



# Simulation of an Energy Efficient Carrier Sensing Multiple Access Protocol for Clustered Wireless Sensor Networks

Chiara Buratti, Andrea Giorgetti, Roberto Verdone

rverdone@deis.unibo.it

IEIIT-BO/CNR, University of Bologna, CNIT



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- INTRODUCTION
- CLUSTER FORMATION ALGORITHM
- MAC PROTOCOL
- SIMULATION RESULTS
- LESSONS LEARNED



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- **INTRODUCTION**
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Wireless Sensor Networks (WSNs) are application-specific

VICOM (Virtual Immersive Communications),  
funded by MIUR, Italy

Analytical paper presented yesterday by Andrea Conti

Simulations to account for MAC aspects  
and to learn lessons to be included in analytical future works

Energy Efficiency is a key issue

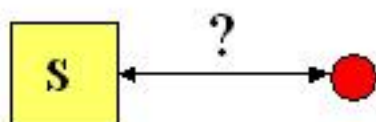
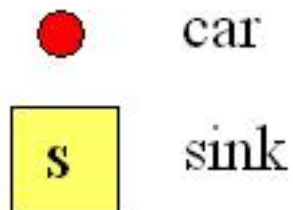
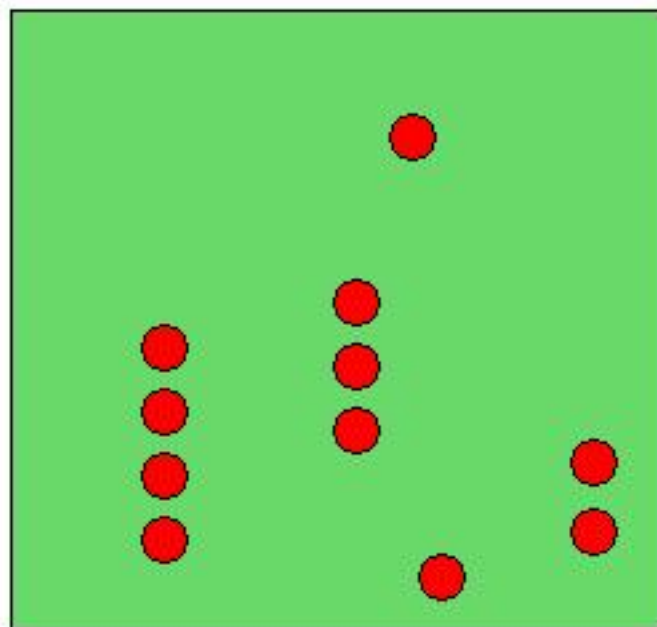
System Lifetime is the performance metric

MAC and Network aspects

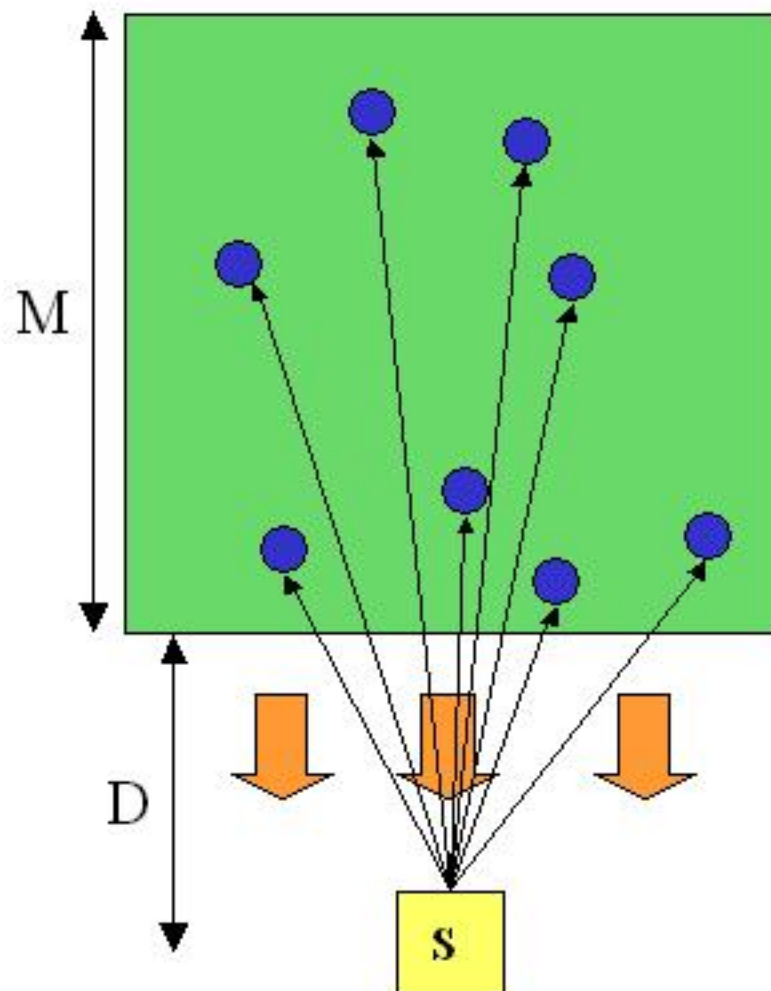
1<sup>st</sup> step: separate optimisation to accumulate experience

2<sup>nd</sup> step: Cross Layer Design

## Application scenario: Parking area



## Application scenario: generalisation



● sensor

■ s sink

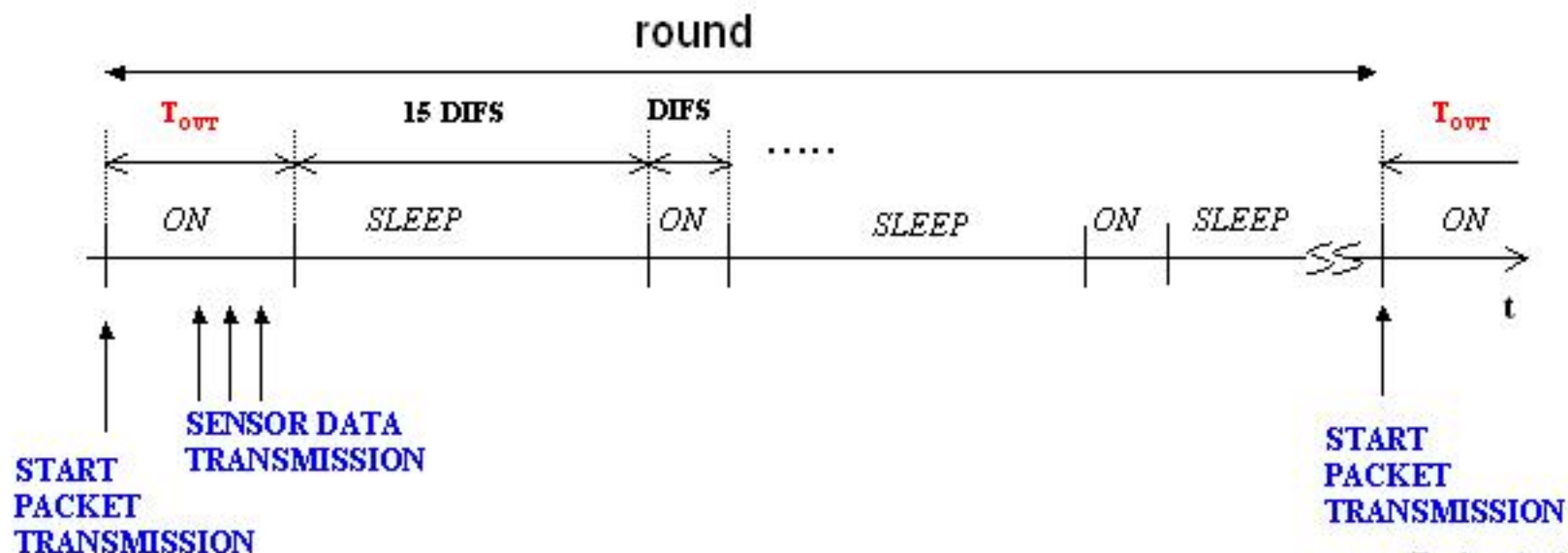
### Main assumptions

- Sensors are uniformly deployed
- No motion
- Sensors do not know their position
- Geometry is known
- $D = 0$  m
- $M = 100$  m



## Definition of ROUND

- round {
- 1) The sink sends the START packet
  - 2) Sensors send the data measured
  - 3) All sensors move to sleep state
  - 4) Sensors periodically wake up to sense the channel till a new start packet is sent by the sink





## Things to be done

Environment (channel): to be specified

$$L \text{ [dB]} = a + b \log(d) + s \quad s \text{ is Gaussian r.v.}$$

Energy budget: to be formalised

Transmission, Reception, Sensing

Assumptions about the physical layer to be fixed

Power control, margin computed based on outage probability

**Cluster formation algorithm: to be designed / chosen**

**MAC protocol: to be designed / chosen**

System Lifetime as an output of the performance evaluation

System Lifetime is defined as the number of rounds  
with the complete set of sensors still alive

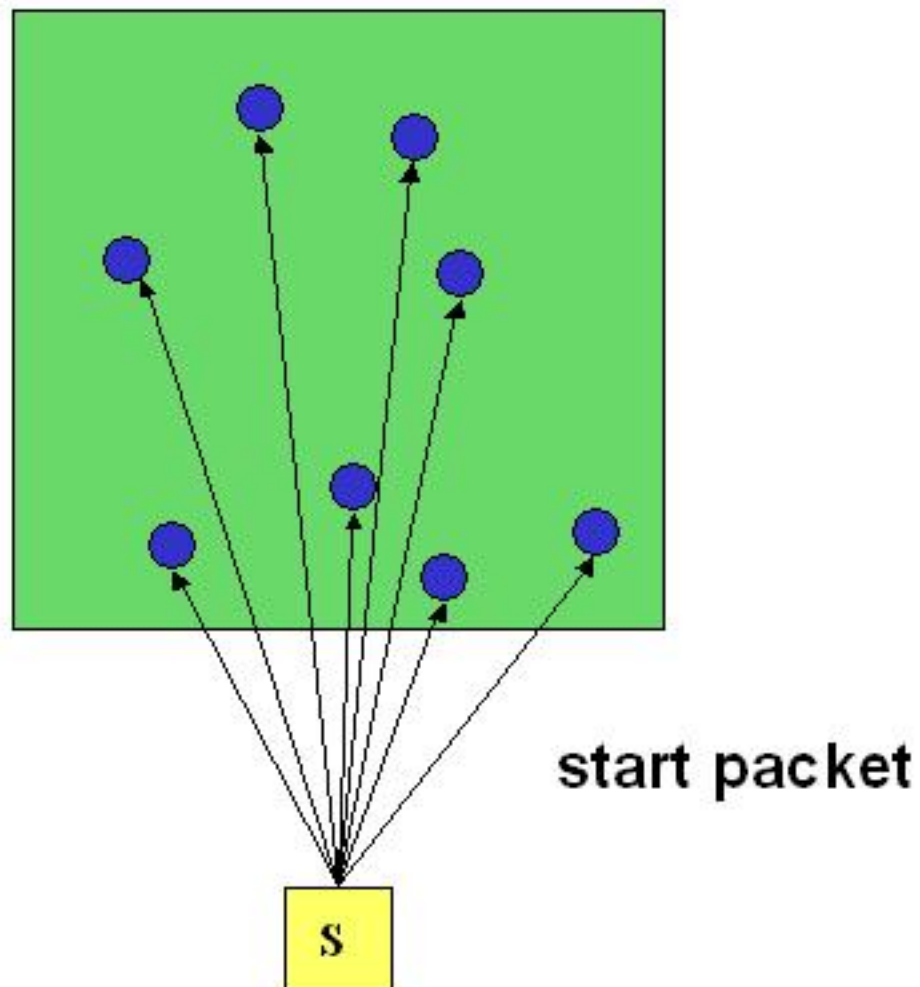


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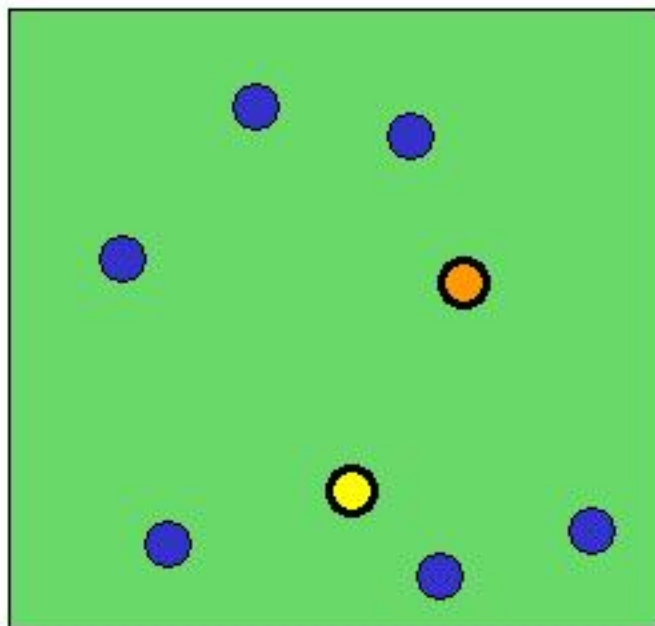
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# LEACH

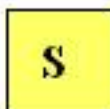


# LEACH



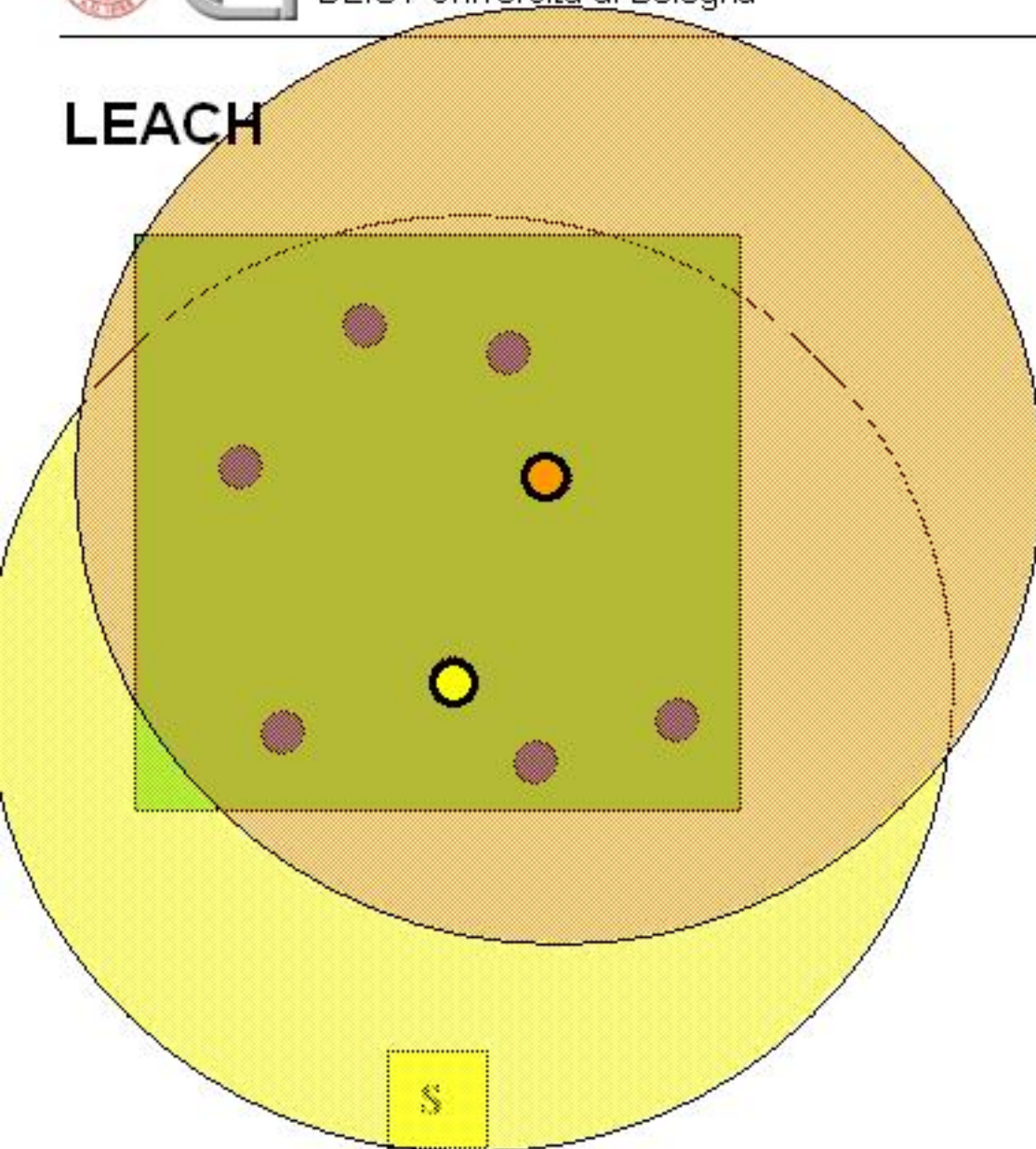
## Cluster Head self-election

- Uncoordinated
- Based on residual energy



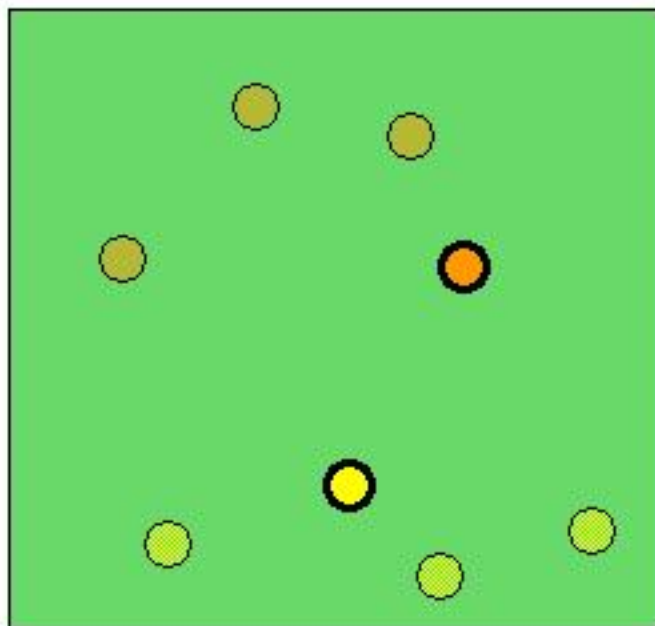


# LEACH



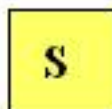
**Broadcast packet(s)**

## LEACH B (A. De Pedri, A. Zanella, R. Verdone, IEEE AINS 2003)

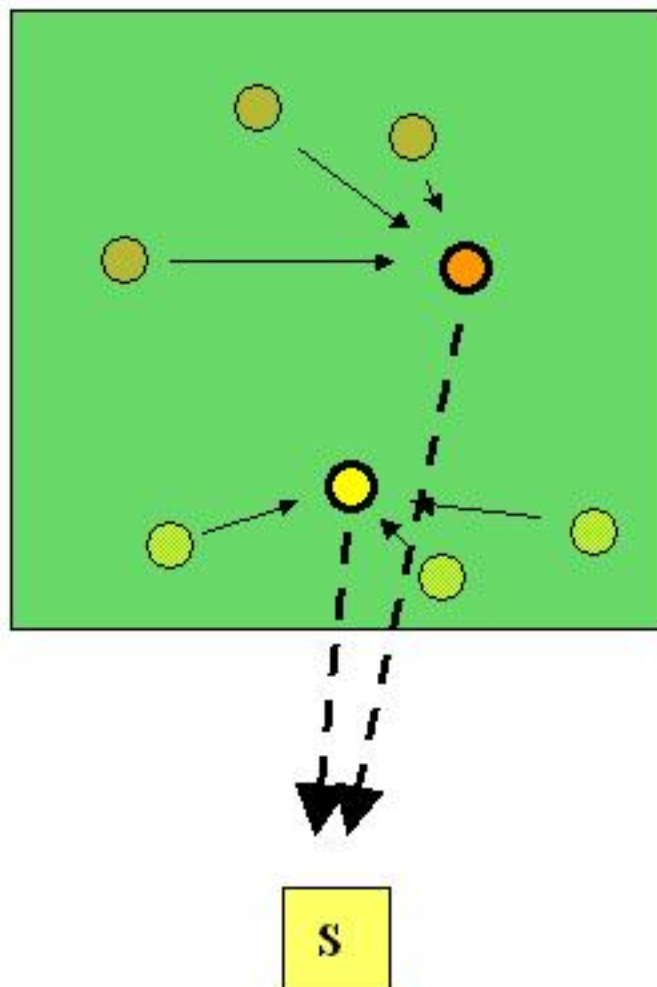


### Cluster formation

- Uncoordinated
- Minimum TOTAL Loss



## LEACH B



### Data transmission

- Two hops (not scalable)
- Direct transmission as a backup procedure

Simple, Energy efficient



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## MAC: collision prone or collisionless?

Collisionless protocols (e.g. TDMA, SMACS)  
require overhead to schedule transmissions

Convenient if the environment is static or slowly varying

Collision prone protocols (e.g. CSMA)  
require retransmission strategies

Convenient if the environment is highly dynamic

$$T_{\text{IR}} \ll T_{\text{COH}}$$

Collisionless

$$T_{\text{IR}} > T_{\text{COH}}$$

Collision prone



CSMA

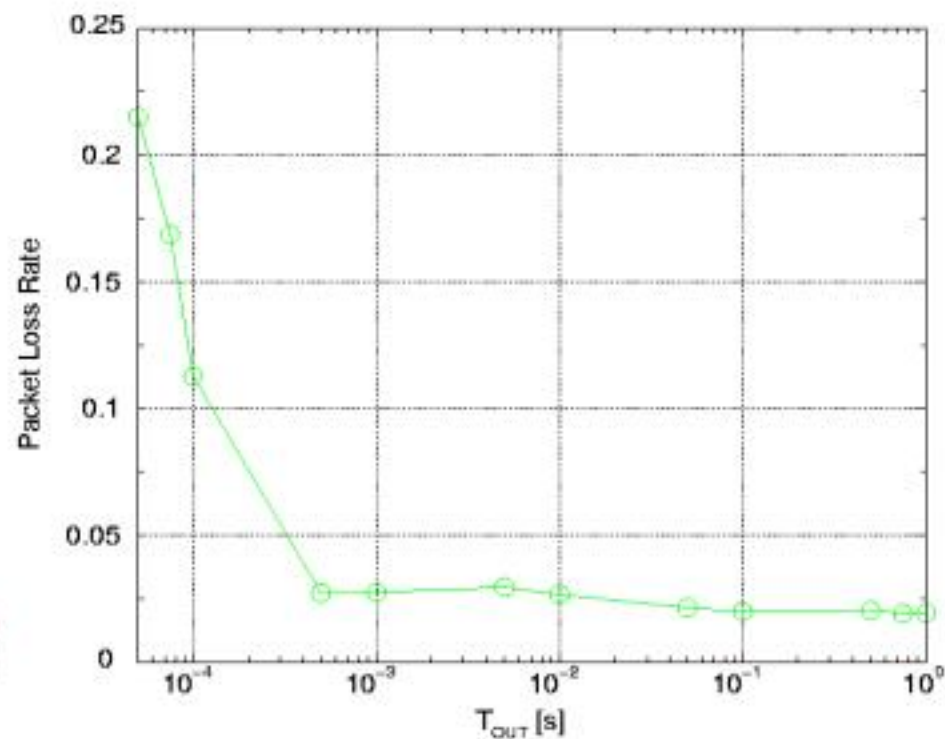
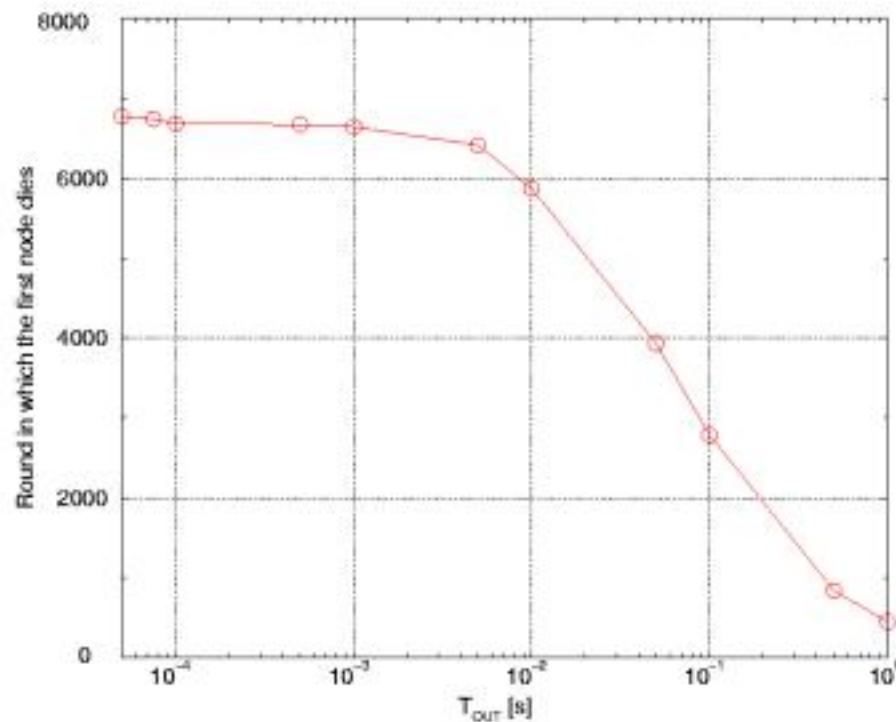


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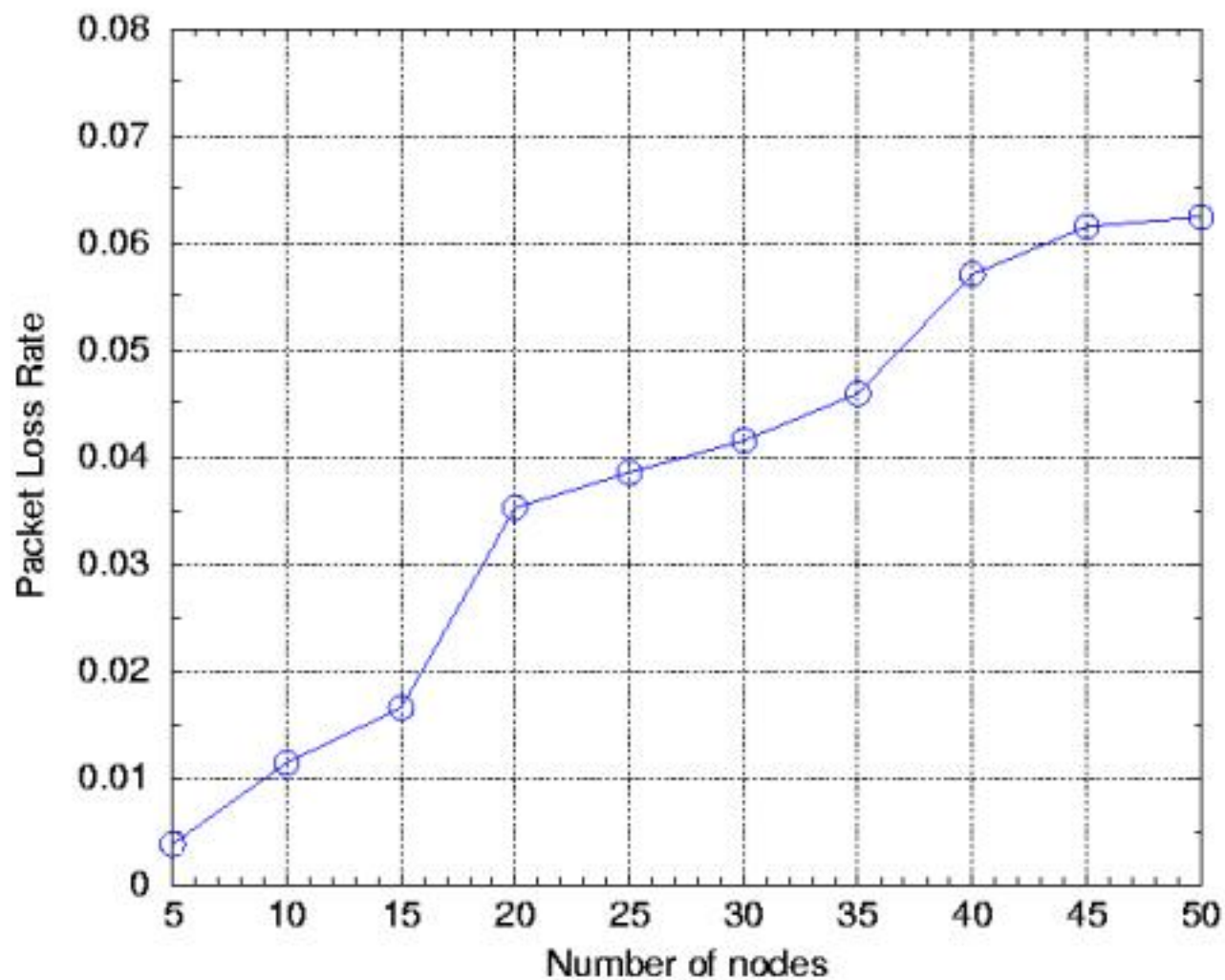


## System Lyfetime and Packet Loss Rate vs Tout



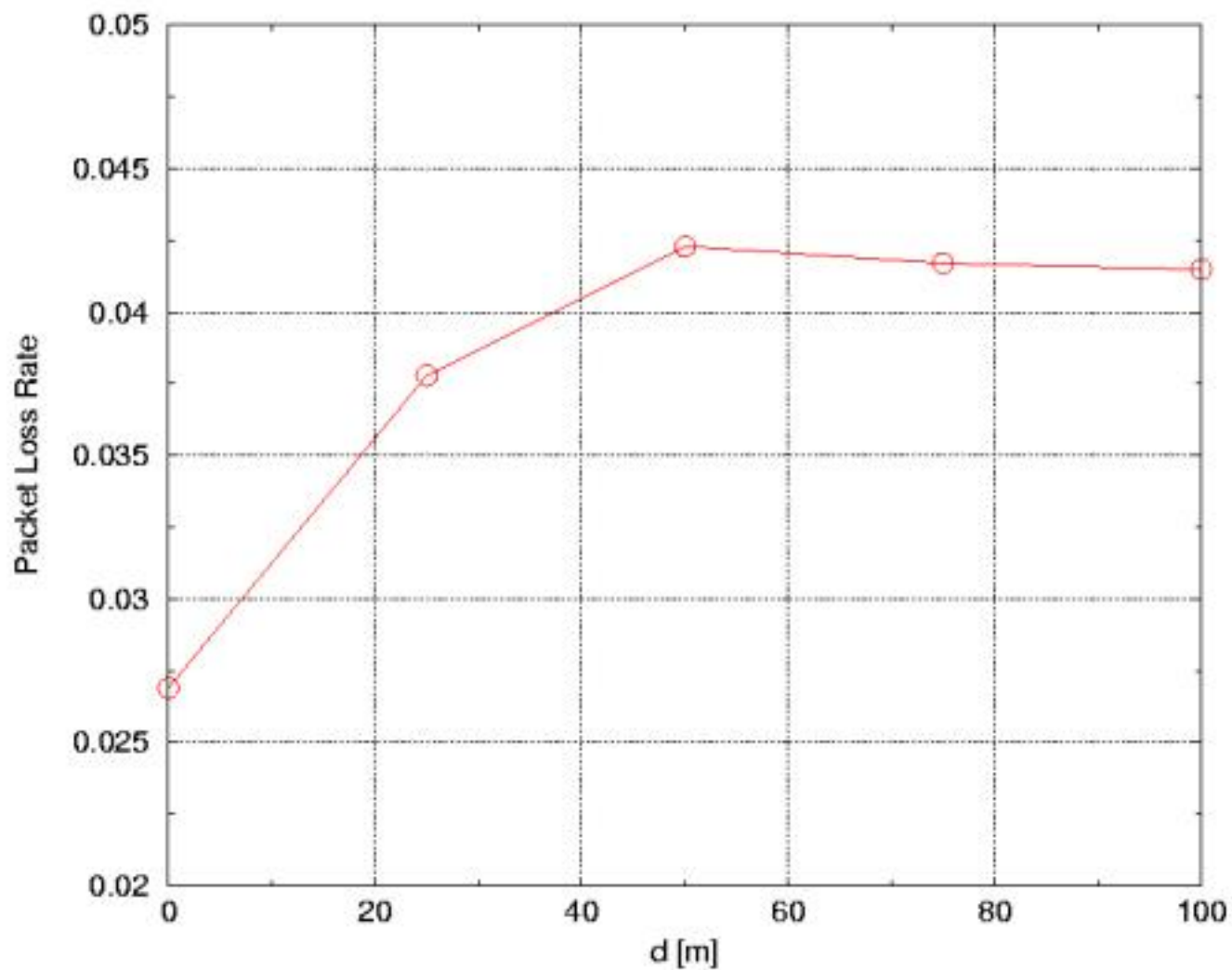


## Packet Loss Rate vs Number of nodes: almost linear



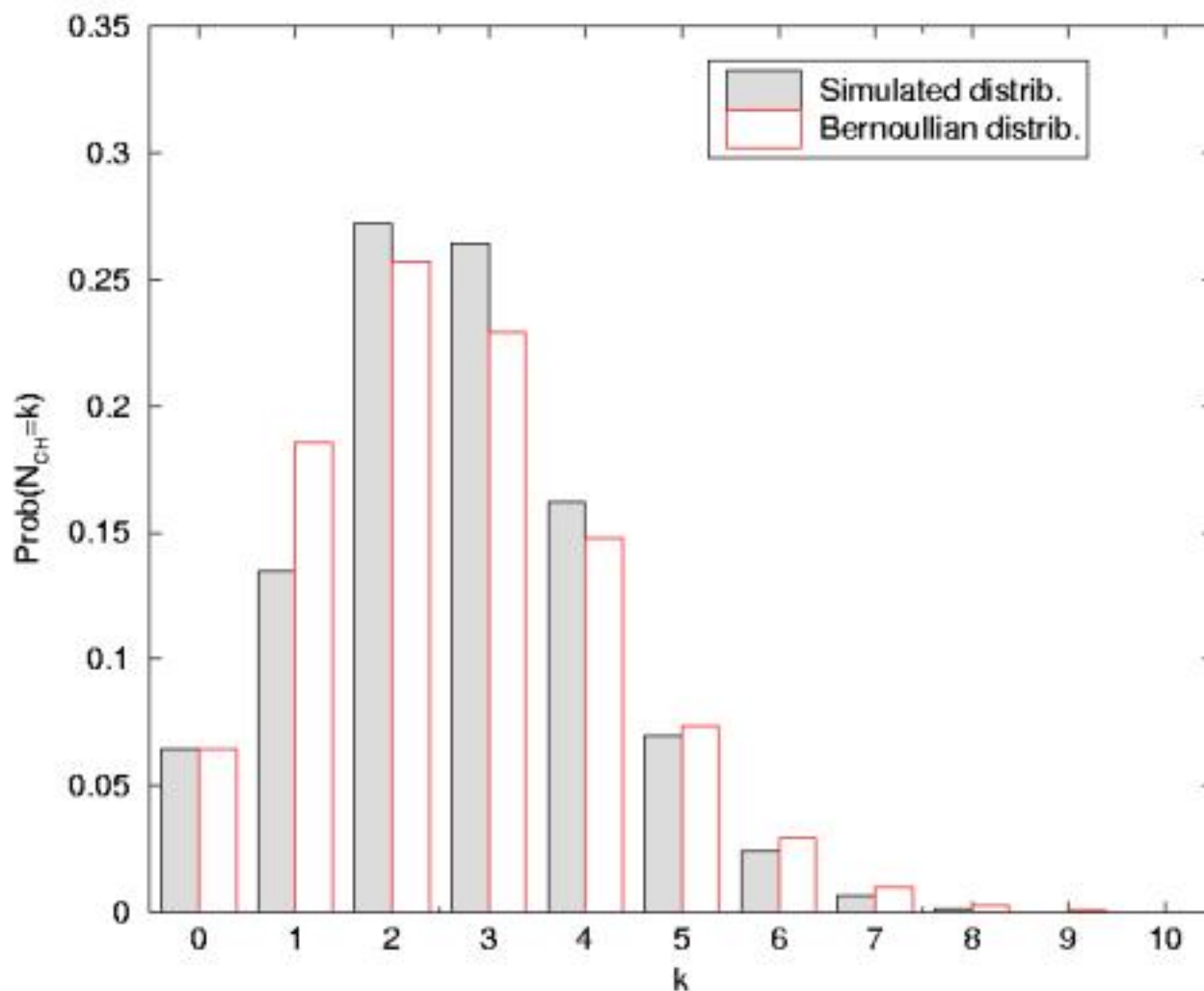


## Packet Loss Rate vs d





## The number of CHs follows a Bernoulli distribution





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## Some hints for analytical descriptions

Packet Loss Rate vs Number of nodes: almost linear

The number of CHs follows a Bernoulli distribution



## Cross Layer Design

There is margin provided that system lifetime is not limited by sensing

Number of MAC retransmissions can provide useful information to the cluster formation algorithm if the environment is static in the slow-term (significant improvements)