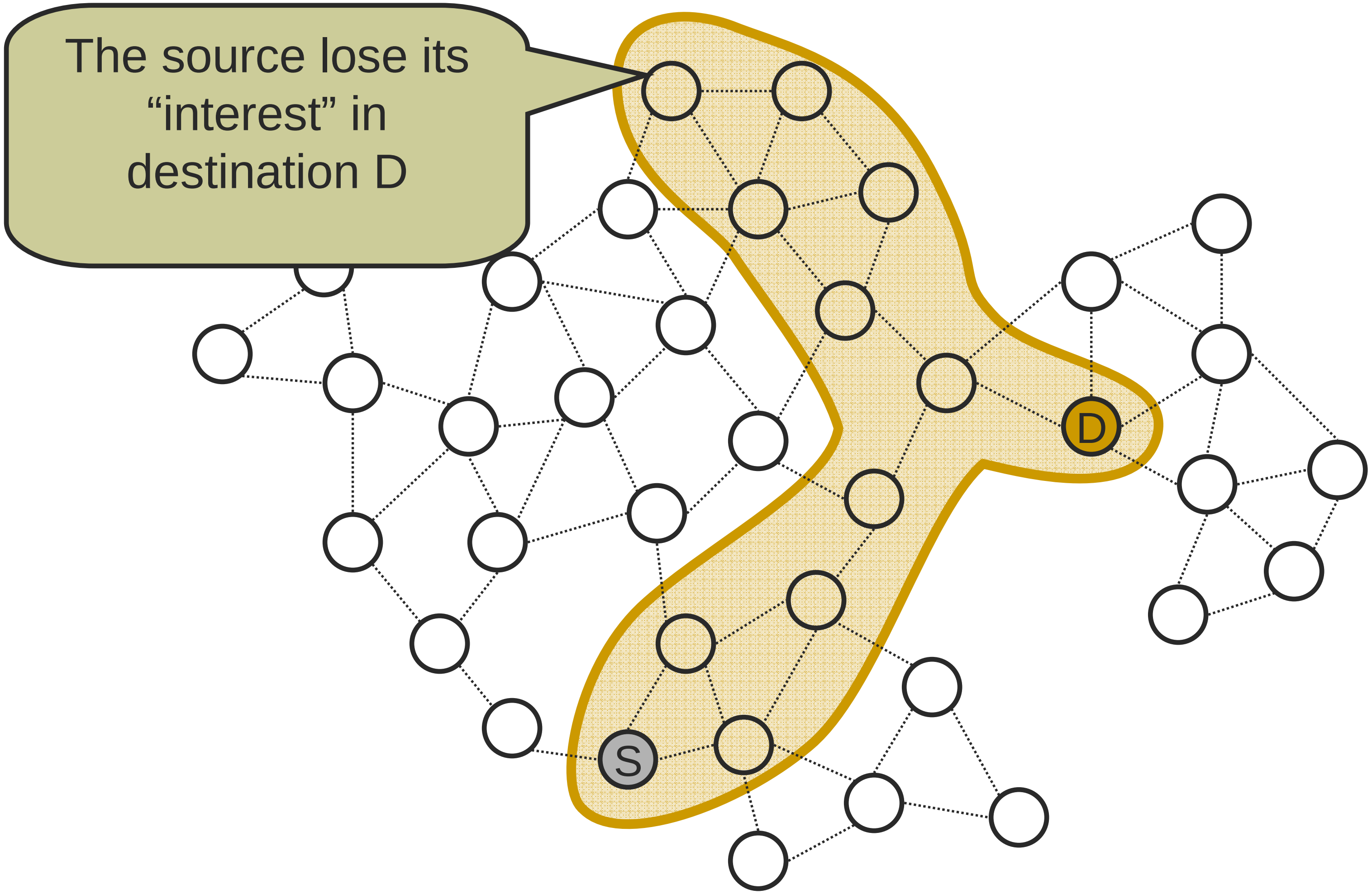

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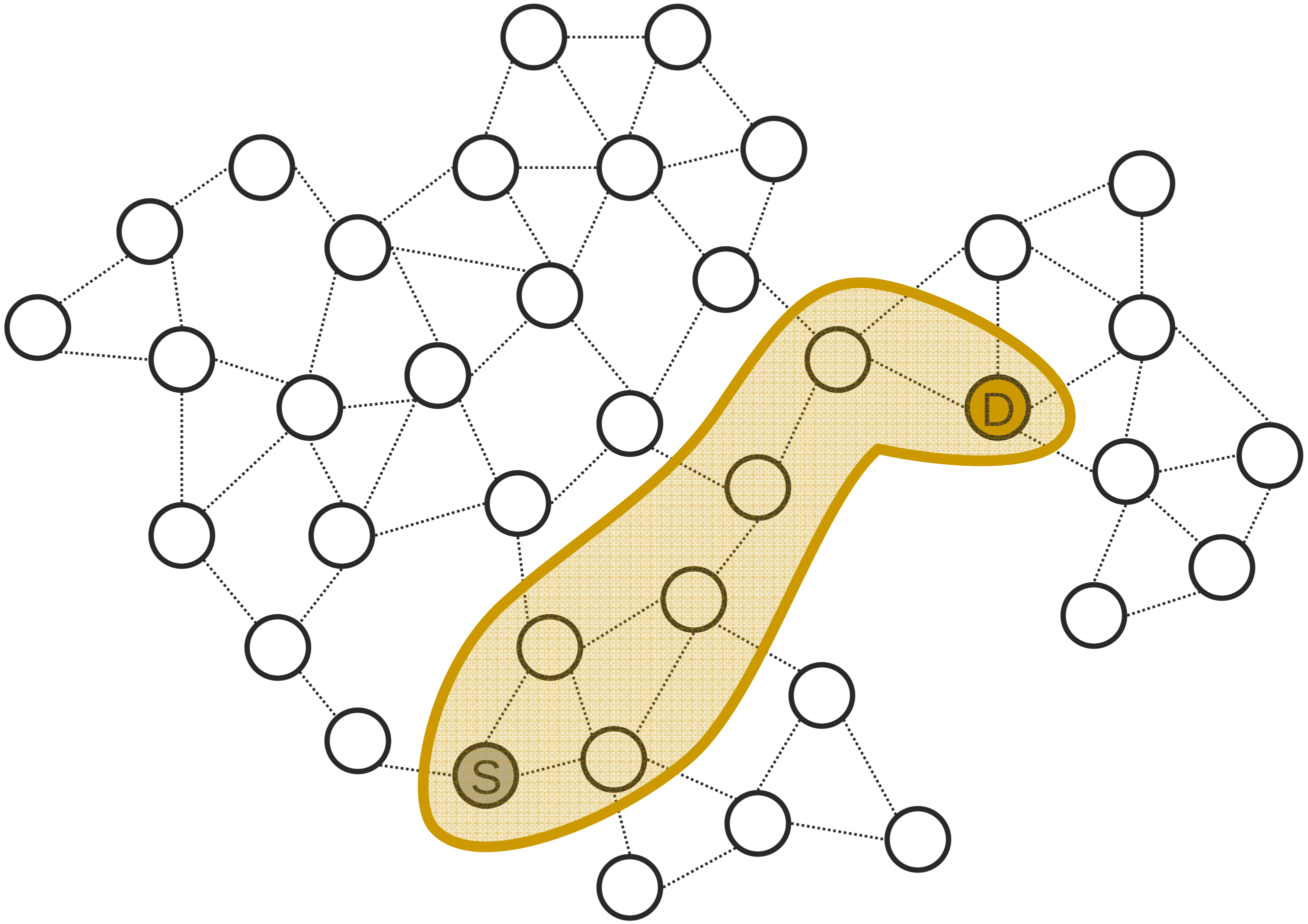
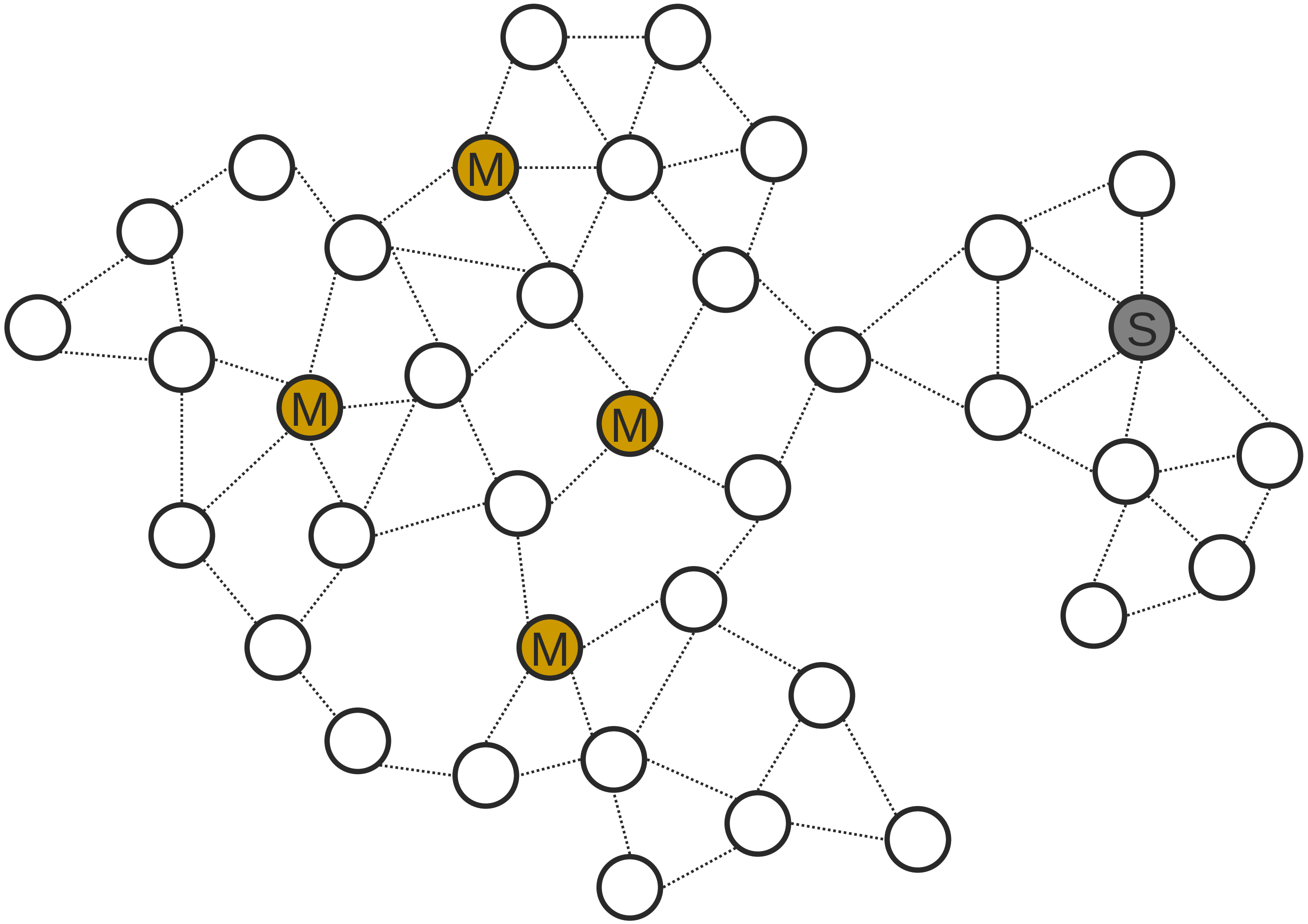


Enclaves: multicast



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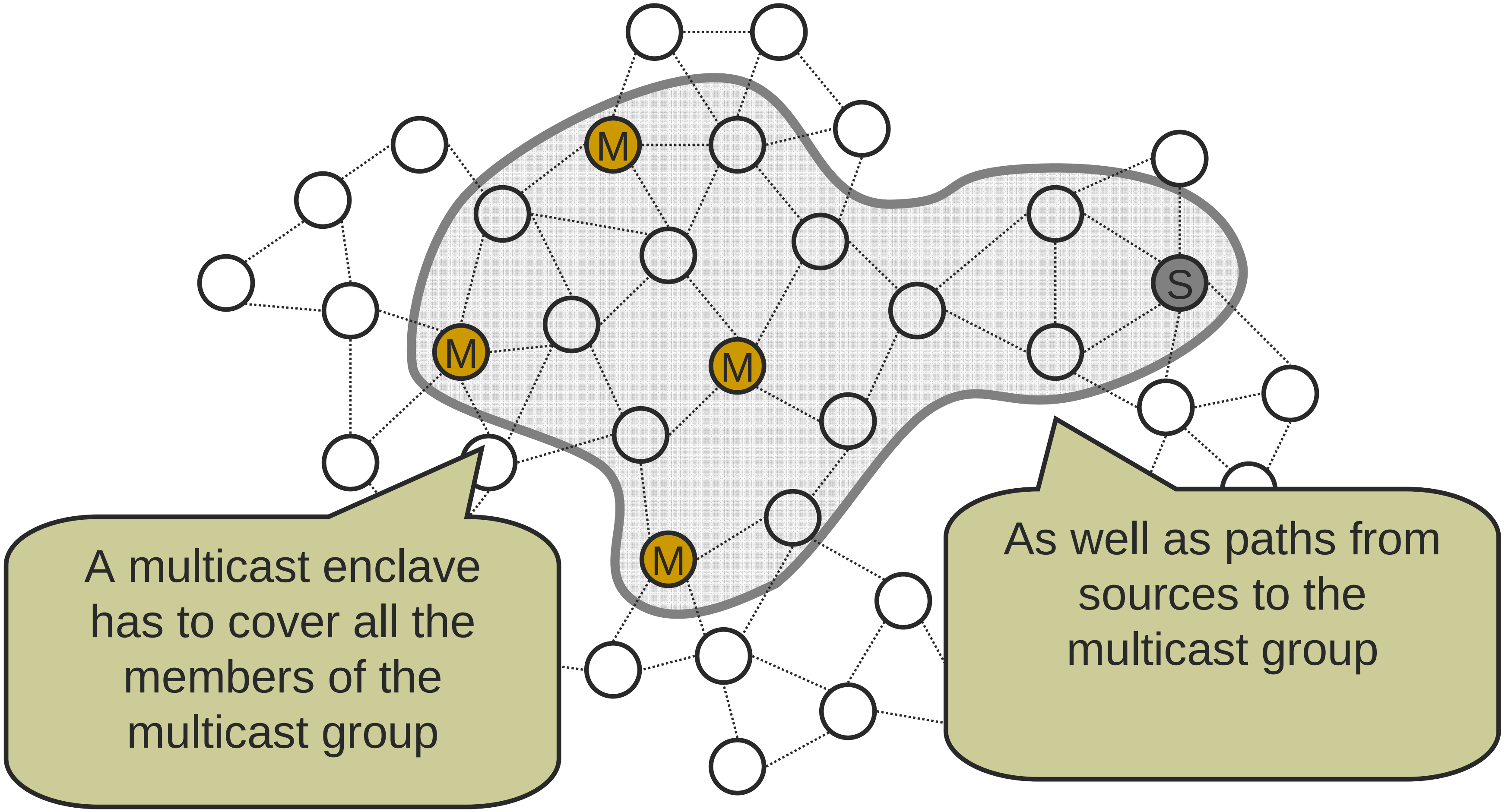

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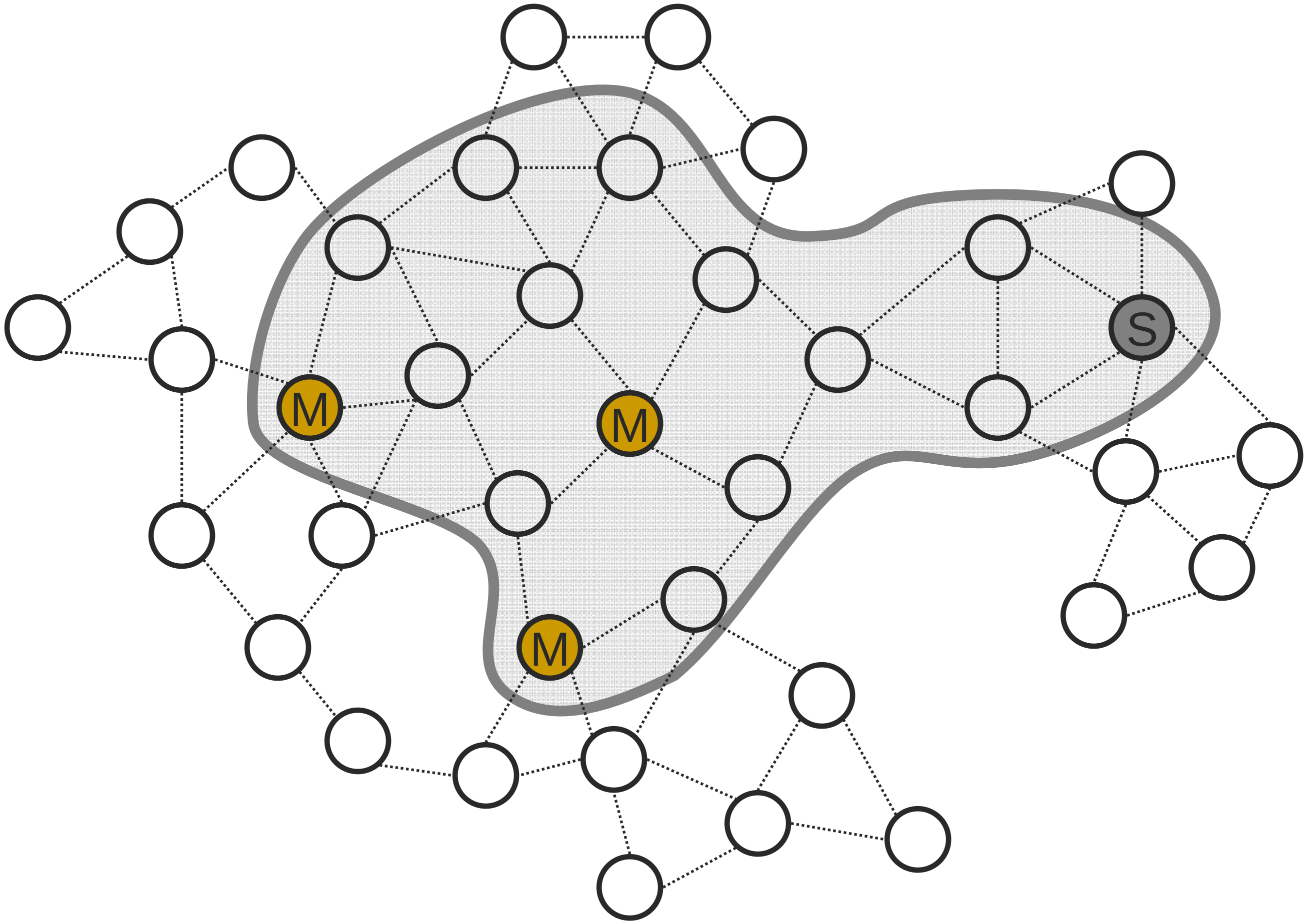

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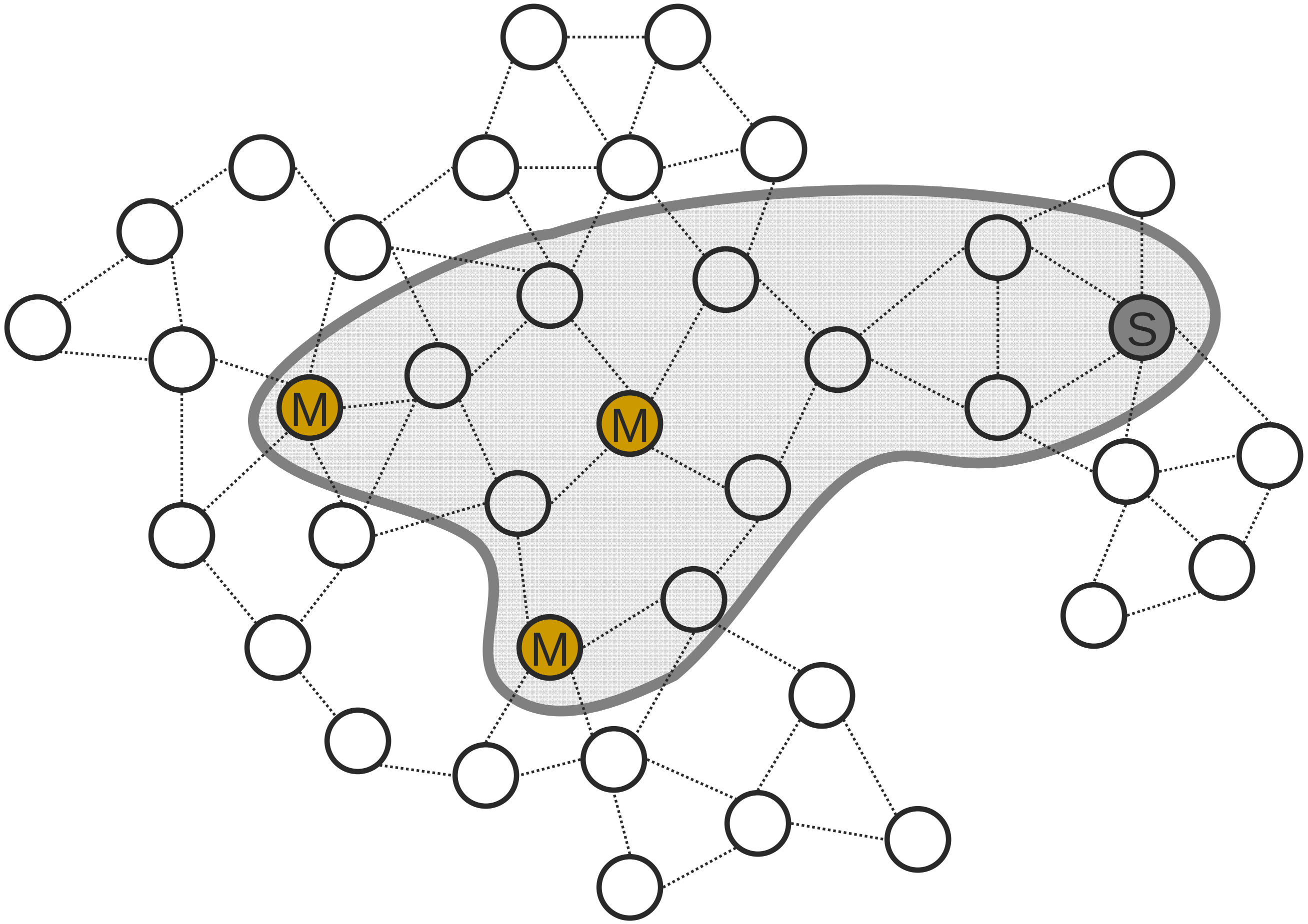

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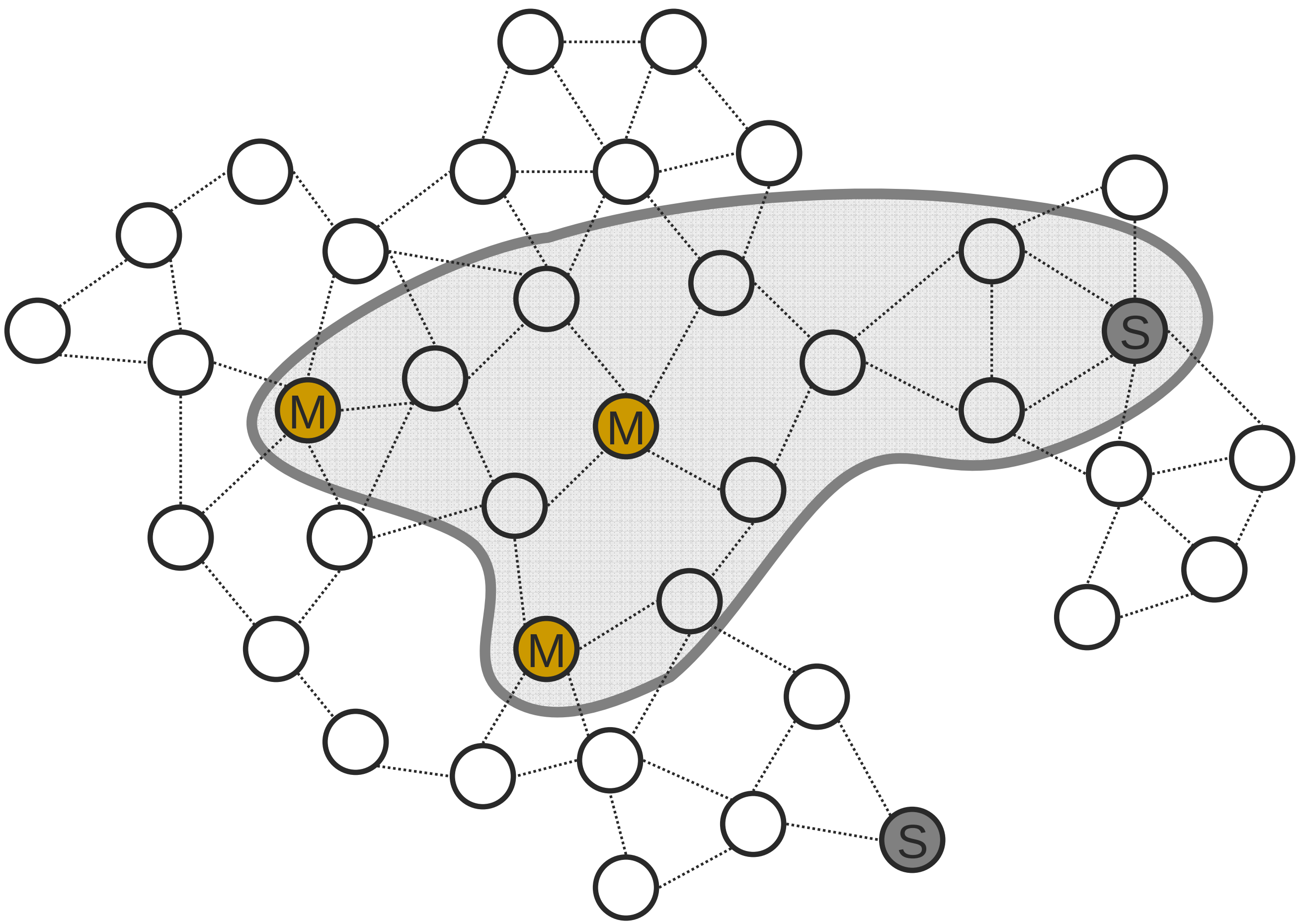

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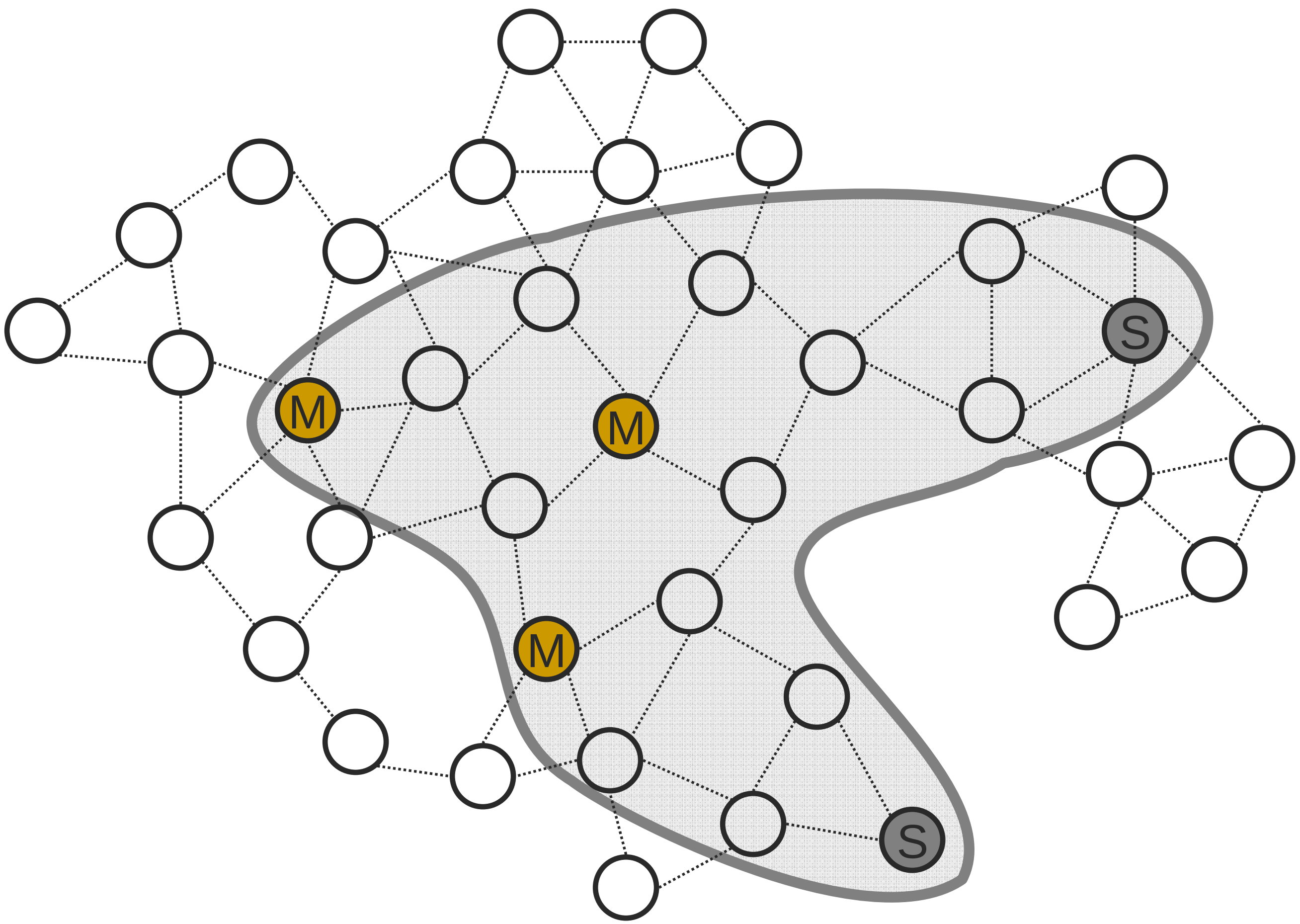
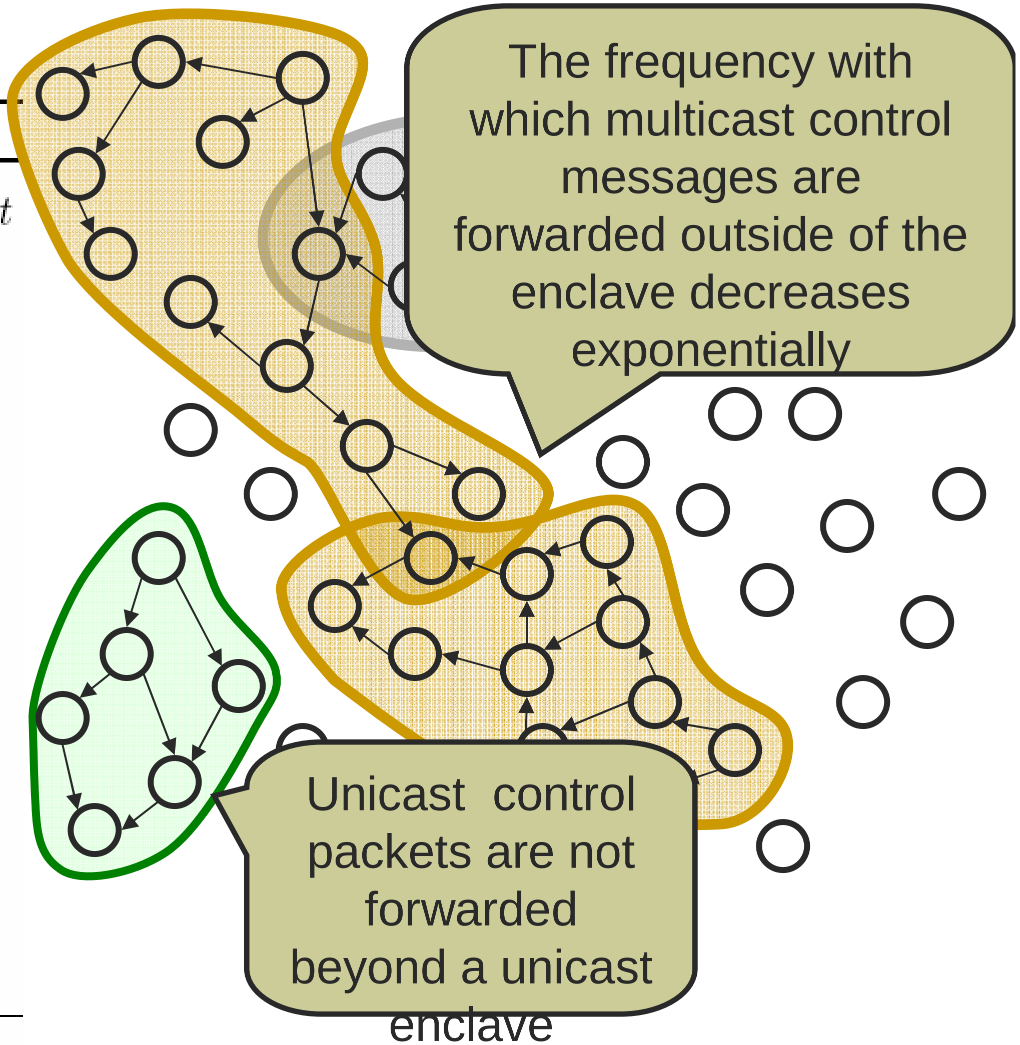


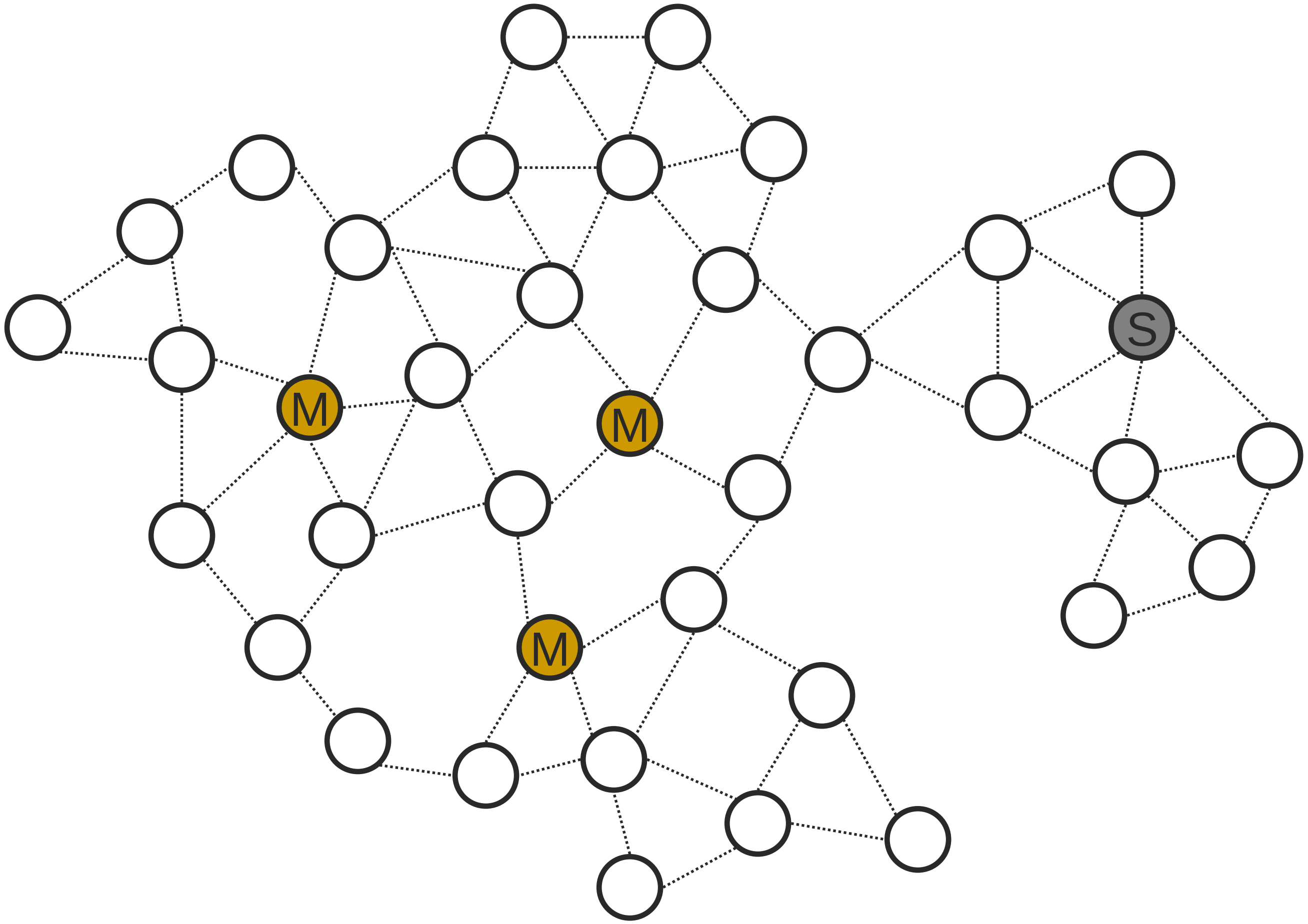
Enclaves

Algorithm 1: ENCLAVE(MA)

```
if AddressType(MA.destination) = multicast then
    if rc ∨ sd ∨ mm ∨ pn then
    else
        if r mod R = 0 then
            r++;
        else
            r++;
            return false;
else
    if pn then
    else
        return false;
return true;
```



Enclaves: Activation and Deactivation



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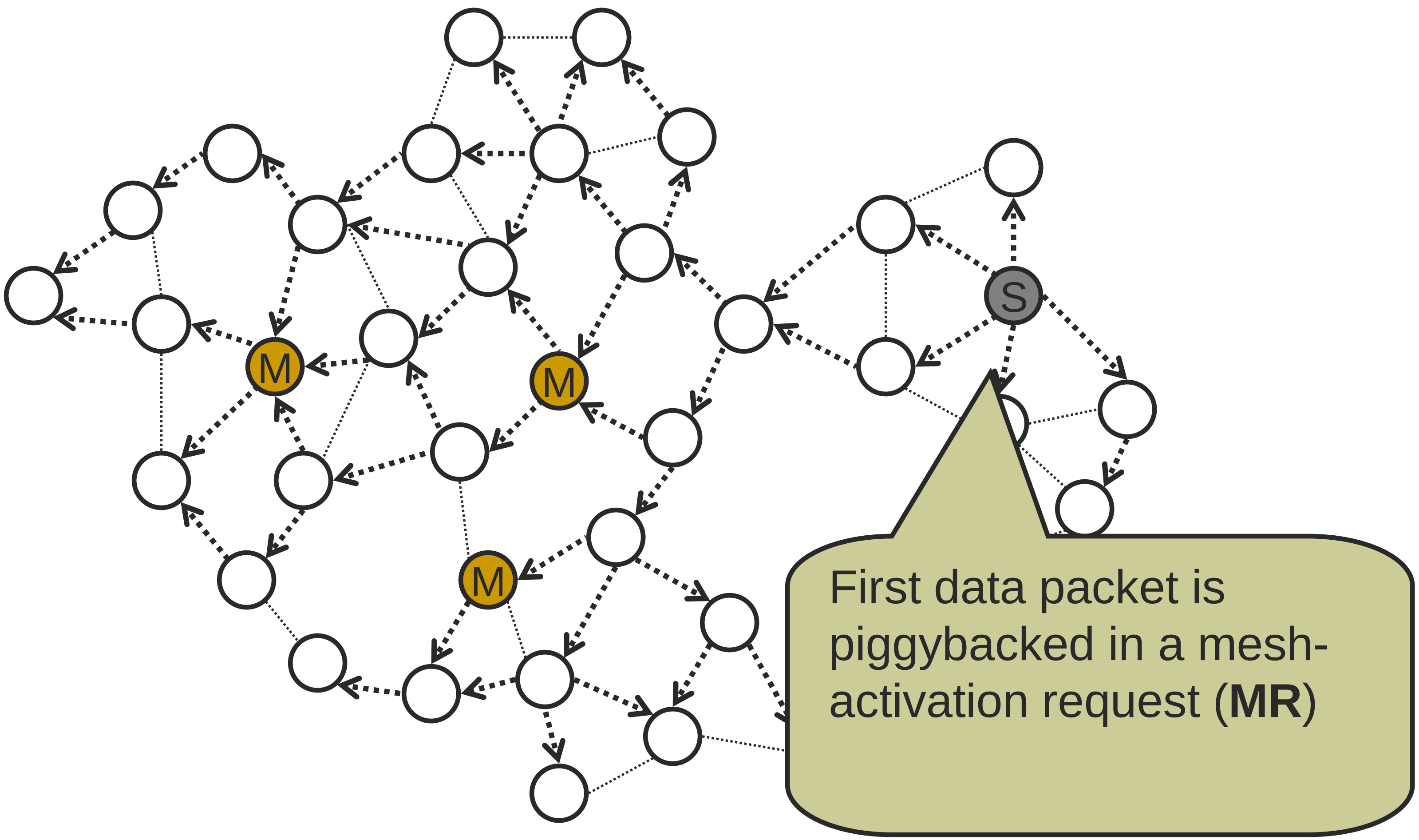

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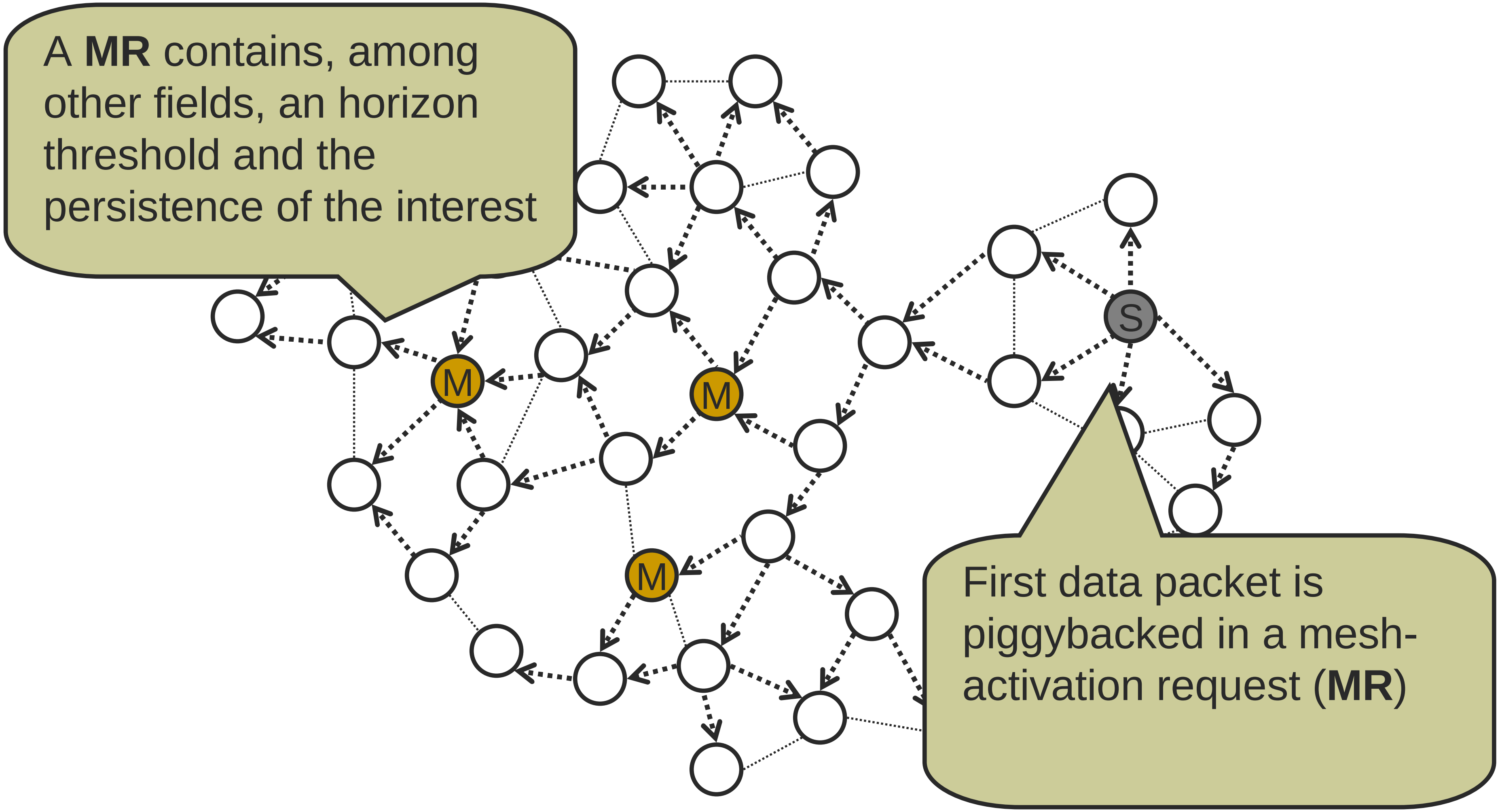

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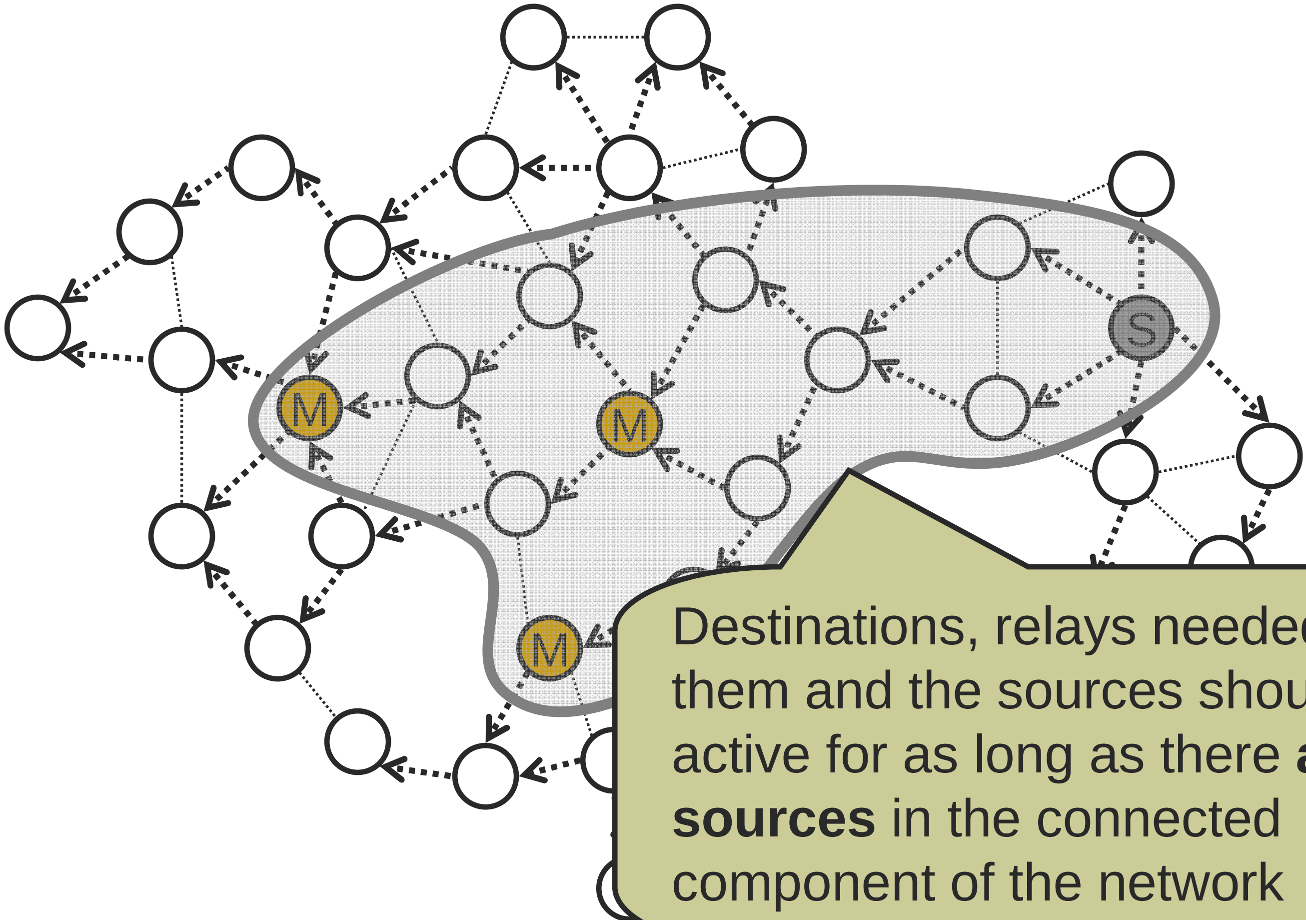
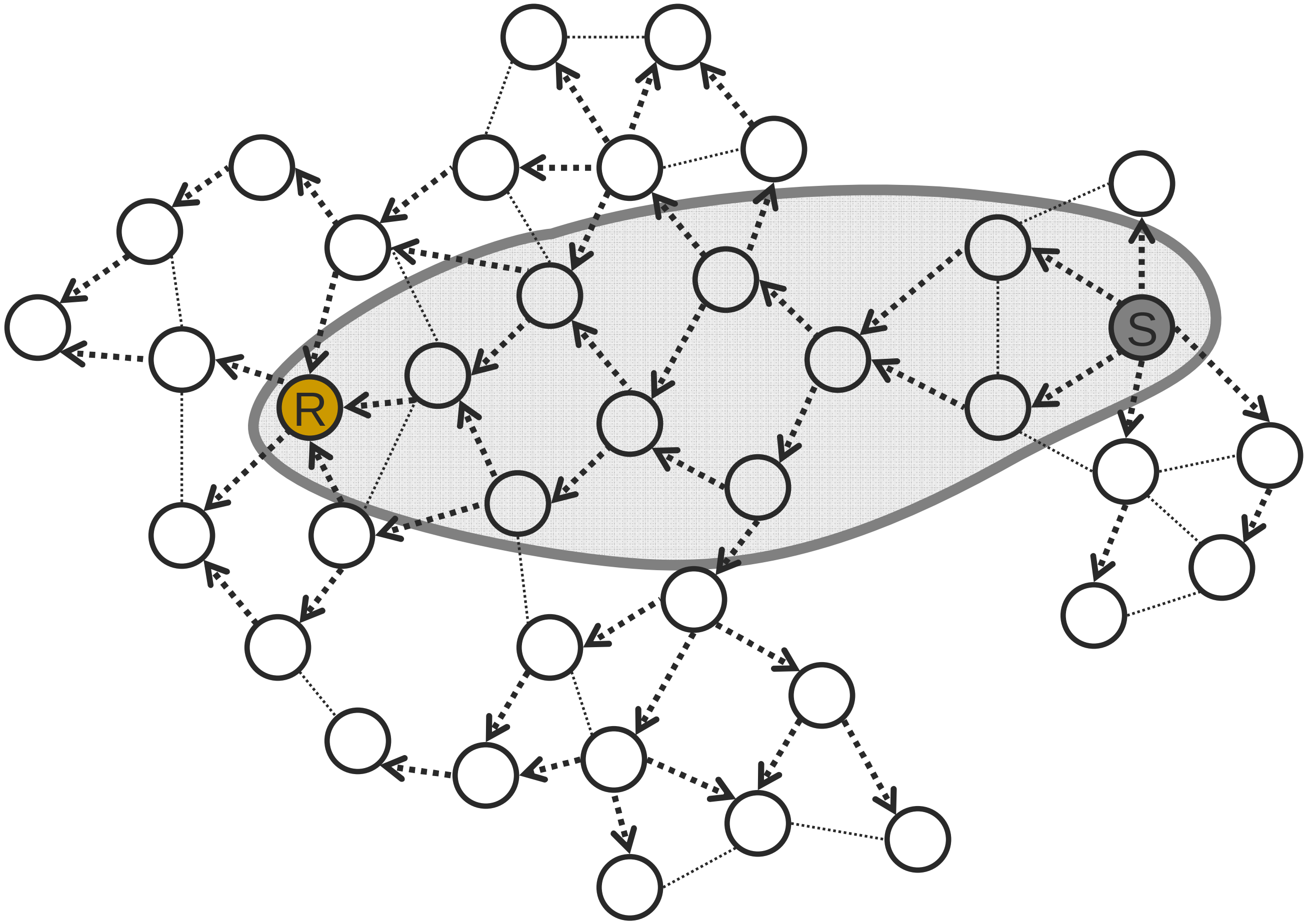


Destinations, relays needed between them and the sources should remain active for as long as there **are active sources** in the connected component of the network

Enclaves and k-Extended Enclaves



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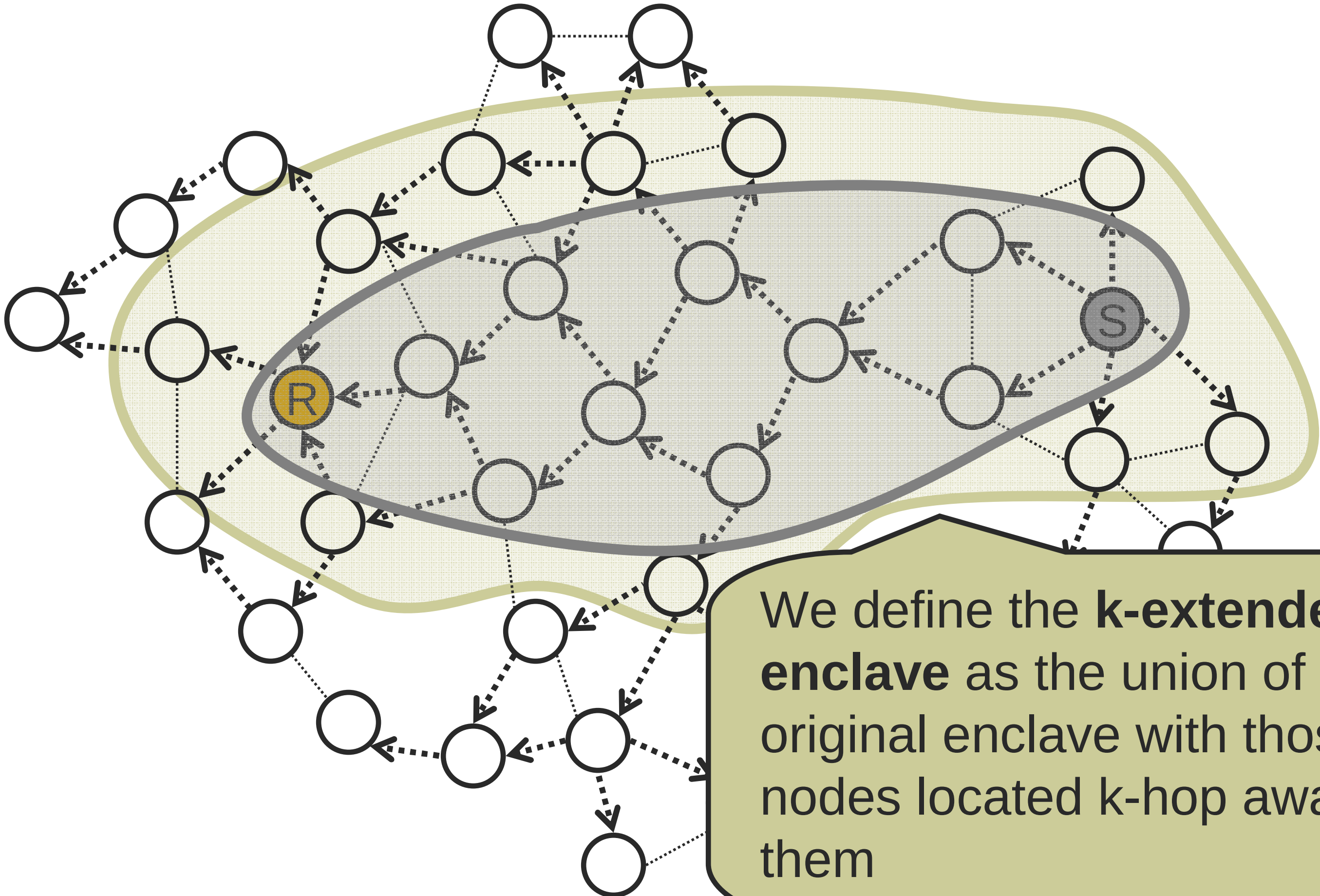
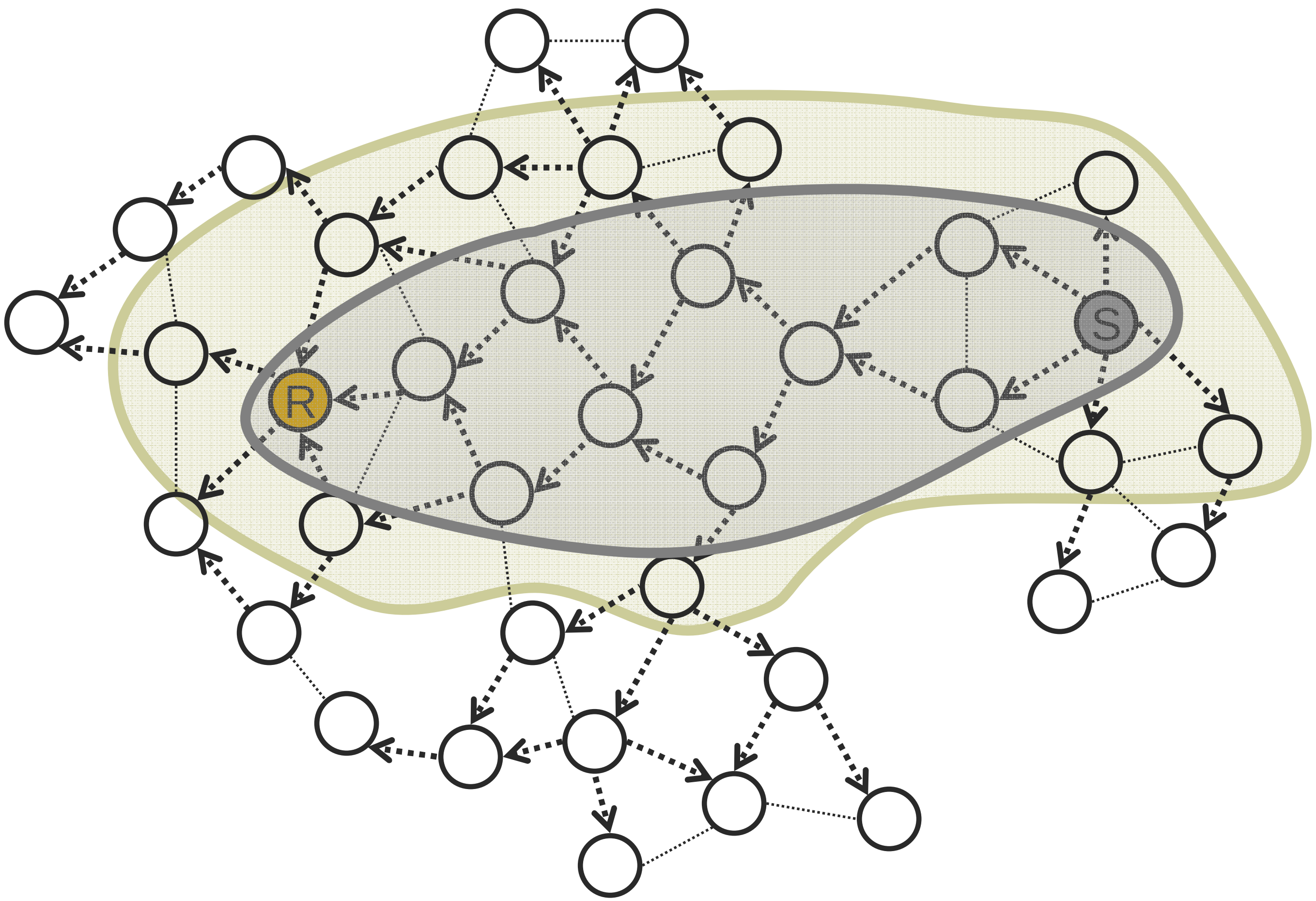
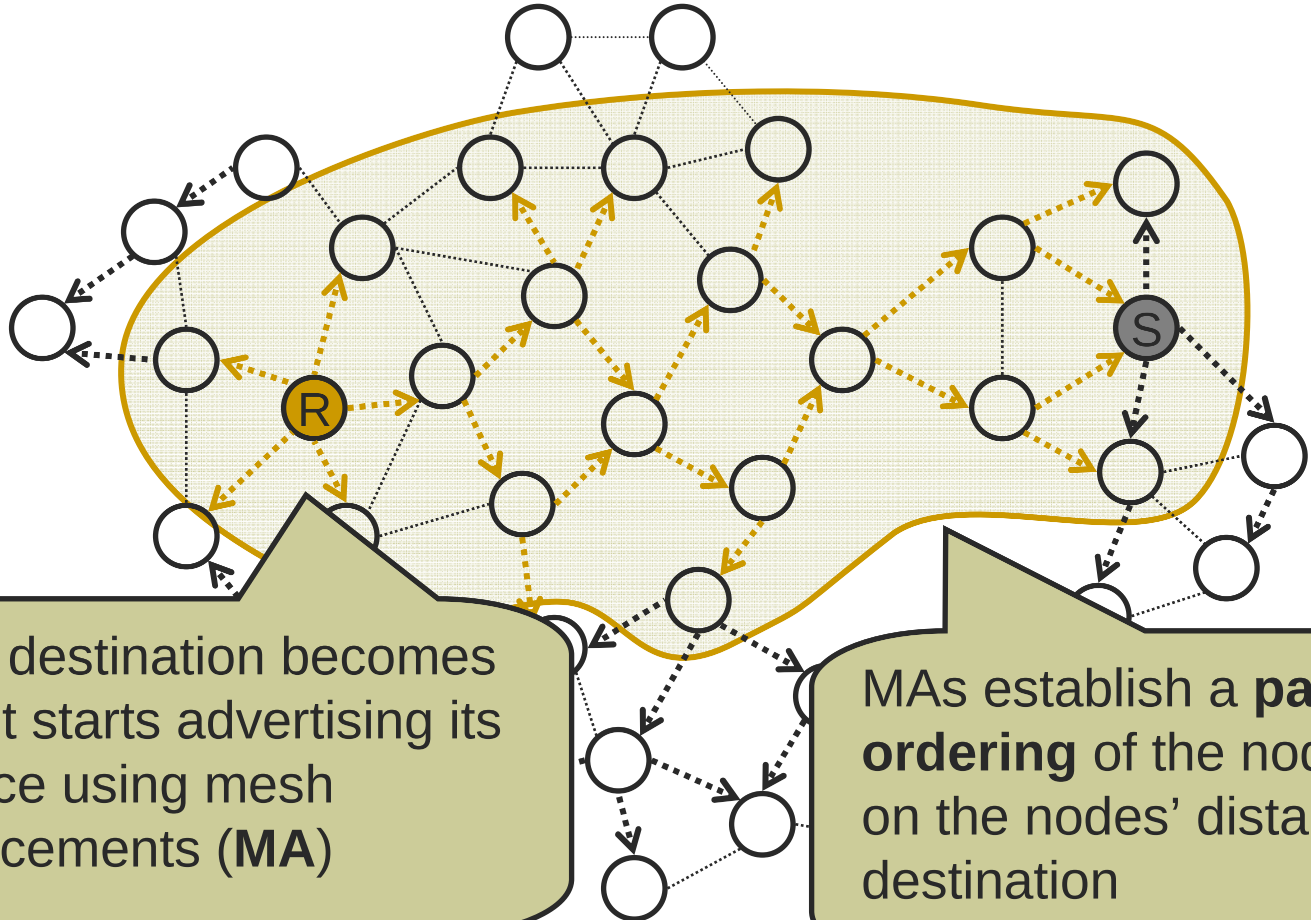


We define the **k-extended enclave** as the union of the original enclave with those nodes located k-hop away from them

Enclaves and k-Extended Enclaves



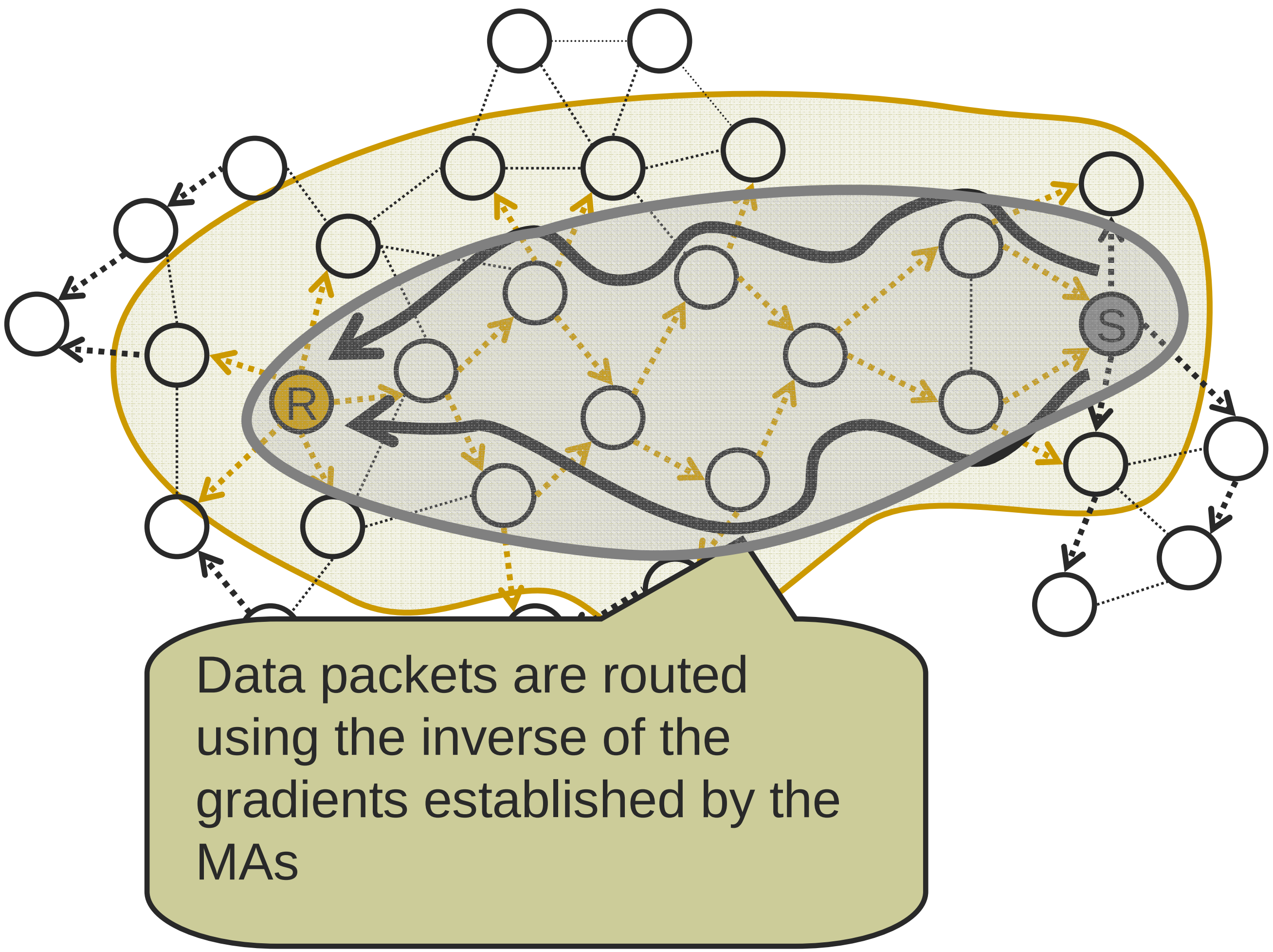
Mesh Establishment and Maintenance



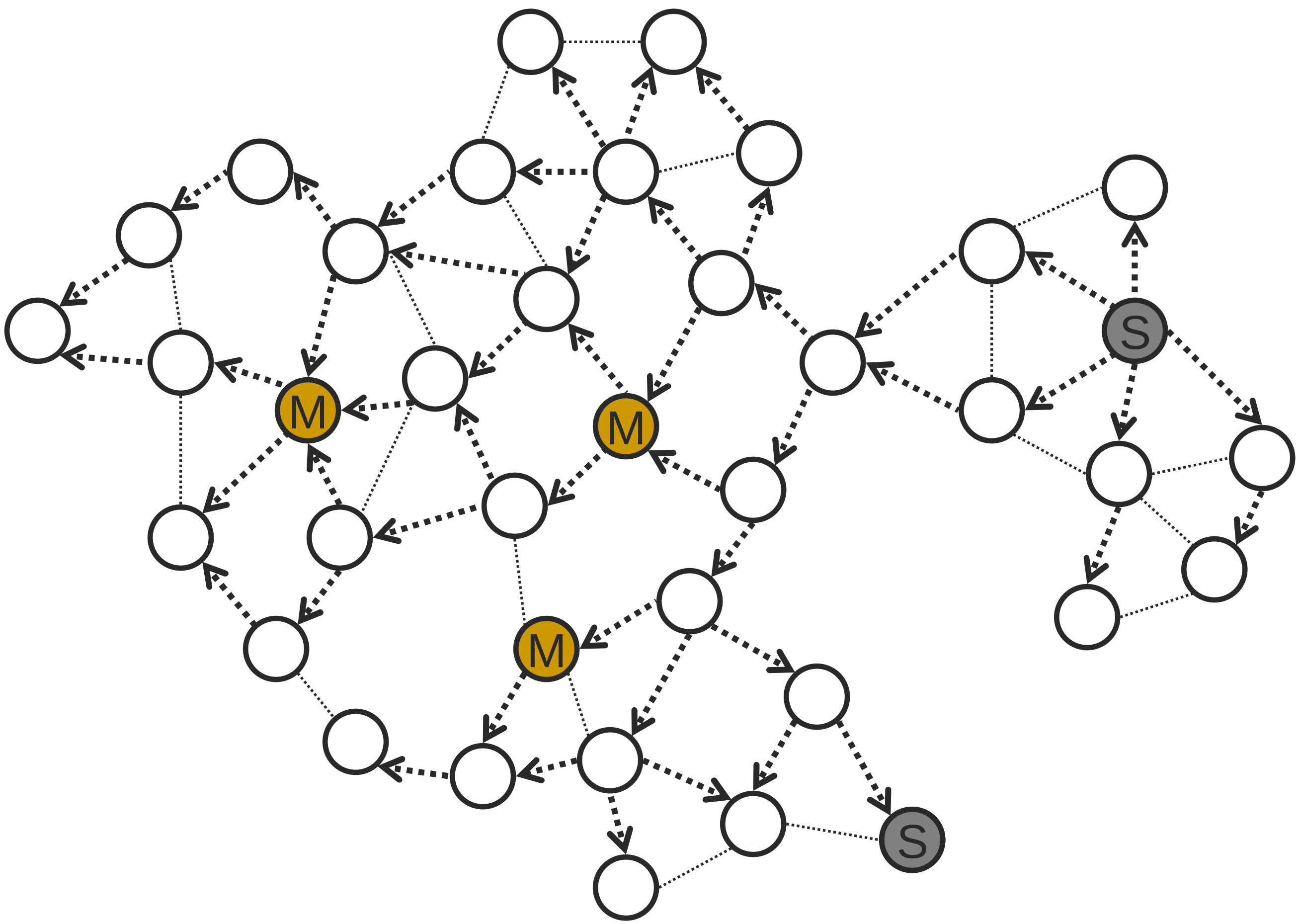
Once a destination becomes active, it starts advertising its existence using mesh announcements (**MA**)

MAs establish a **partial ordering** of the nodes based on the nodes' distance to the destination

Data Packet Forwarding: Unicast



Mesh Establishment and Maintenance: Multicast



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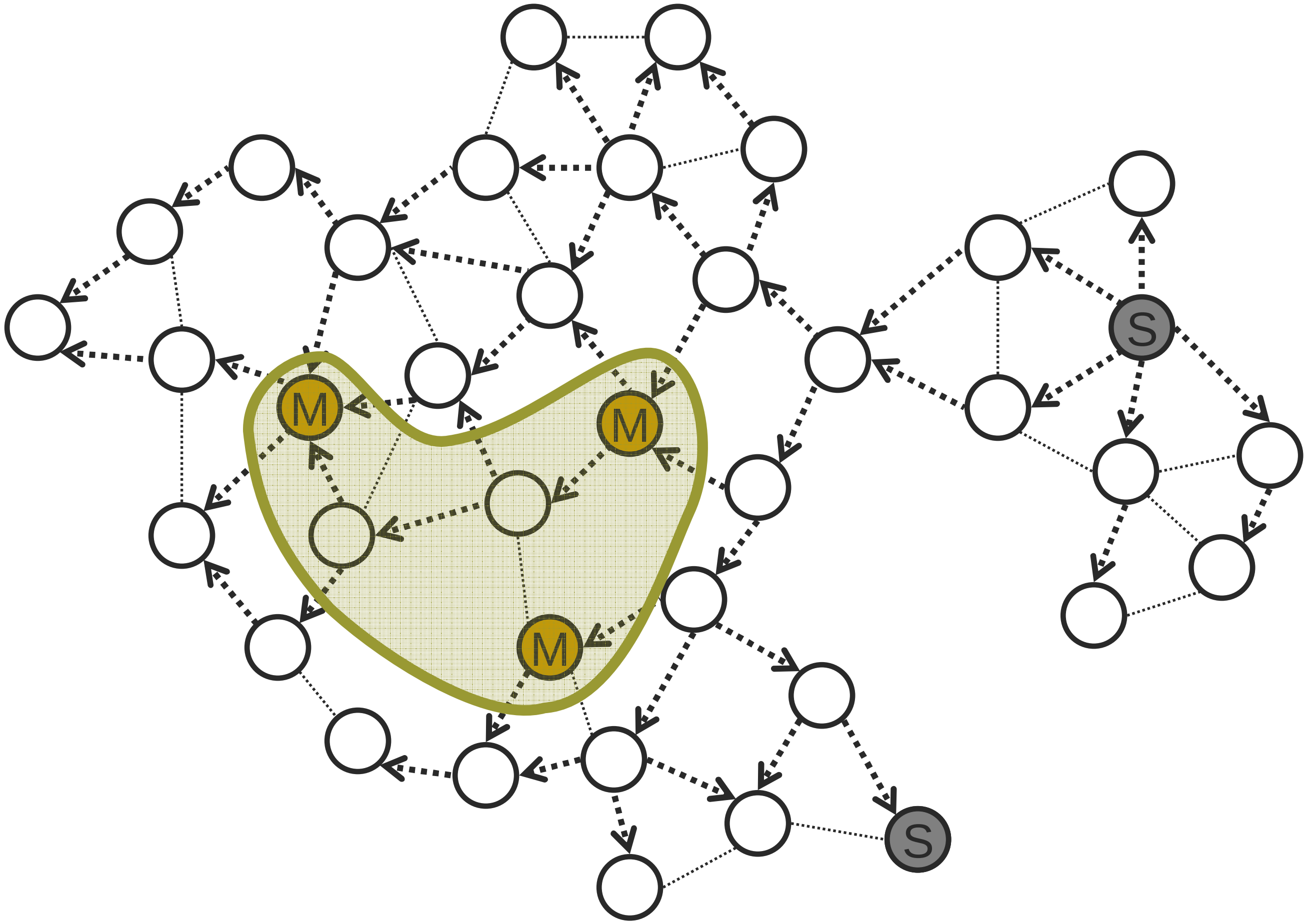

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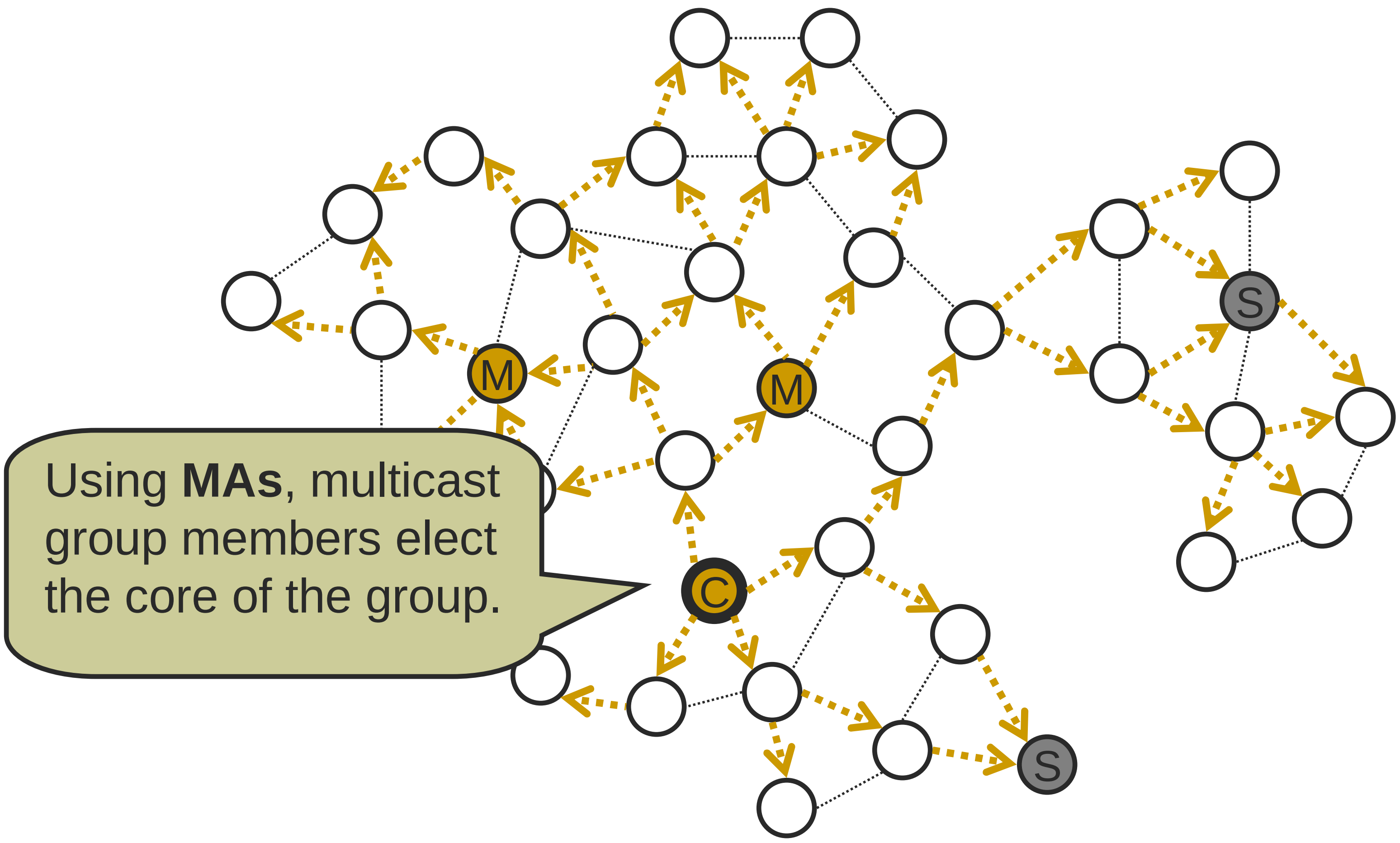

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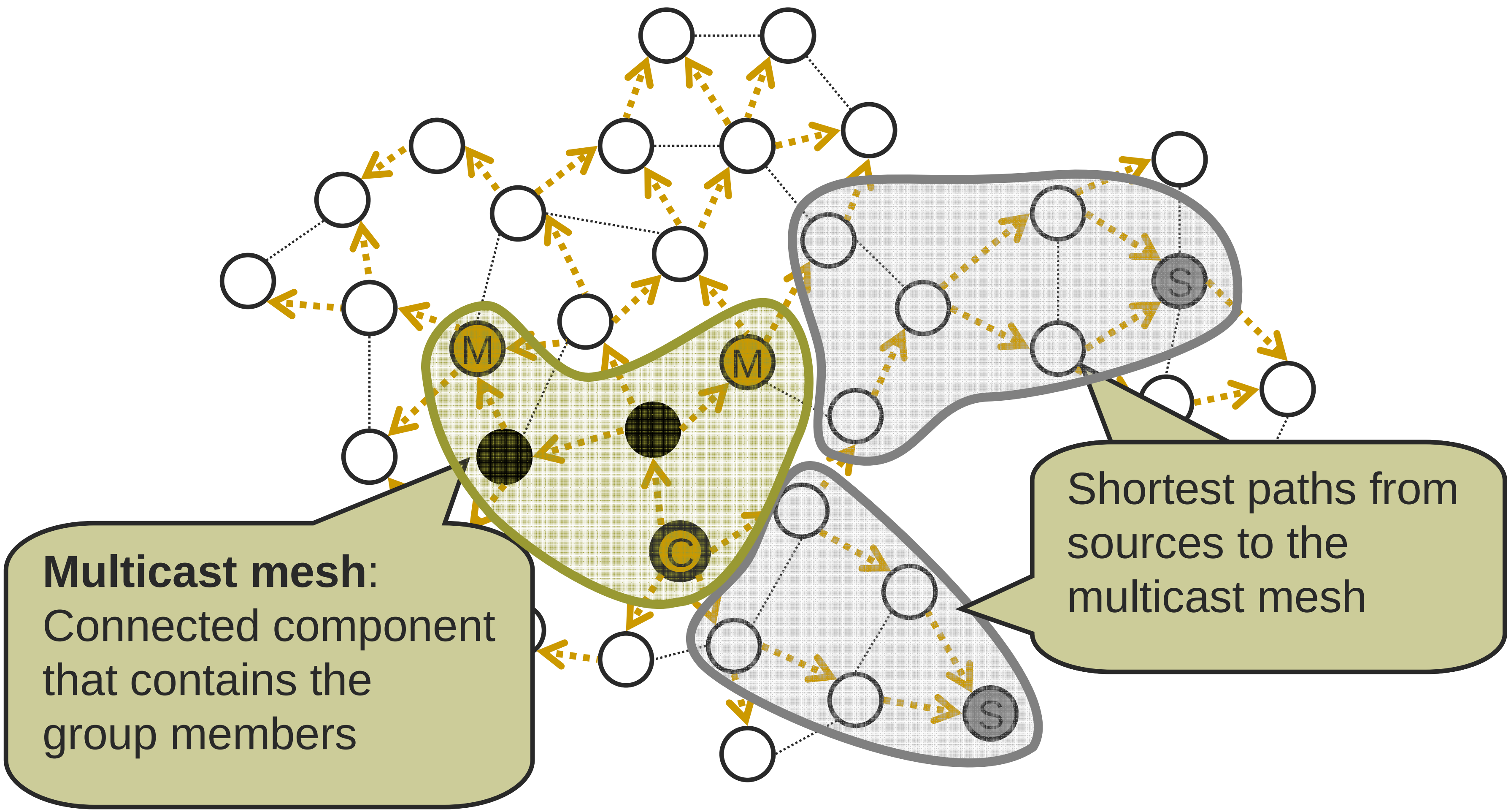

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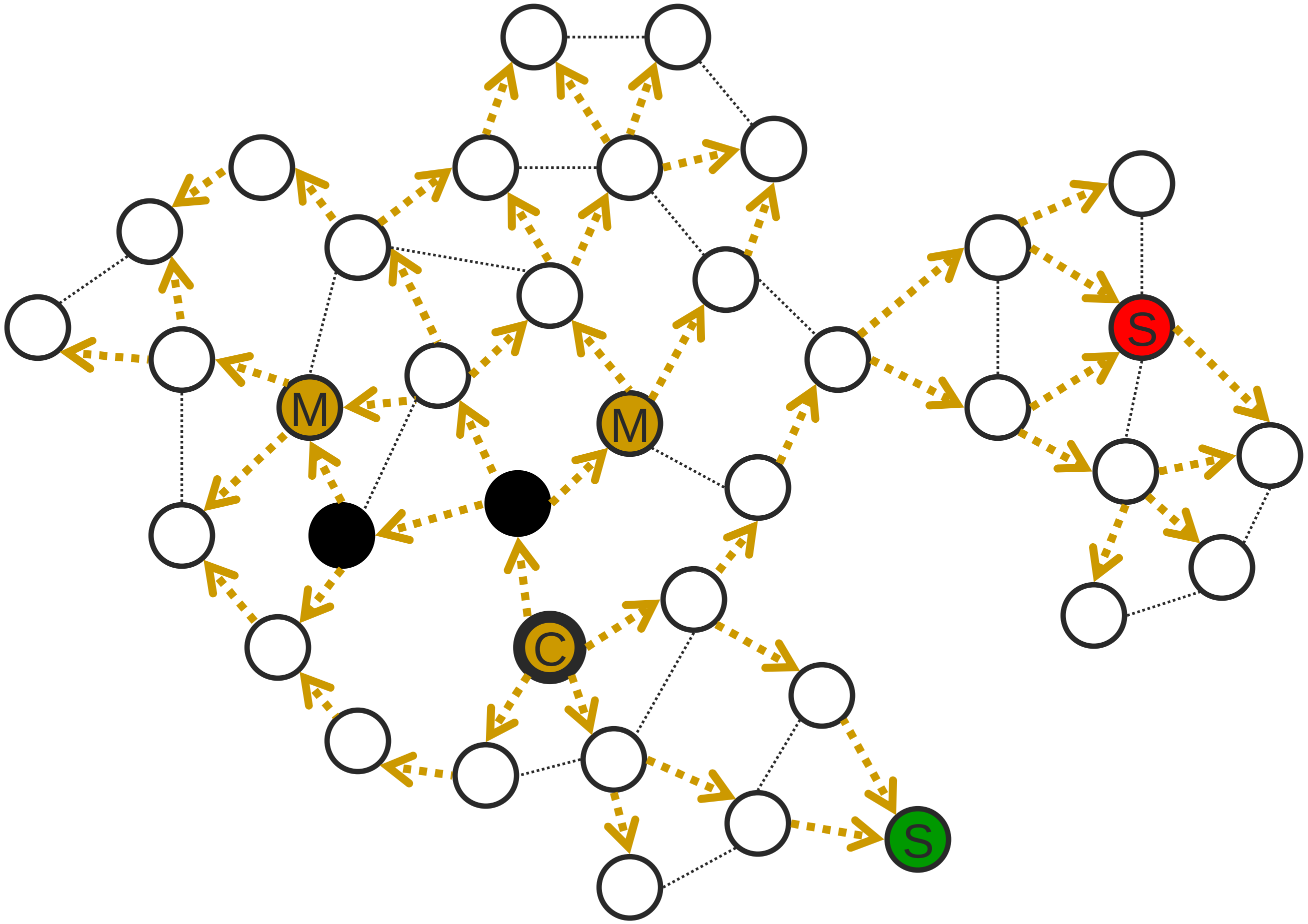

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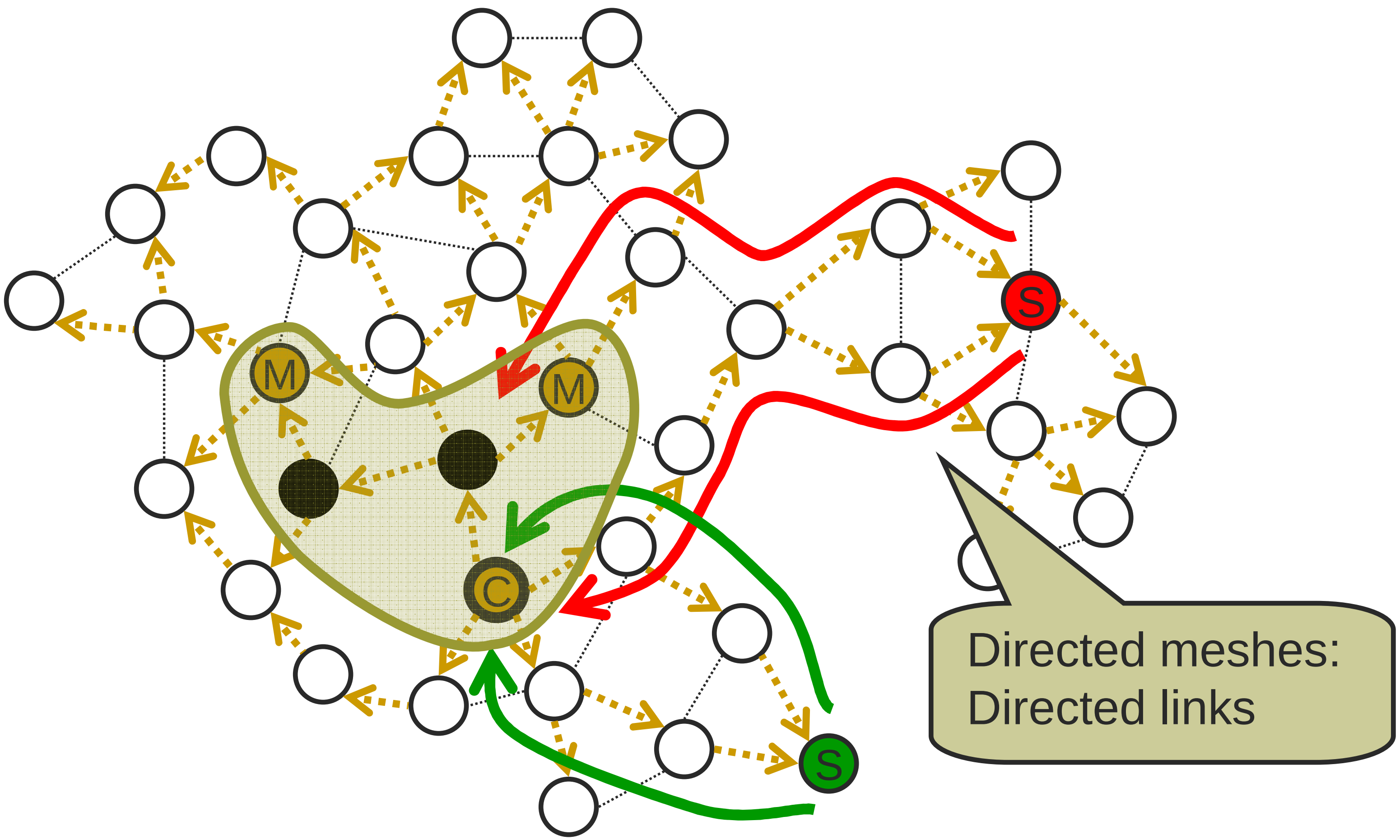

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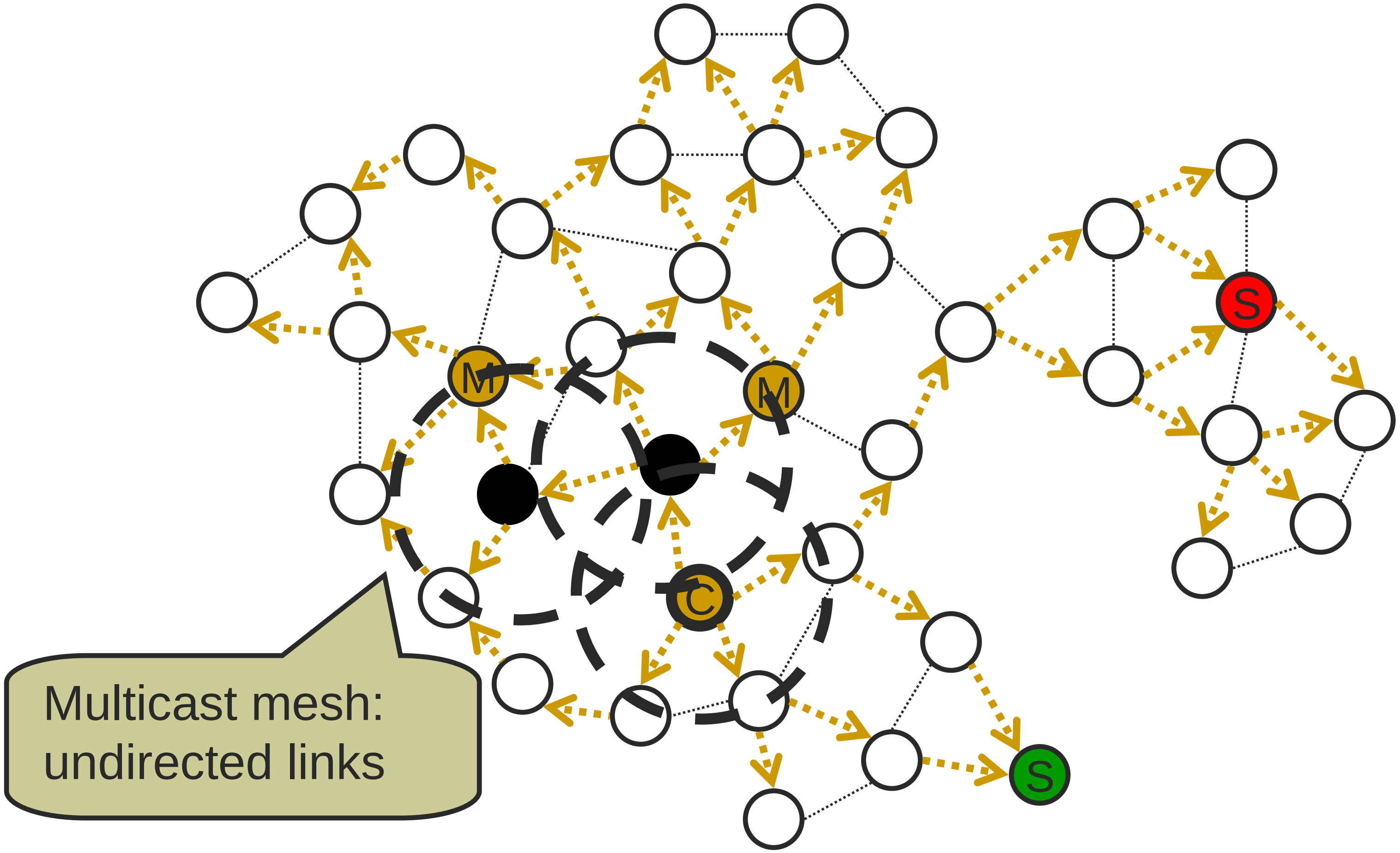


Local Repairs

- Nodes located at directed meshes employ the transmission of data packets by their next hops as implicit ACKs
- If a node fails to receive three consecutive implicit ACKs from a neighbor:
  - It removes that node from the neighborhood list and locally repair the mesh to the core or unicast destination
  - These repairing mechanisms guarantee **instantaneous loop freedom**

Adaptive Enclaves

- Nodes employ information collected at the MAC layer to select the strategy that best fits the nodes perceived channel conditions
- We use the following three strategies to take advantage of that information:
  - Adjust the size of the mesh
  - Adjust the mesh dynamics
  - Adjust timers

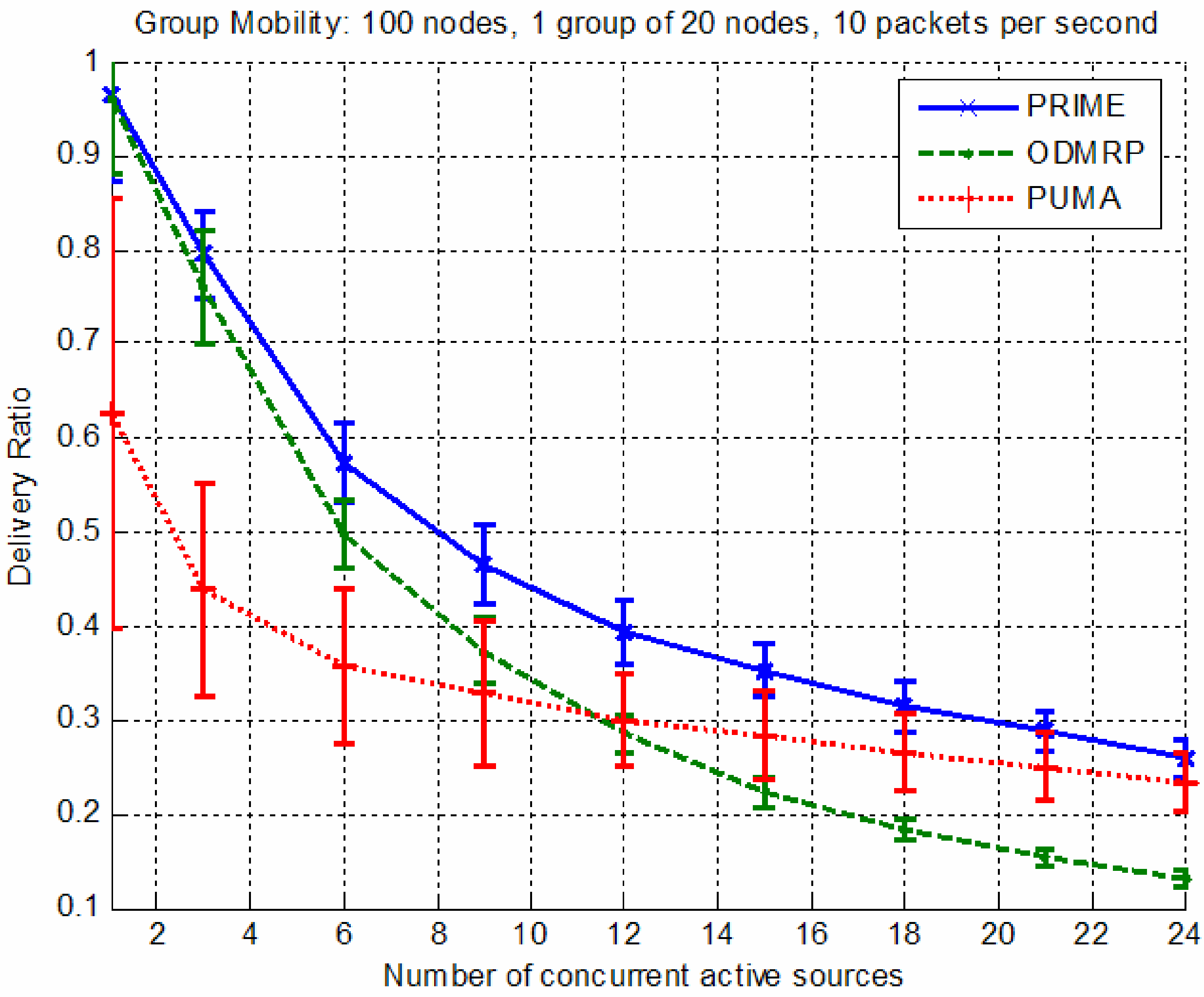
Performance Results

- We present simulation results comparing **PRIME** against **ODMRP** and **PUMA** for the case of multicast traffic, as well as against **AODV** with **ODMRP** and **OLSR** with **ODMRP** for the case of combined unicast and multicast traffic
- Performance metrics:
  - Packet delivery ratio
  - Generalized group delivery ratio (multicast)
  - End-to-end delay and
  - Total overhead

Performance Results: Simulation Environment

Total Nodes	100	Node Placement	Random	Data Source	MCBR
Simulation Time	150s	MAC Protocol	802.11	Pkts. sent per src.	1000
Simulation Area	1800x1800m	Channel Capacity	2000000 bps	Transmission Power	15 dbm
Mobility Model	Random Waypoint	Pause Time	10s	Min-Max Vel.	1-10m/s
Mobility Model	Group Mobility	Grp. Pause Time	10s	Grp. Min-Max Vel.	1-10m/s
		Node Pause Time	10s	Node Min-Max Vel.	1-10m/s

Increasing Number of Sources: Group Mobility – Delivery Ratio



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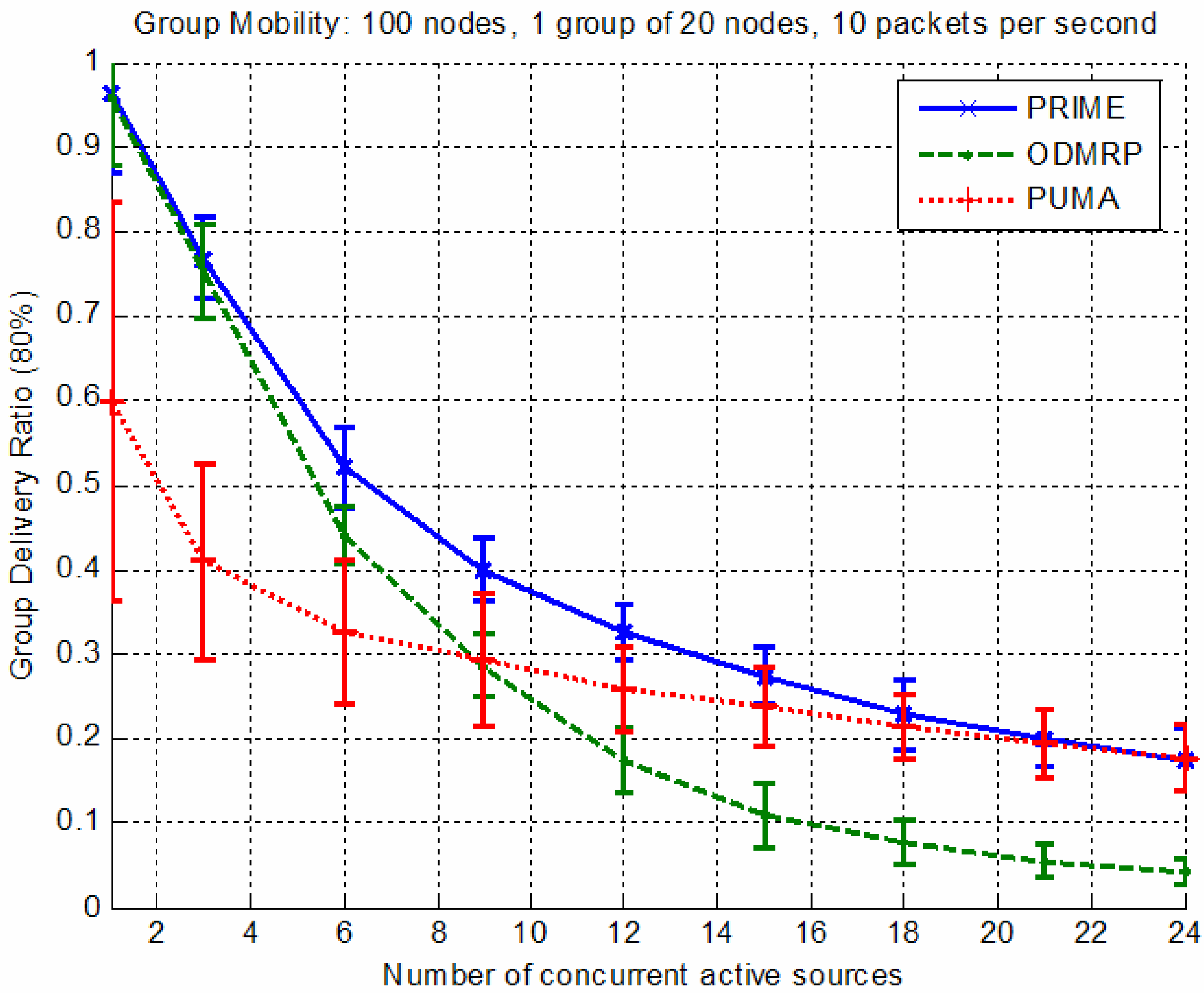
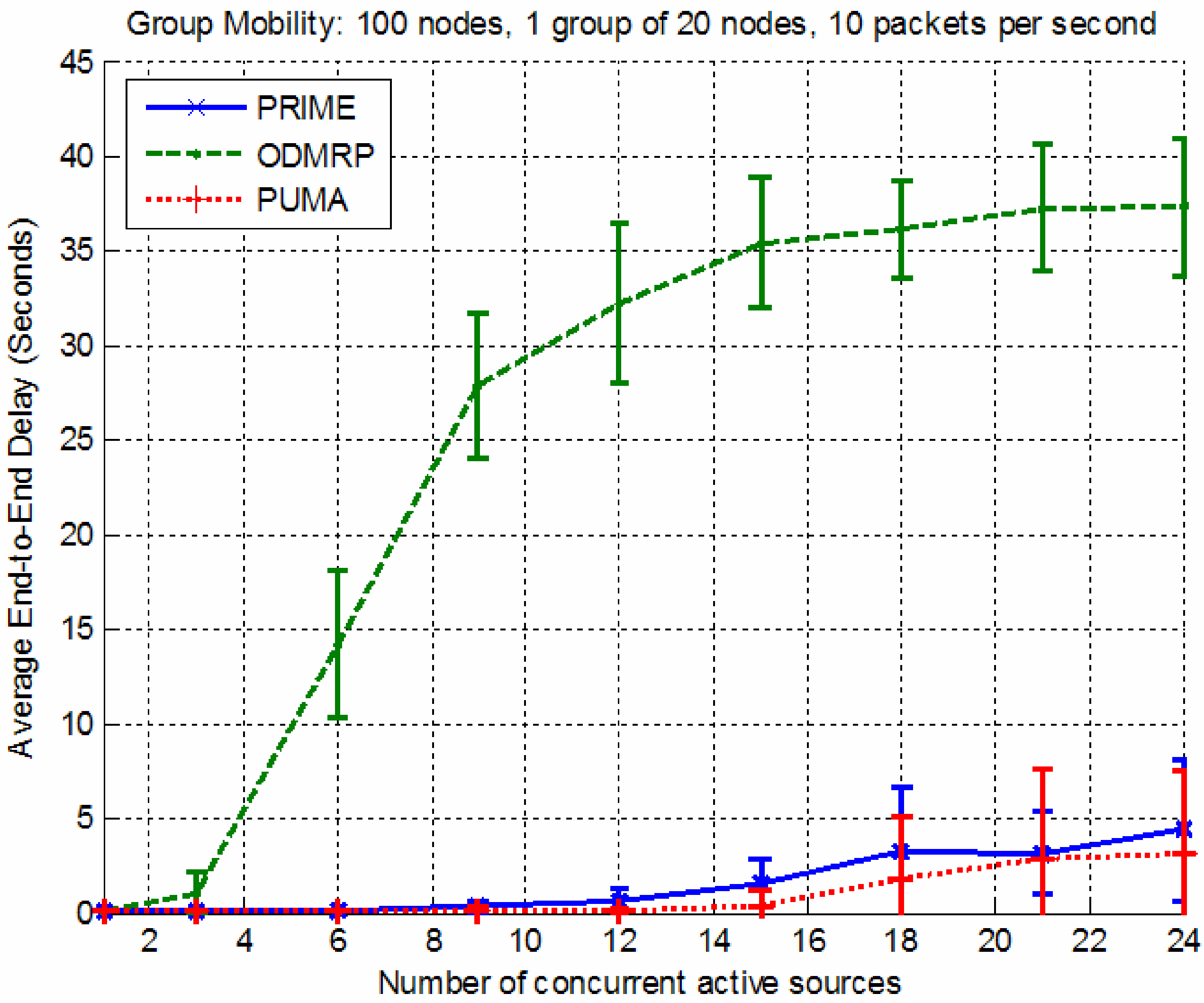
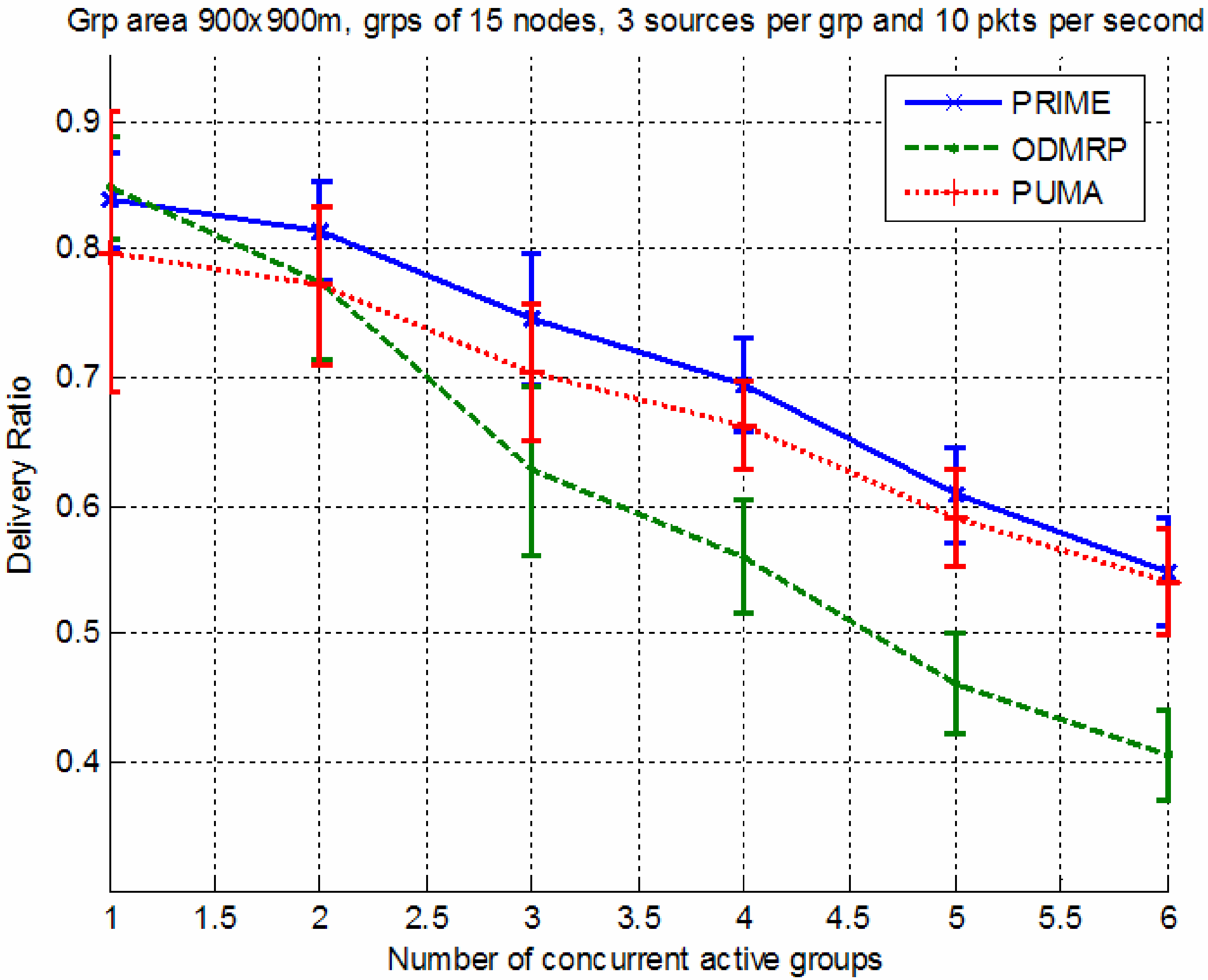


Increasing Number of Sources: Group Mobility – E2E Delay



3 Sources per Group, Group Areas of 900x900m – Delivery Ratio



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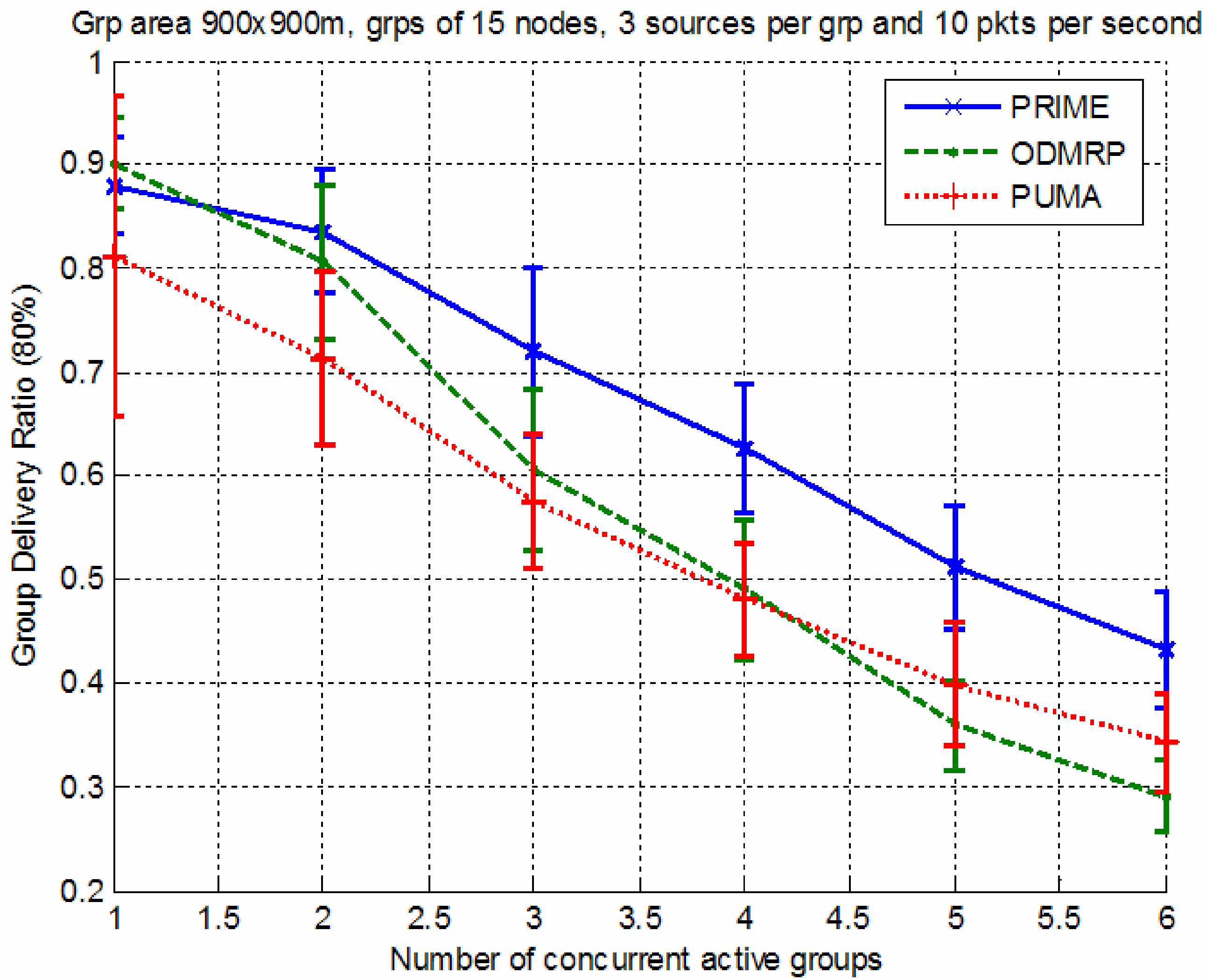

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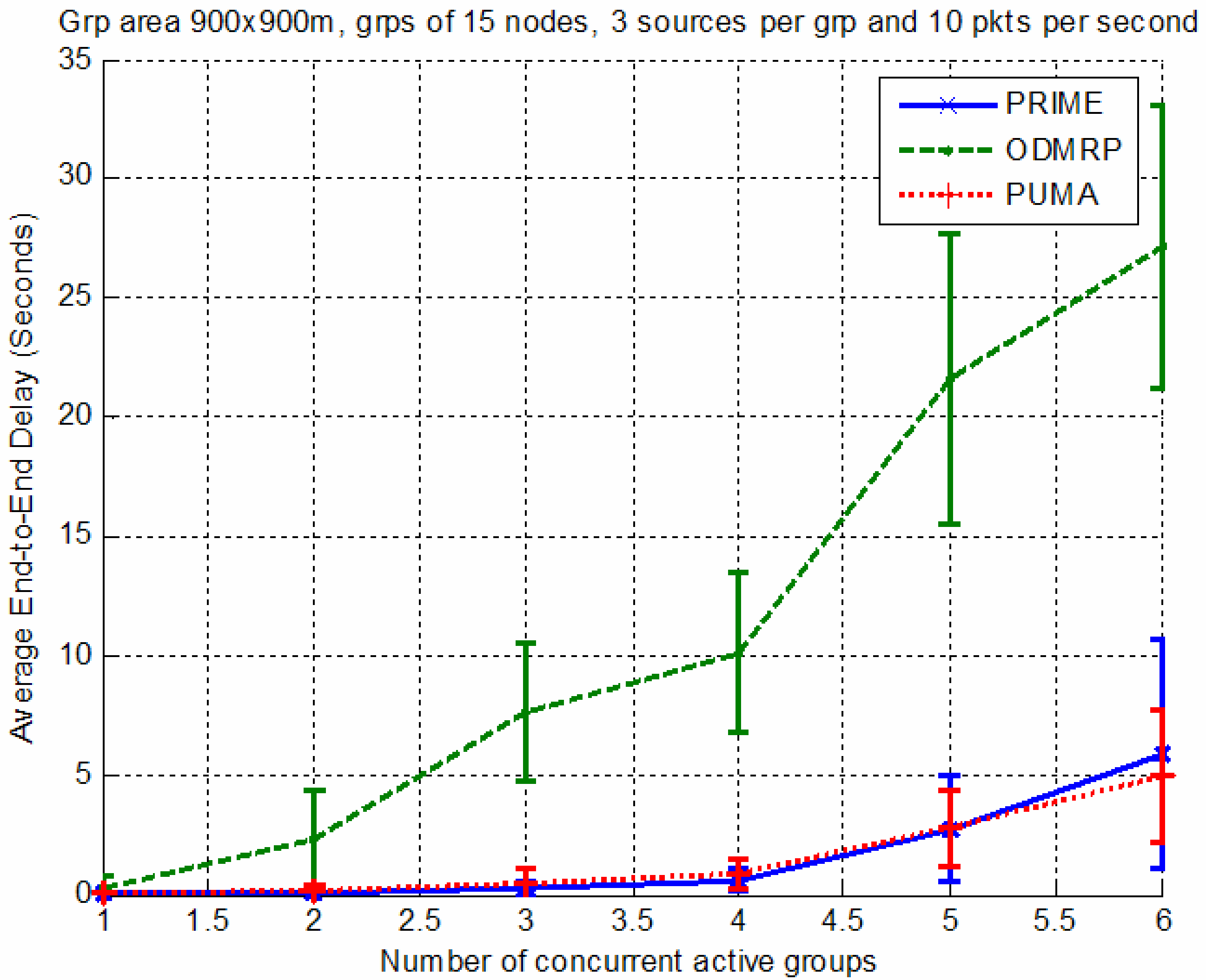
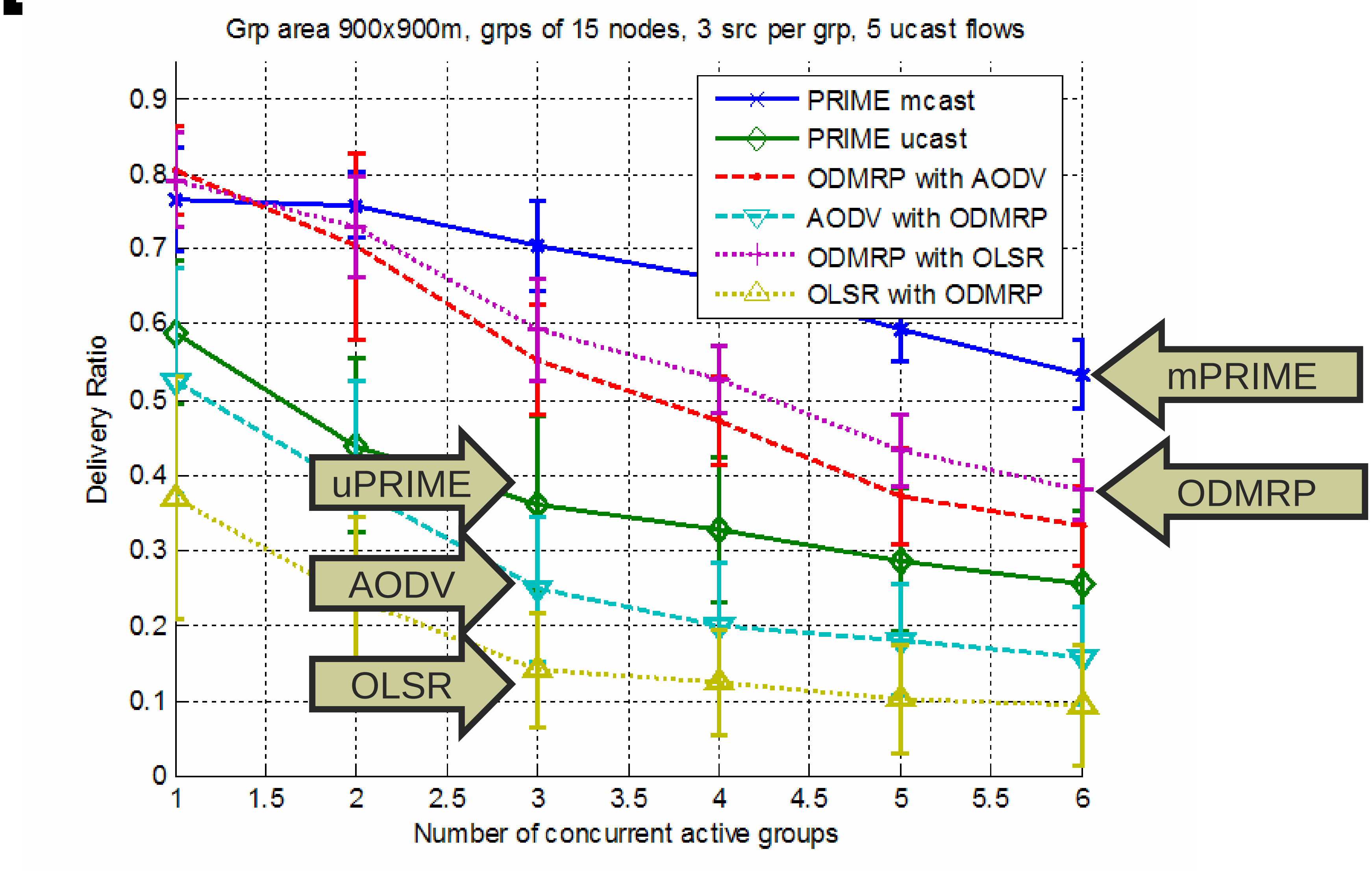


Combined Multicast and Unicast Traffic – Delivery Ratio (5 ucast flows)



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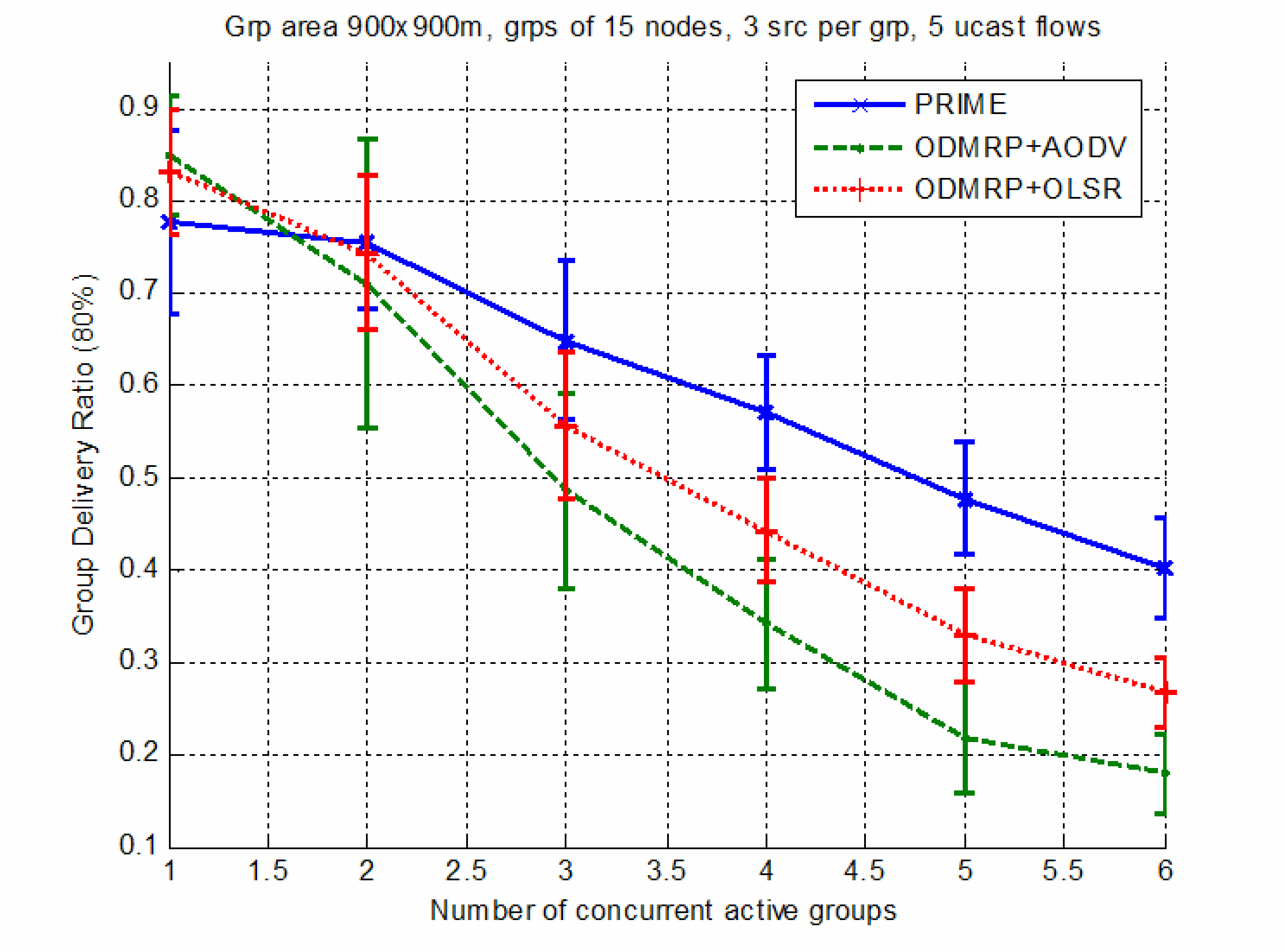

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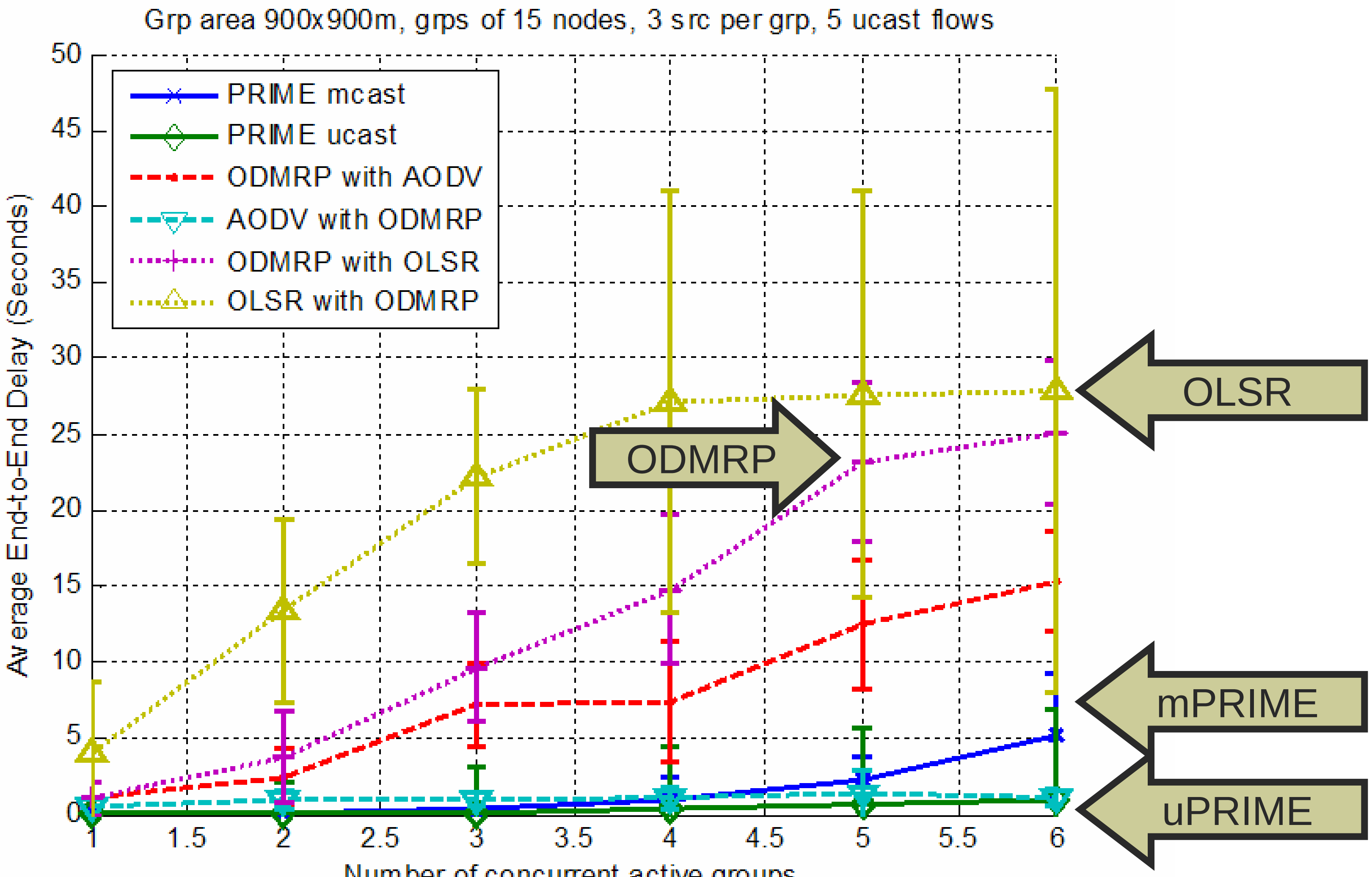
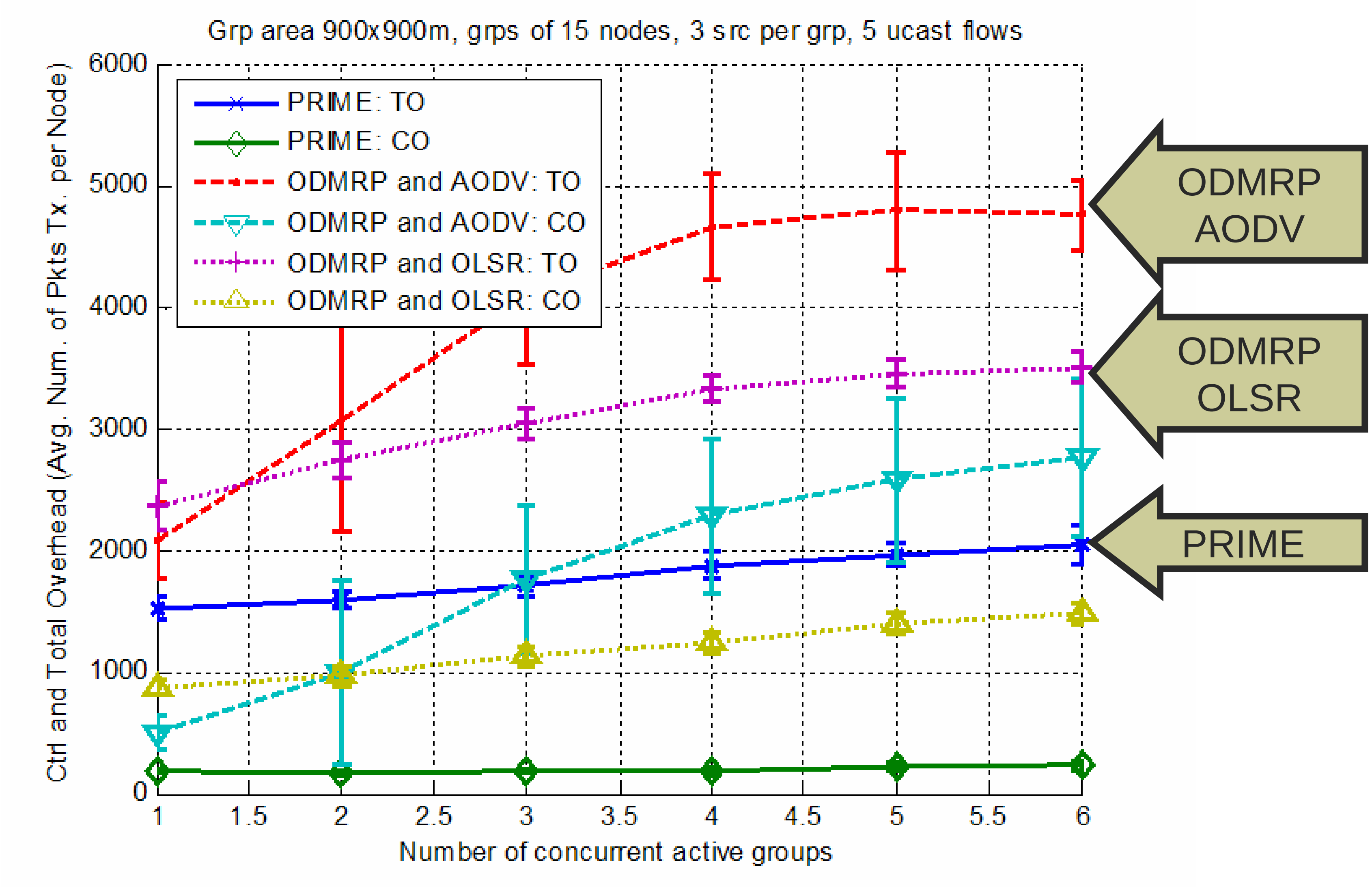


Combined Multicast and Unicast Traffic – Ctrl and Total Overhead (5 ucast flows)



Conclusions

- We have shown by example that it is possible and perhaps desirable to support the dissemination of information for end user applications using a single routing protocol, and
  - Should Interest-driven routing be adopted for MANETs?

Conclusions

- The results of a series of simulation experiments illustrate that PRIME attains:
  - Higher delivery ratios than ODMRP and PUMA for multicast traffic
  - Higher delivery ratios than AODV and OLSR for unicast traffic.
  - At the same time, PRIME induces much less communication overhead and attains lower delays than the other routing protocols.

Thanks!

Questions?