Adaptive Event Dissemination for Peer-to-Peer Multiplayer Online Games

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DIstributed **SI**mulation & **O**nline gaming (**DISIO**), 2011

Presentation **outline**

- Multiplayer Online Games: scalability and responsiveness
- MOGs: a peer-to-peer approach
- Gossip protocols: fixed-probability and conditional broadcast
- Adaptive gossip protocols based on stimuli
- Adaptive gossip: implementation and variants
- Performance evaluation: simulation-based
- Performance evaluation: metrics
- Conclusions and future work

MOGs: scalability and responsiveness

- **Scalability** and **responsiveness** are among the main issues in the implementation of **M**ultiplayer **O**nline **G**ames (**MOG**s)
- Many architectures have been proposed:
  - client/server
  - mirrored servers
  - peer-to-peer
- In all of them, the **dissemination** of game events can be a very **costly** task
- In terms of **scalability**, the **peer-to-peer approach** is very promising but with some open issues

MOGs: a **peer-to-peer** approach

- Each peer locally manages its copy of the **game state**
- The peers are organized in some form of **overlay network** (many **different topologies** can be used)
- The **dissemination** of game events is obtained by passing messages through the overlay
- **Gossip protocols** are very **simple** and **well suited** for P2P systems
- If **all nodes** in a network have to be reached by **every generated message**, then traditional gossip protocols are **quite inefficient**

Gossip protocol: **probabilistic broadcast**

- If the message is locally generated then it is broadcasted to all neighbors, otherwise it is decided at random if it will be broadcasted or ignored

PARAMETERS:

- $\mathbf{p_b}$ = probability to broadcast a message

ADDITIONAL MECHANISMS:

- time to live (**ttl**) in each message
- local **cache** in each node

ALGORITHM

```
function INITIALIZATION()
p_b ← PROBABILITY_BROADCAST()

function GOSSIP(msg)
if  (RANDOM() < p_b or
    FIRST_TRANSMISSION())
    then
        for all n_j in Π_j do
                SEND(msg, n_j)
        end for
end if
```

Gossip protocol: **fixed probability**

- For each received message, the node randomly selects those edges through which the message must be propagated

PARAMETERS:

- **v** = threshold value

ADDITIONAL MECHANISMS:

- time to live (**ttl**) in each message
- local **cache** in each node

ALGORITHM

```
function INITIALIZATION()
v ← CHOOSE_PROBABILITY()

function GOSSIP(msg)
for all n_j in Π_j do
    if RANDOM() < v then
        SEND(msg, n_j)
    end if
end for
```

Adaptive gossip

- Is it possible to exploit the **characteristics of online games** to enhance the message distribution among nodes?
- Is it possible to build "**smarter**" gossip protocols?

- In a MOG, game events are generated at a rate that can be approximated using some (game dependent) probability distribution
- Periodically each node **checks the reception rate** of game events from all other nodes in the network
- If this rate is **lower than a threshold** value, then it can send one or more **stimuli** to **neighbor nodes**

Adaptive gossip: **implementation** and **variants**

- Many different implementations and variants are possible:
  - **stimuli associated to receivers (alg. #1)**

    upon reception of a stimulus from a neighbor, a peer increases its dissemination probability towards that node
  - **stimuli associated to generators (alg. #2)**

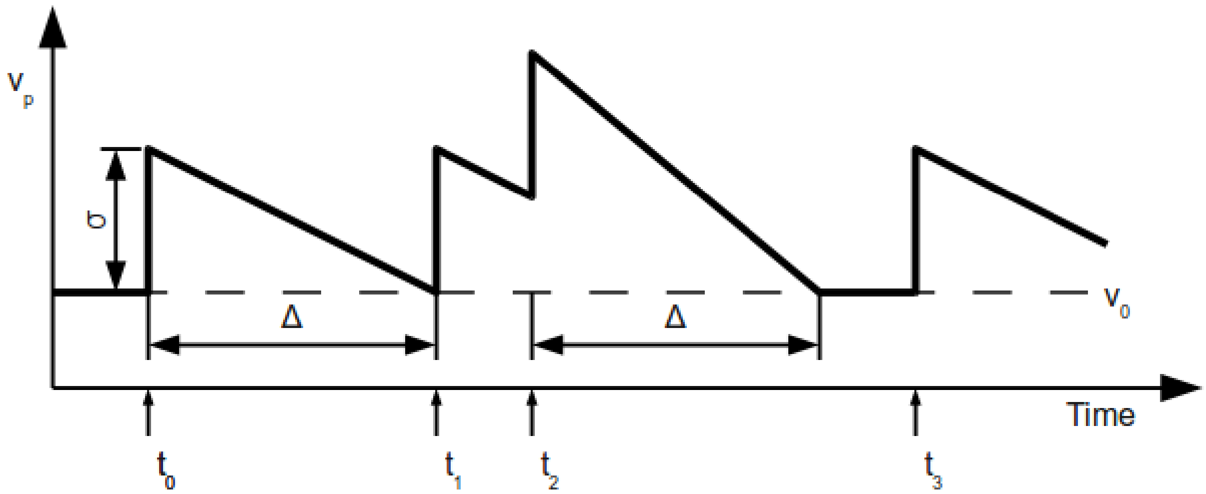
    the peer increases the dissemination probability of all messages from a given sender towards all its neighbors
  - **stimuli associated to generators and receivers (alg. #3)**

    in this case, the dissemination probability of all messages from a given sender and for a given neighbor is increased

    note*: this variant is much more specific than the previous ones*

Adaptive gossip: **stimulus management**

- In practice it is a “fixed probability” scheme in which the **probability to disseminate a message** to a given neighbor is **modified by the received stimuli**



- A given node receives a new stimulus (of magnitude **σ**) at times t_0, t_1, t_2 and t_3. At time t_2, the stimulus adds **σ** to the current value of v_p (*current dissemination probability*)
- v_p *decays linearly* to v_0 (*baseline dissemination probability*) after time **Δ** from the last received stimulus

Performance evaluation: **simulation**-based

- The following performance evaluation is based on **simulation**
- We have designed and implemented a brand new simulator called **L**arge **U**nstructured **NE**twork **S**imulator (**LUNES**): http://pads.cs.unibo.it

Parameter	Value
number of **nodes**	*100*
number of **edges** per node	*2*
number of **graphs** per evaluation	*100*
construction method	*Erdos-Renyi generator*
cache size (local to each node)	256 *slots*
message Time To Live (**ttl**)	*8*
simulated time (gaming time)	5000 *time-steps* *(after building)*

Performance evaluation: **metrics**

- **Coverage**
  - percentage of nodes that have received **all the messages** that have been produced during the whole game execution

    "*are the game events received by all gamers?*"

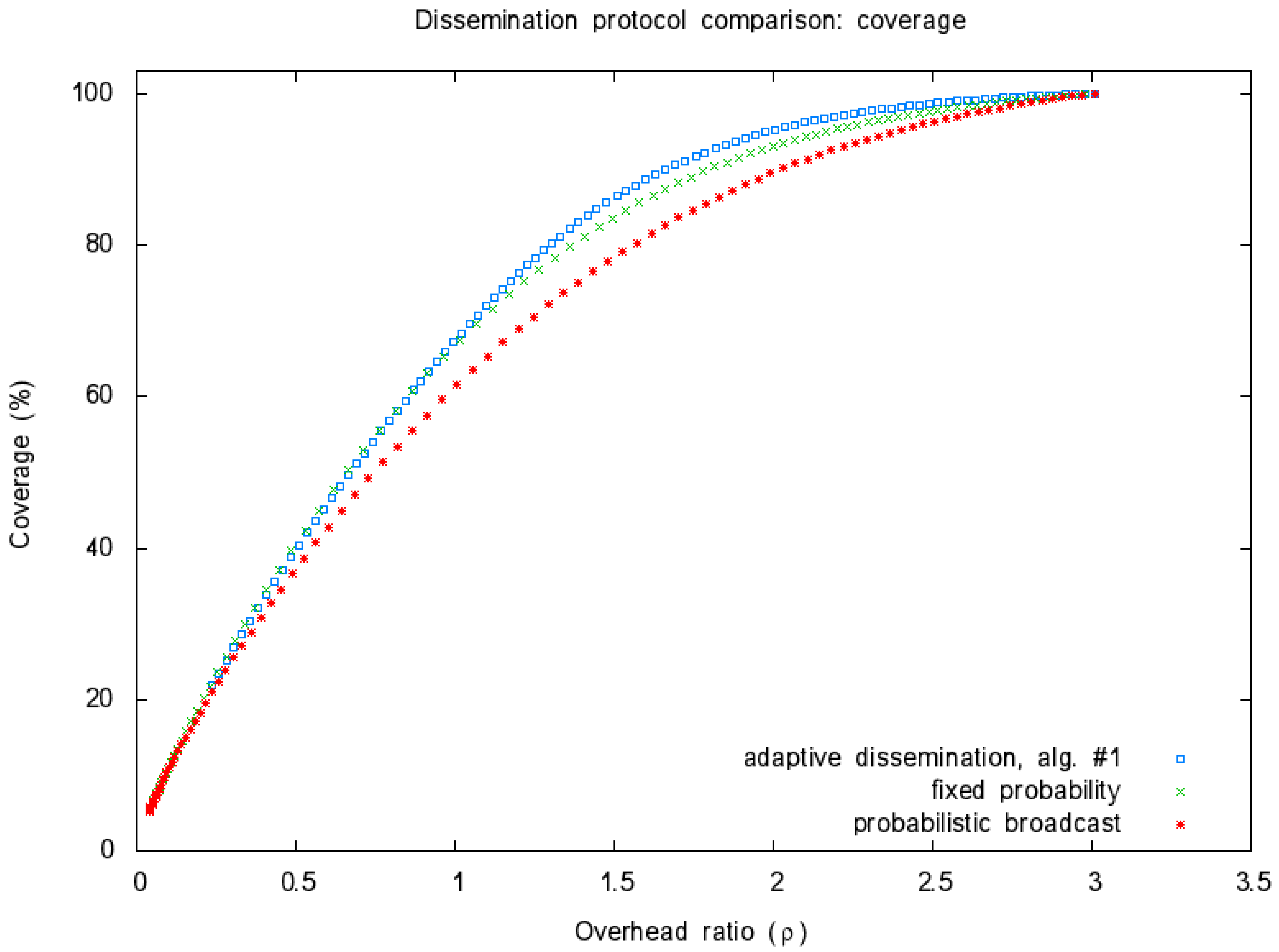
- **Delay**
  - average number of **hops** that are necessary to receive a message after its creation

    "*is the dissemination of new events timely?*"

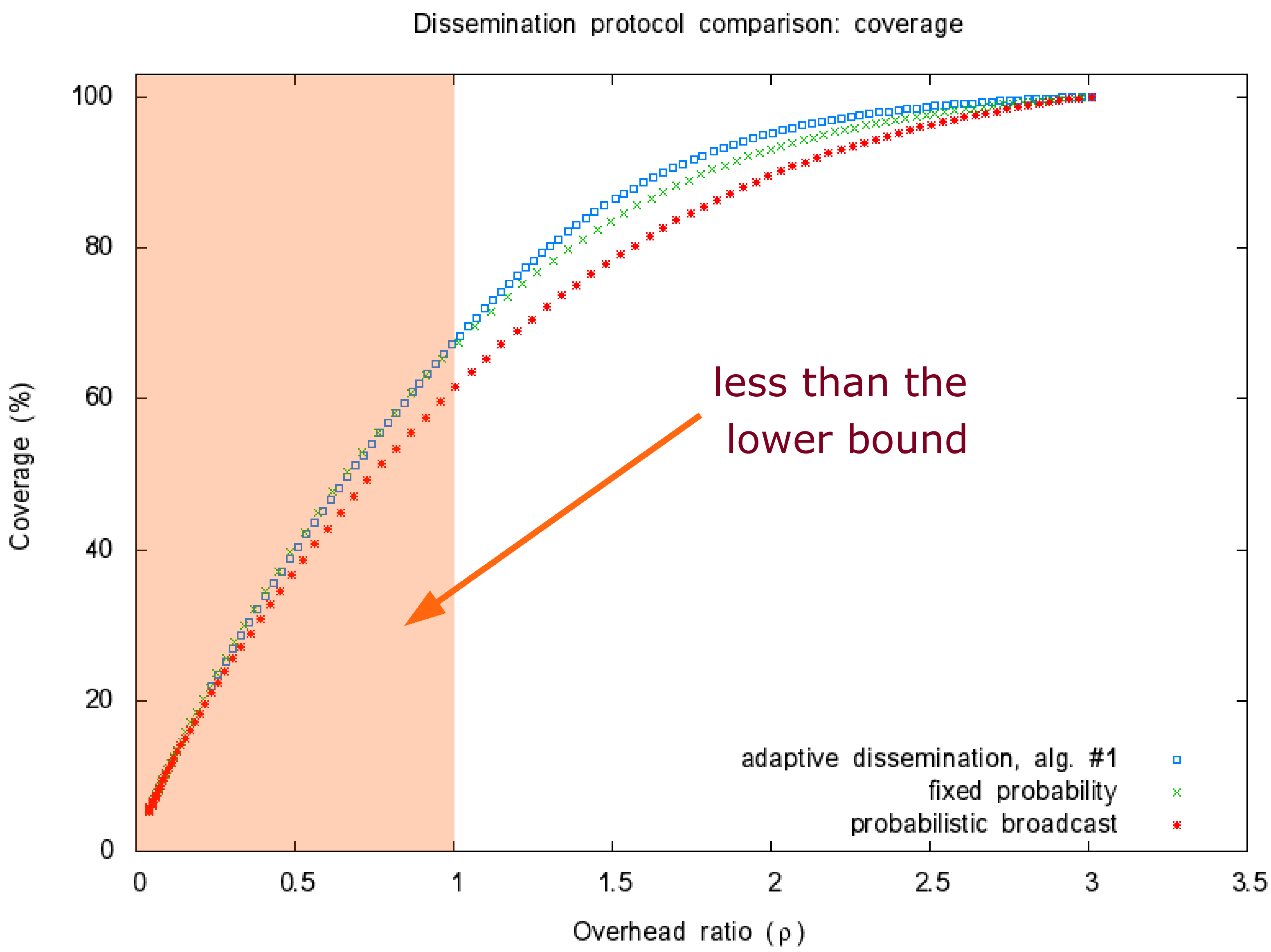
Performance evaluation: **cost metrics**

- Defining an appropriate **cost metric** is necessary to compare all the dissemination protocols in the same conditions
- **Overhead ratio** $\rho = \frac{\text{delivered messages}}{\text{lower bound}}$
  - ***delivered messages*** *=* ***total number*** *of messages delivered in a simulation run by a specific dissemination protocol*
  - ***lower bound*** *=* ***minimum number*** *of messages that have to be sent by a dissemination protocol that never sends duplicates but obtains full coverage*
- In the following we will compare all the dissemination protocols in terms of **coverage** and **delay** for **many different overhead ratios**

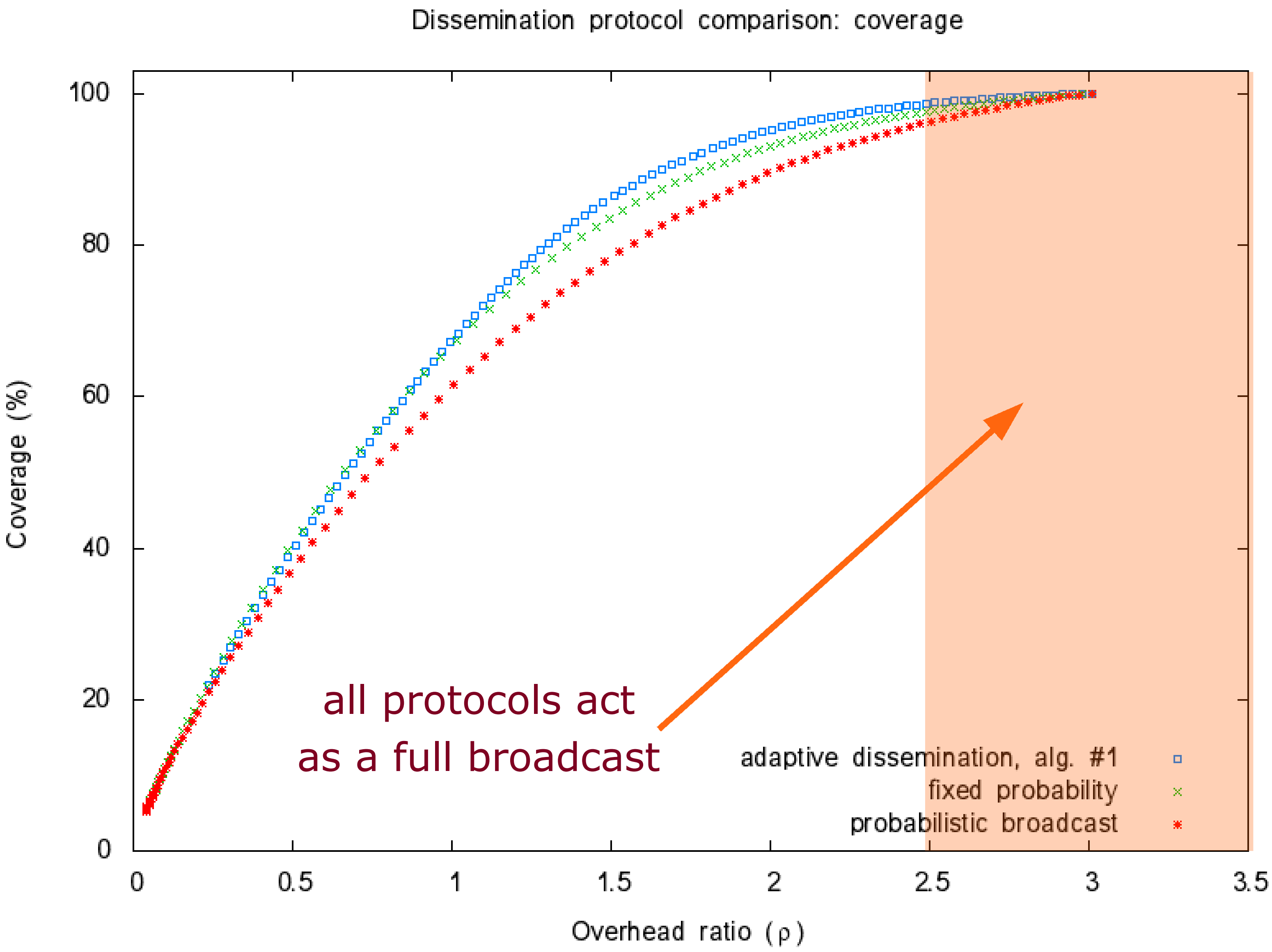
Evaluation: **coverage** rate (%)



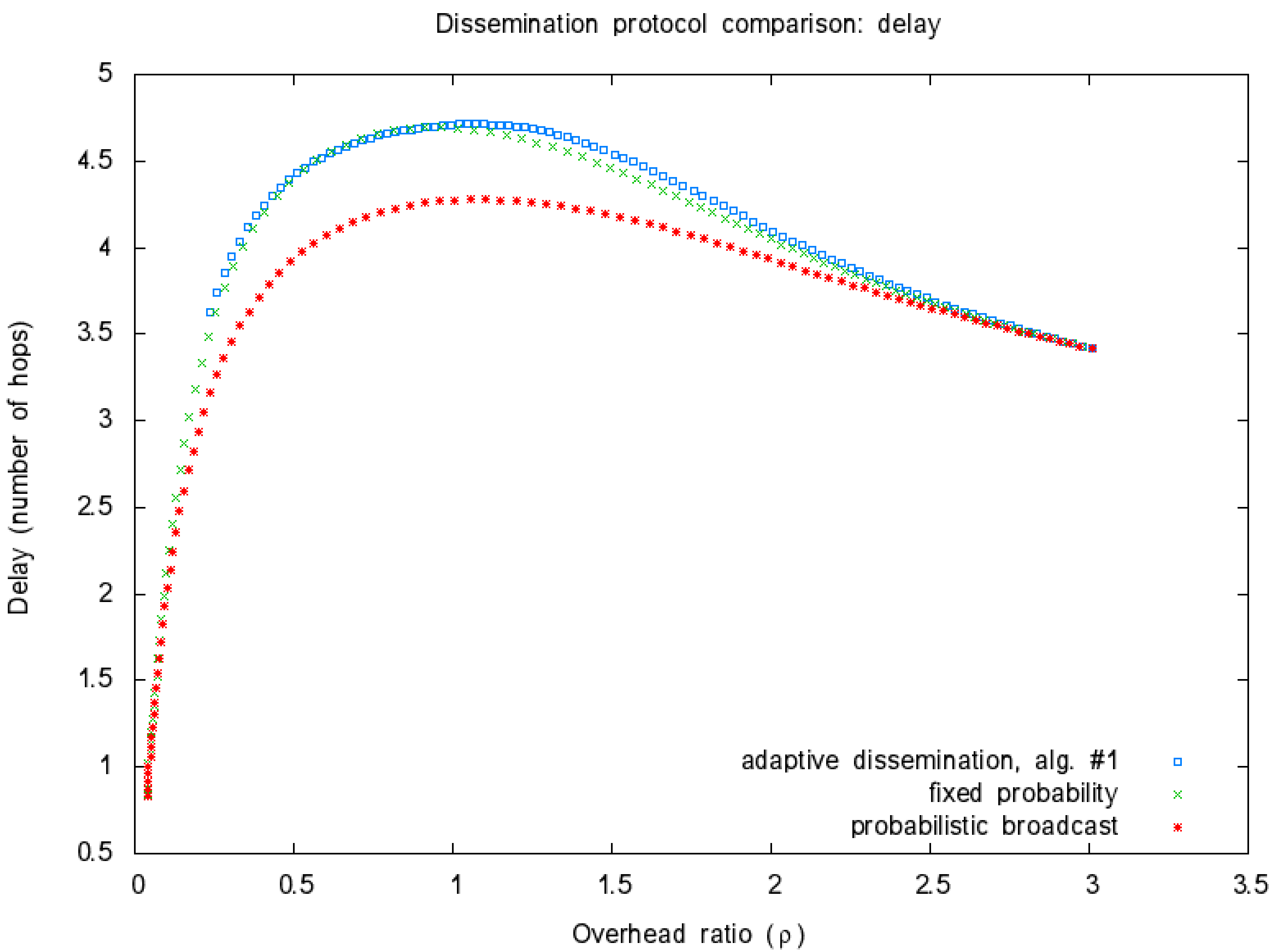
Evaluation: **coverage** rate (%)



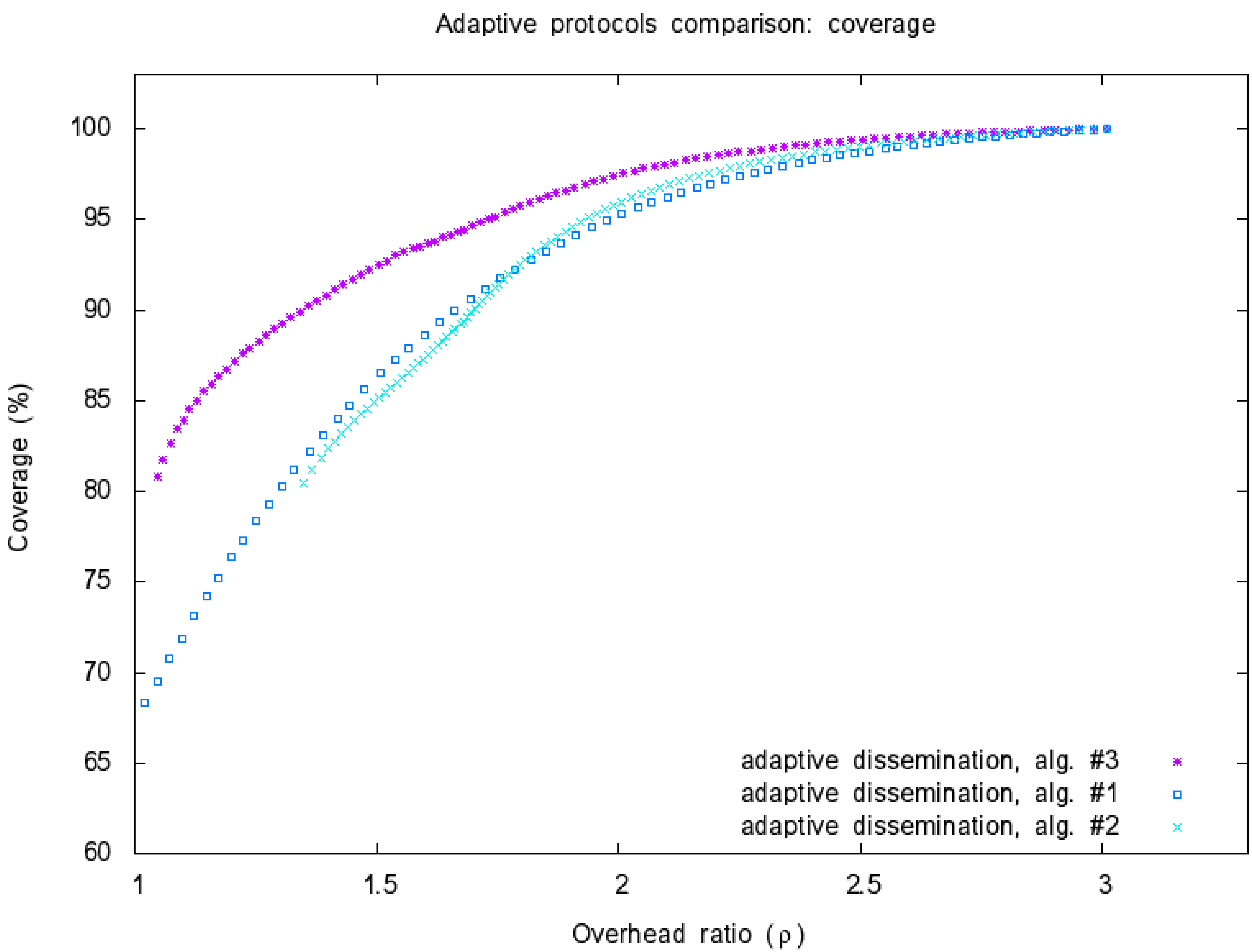
Evaluation: **coverage** rate (%)



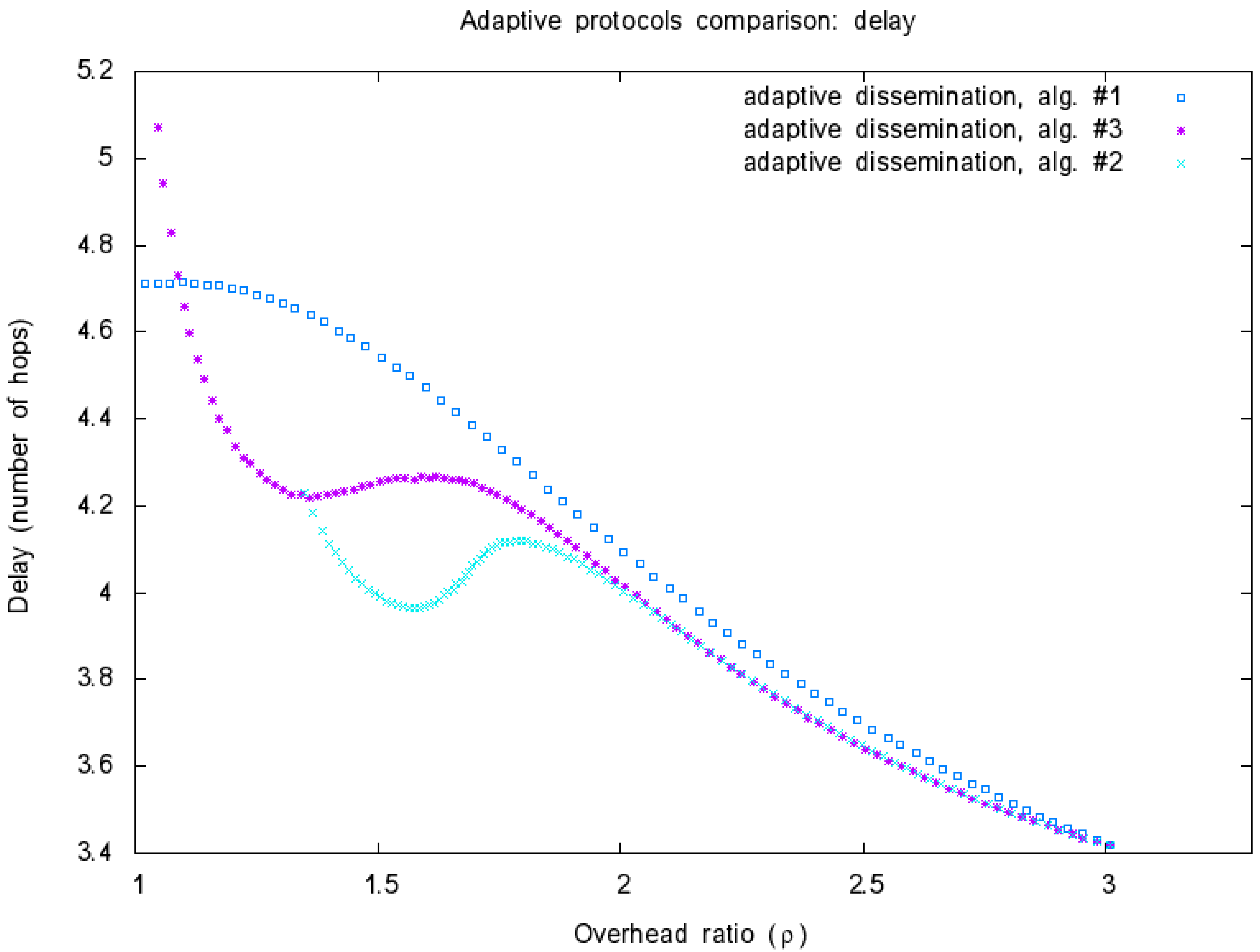
Evaluation: **delay** (number of hops)



Evaluation: **coverage** rate (%)



Evaluation: **delay** (number of hops)

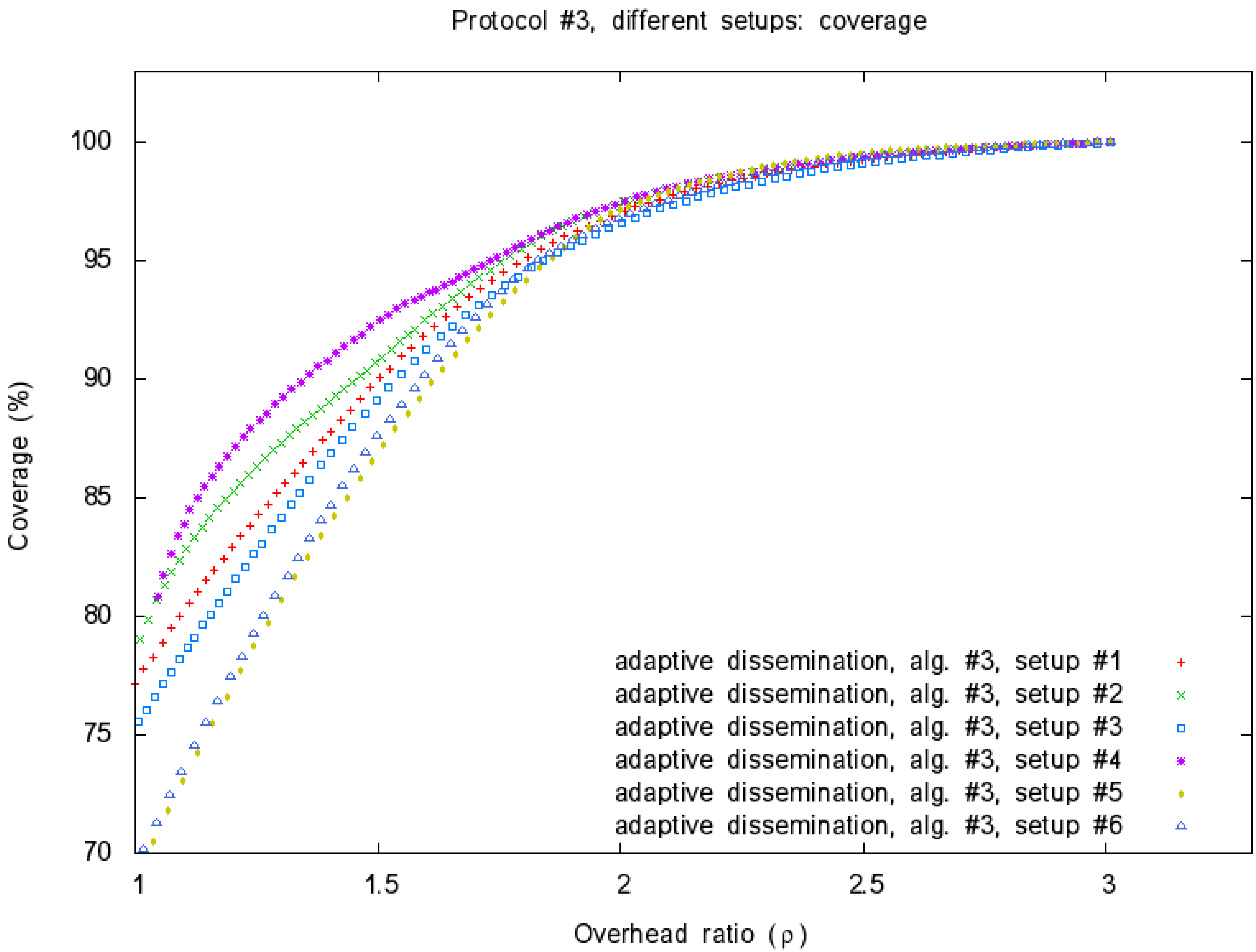


Tuning of the gossip protocol

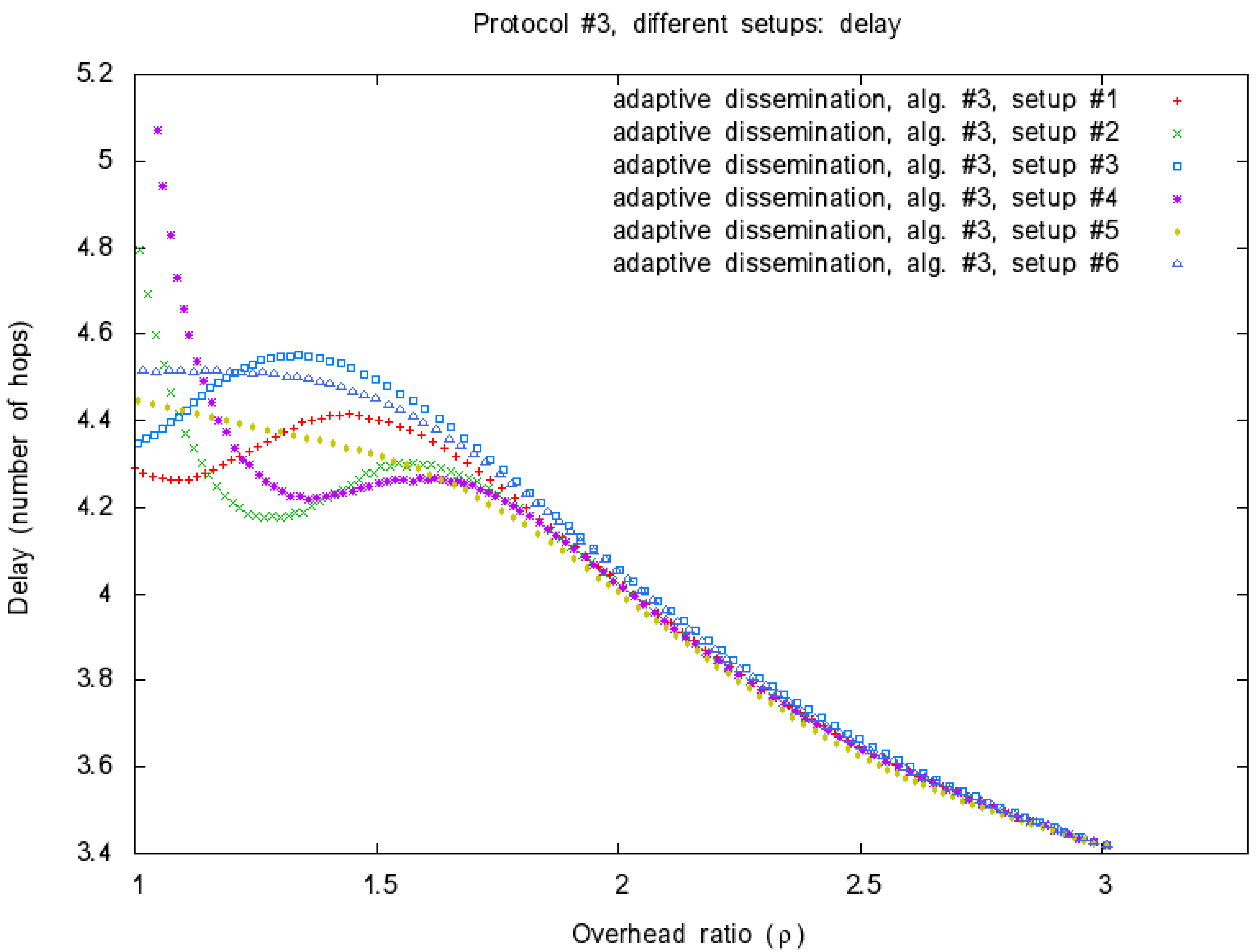
- In terms of **coverage**, protocol #3 "**stimuli associated to generators and receivers**" is the clear **winner**
- In terms of **delay** it is comparable with the others
- Many parameters can be used for the tuning of **protocol #3**

setup	monitoring period	stimulus magnitude	stimulus length	stimulus threshold
#1	50	0.5	1000	1
#2	50	0.5	5000	1
#3	50	0.5	1000	3/4
#4	50	0.7	10000	1
#5	30	0.25	10000	1
#6	30	0.25	10000	1/2

Evaluation: **coverage** rate (%)



Evaluation: **delay** (number of hops)



Conclusions and future work

- It is possible to build **smarter gossip protocols**
- The characteristics of many systems can be exploited for the implementation of **adaptive dissemination protocols**
- We have proposed a new methodology for the **comparison** of dissemination protocols: **outcomes** and **cost** of each protocol have to be both considered
- Very simple mechanisms have shown good performance in terms of **coverage** and **delay**
- What about more complex forms of adaptivity?
- **LUNES**: a new simulator for the experimental evaluation of protocols on large scale networks

Further information

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A draft version of this paper is freely available at the following link:

- http://arxiv.org/abs/1102.0720

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