Adaptive Scheduling of Wireless Video Sensor Nodes for Surveillance Applications.

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Outline

- Introduction
- Our proposal :
  - Avoid redundancy
  - Manage frame capture rate
- Simulations
- Conclusion & perspective

Traditional Video surveillance infrastructure

- Fixed Camera
- Manuel deployment

Video sensor surveillance infrastructure

Dynamic reconfiguration

Adaptive application

Save energy

Problematics

- How to Maximize the network lifetime and the coverge area wrt:
  - The camera view constraints.
  - The application criticality.

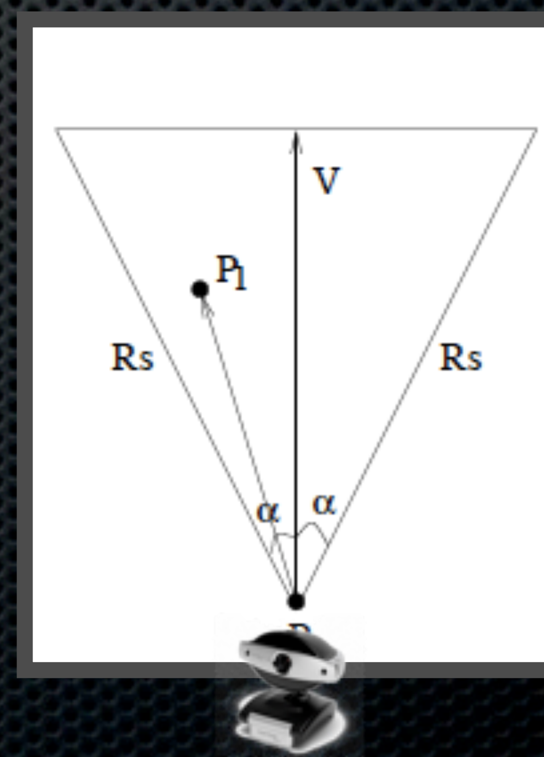
Our proposal

- Avoid redundancy with a new method based on the cover set classification.
    - **Some nodes will sleep to preserve their energies**
- Regulate the frame capture rate wrt the application criticality level.
    - **Some nodes will decrease their fps to preserve their energies**

Avoid redundancy

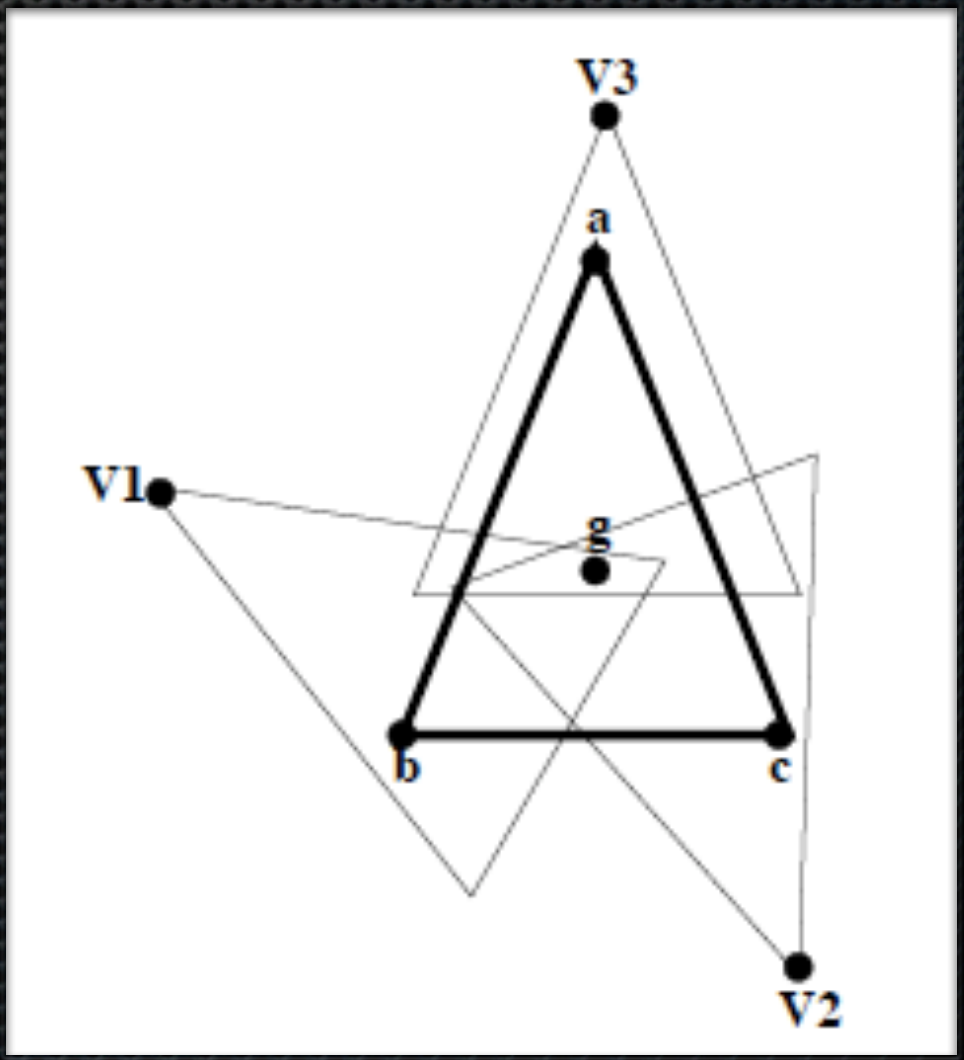
Node’s cover set

- Each node v has a Field of View, FoV_v
- $Co_i(v)$ = set of nodes v’ such as $\cup_{v' \in Co_i(v)} FoV_{v'}$ covers FoV_v
- $Co(v)$= set of $Co_i(v)$



Finding v's cover set

A = {v ∈ N(V) : v covers the point "a" of the FoV}
B = {v ∈ N(V) : v covers the point "b" of the FoV}
C = {v ∈ N(V) : v covers the point "c" of the FoV}
G = {v ∈ N(V) : v covers the point "g" of the FoV}



$AG=\{A \cap G\}$

$BG=\{B \cap G\}$

$CG=\{C \cap G\}$

$Co(v)=AG \times BG \times CG$

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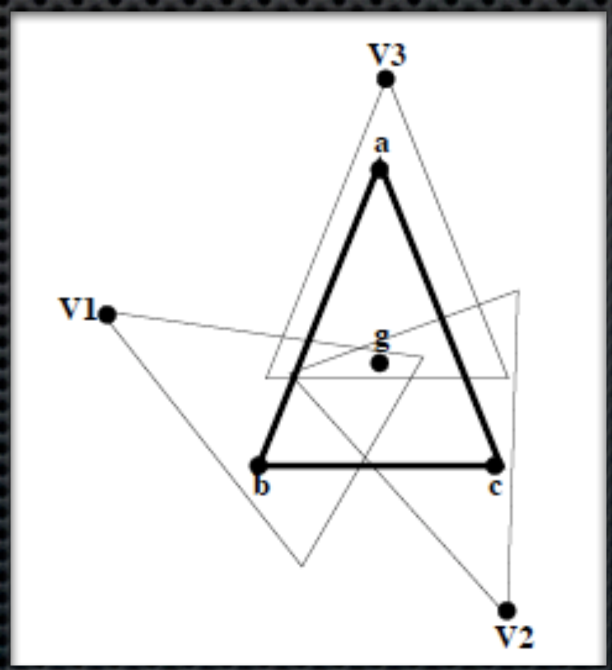
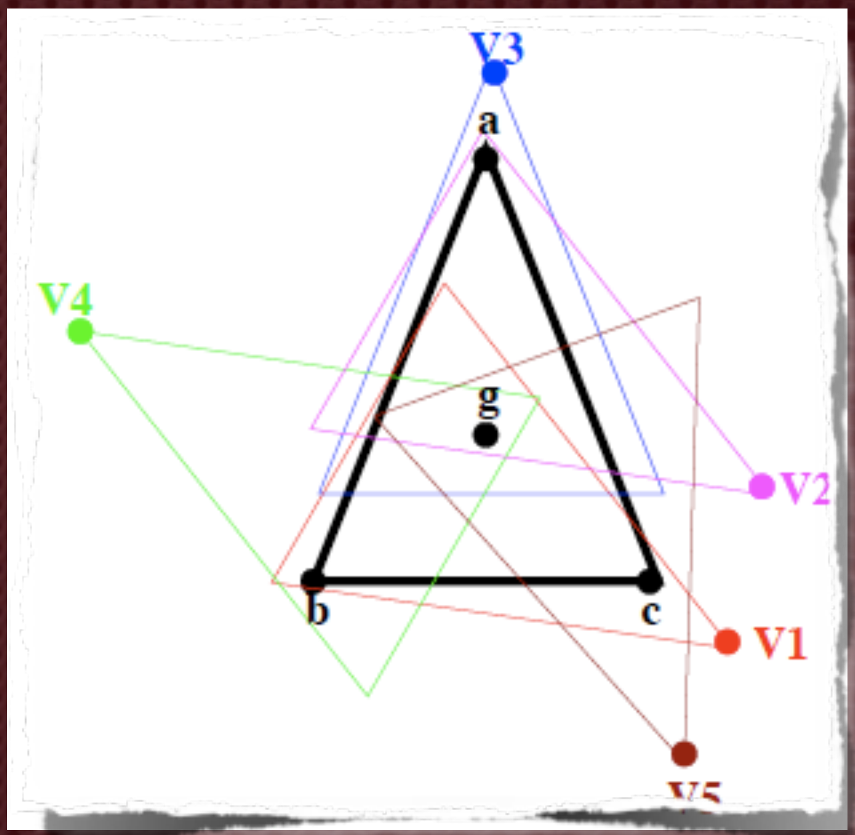
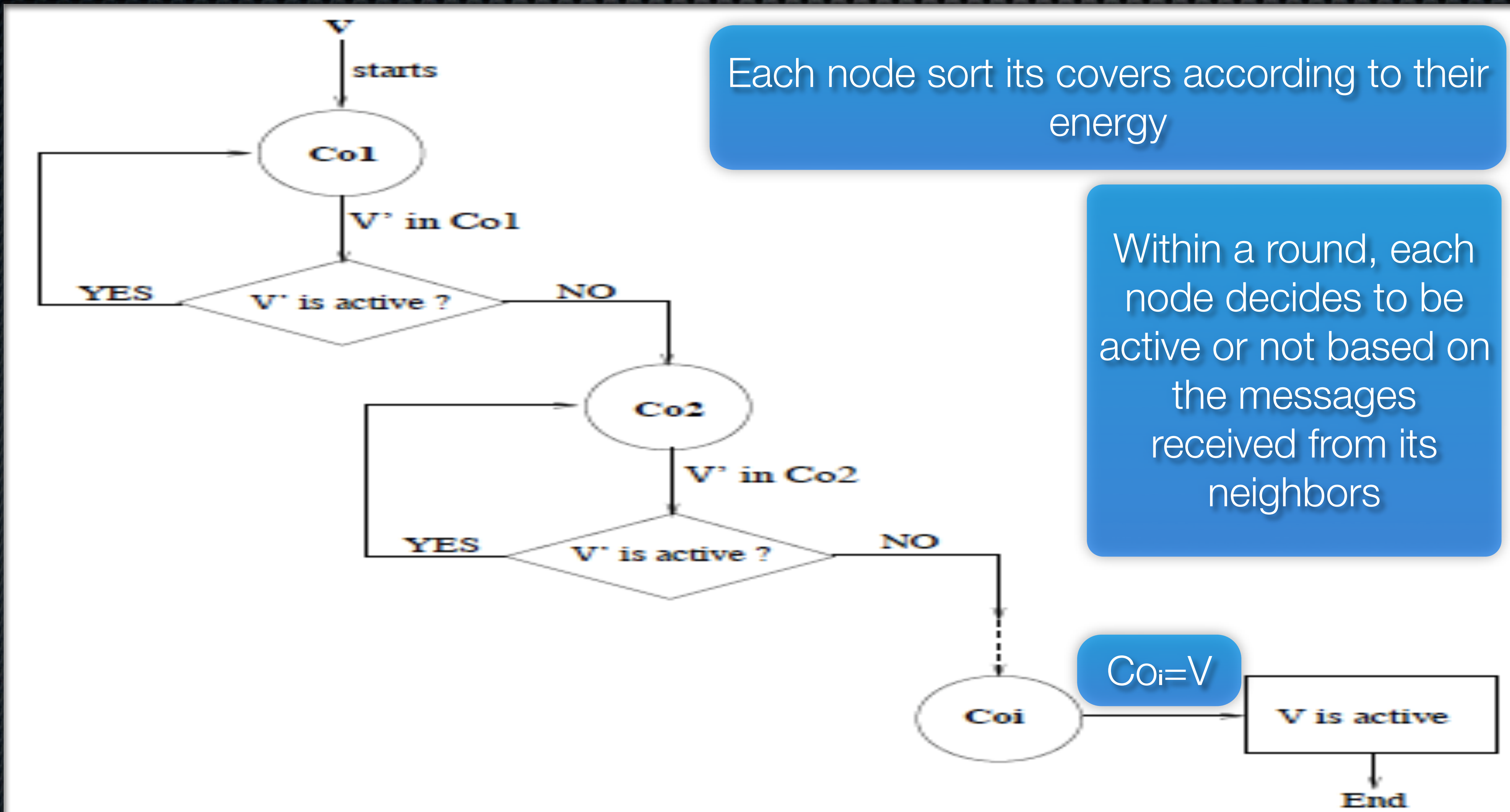


Exemple



Co(V)= {
{V },
{V 2, V 1},
{V 3, V 1},
{V 2, V 4, V 5},
{V 3, V 4, V 5}}

Active node selection



Each node sort its covers according to their energy

Within a round, each node decides to be active or not based on the messages received from its neighbors

Co_i=V

Regulate the frame capture rate

Application's criticality

- All surveillance applications may not have the same criticality level, r° in [0,1]
  - e.x. Environmental, security, healthcare,…
- Capture speed should decrease when r° decreases
- Sensor nodes could be initialized with a given r° prior to deployment

How to meet app's criticality

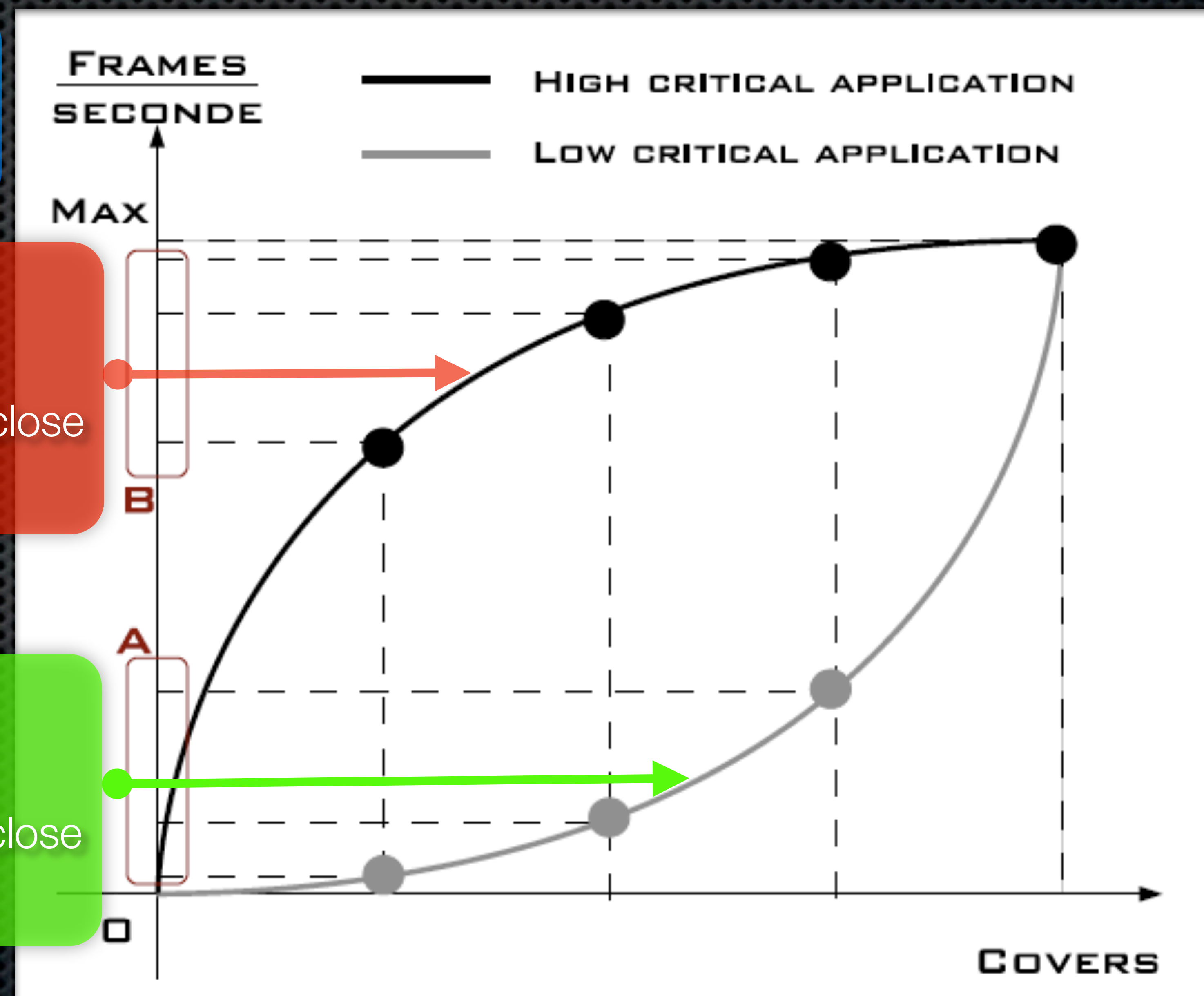
- Capture speed can be a « quality » parameter
- Capture speed for node v should depend on the app's criticality and on the level of the cover redundancy for node v
- V's capture speed can increase when as V has more nodes covering its own FoV - cover set

Criticality model

Link the capture rate to the size of the cover set

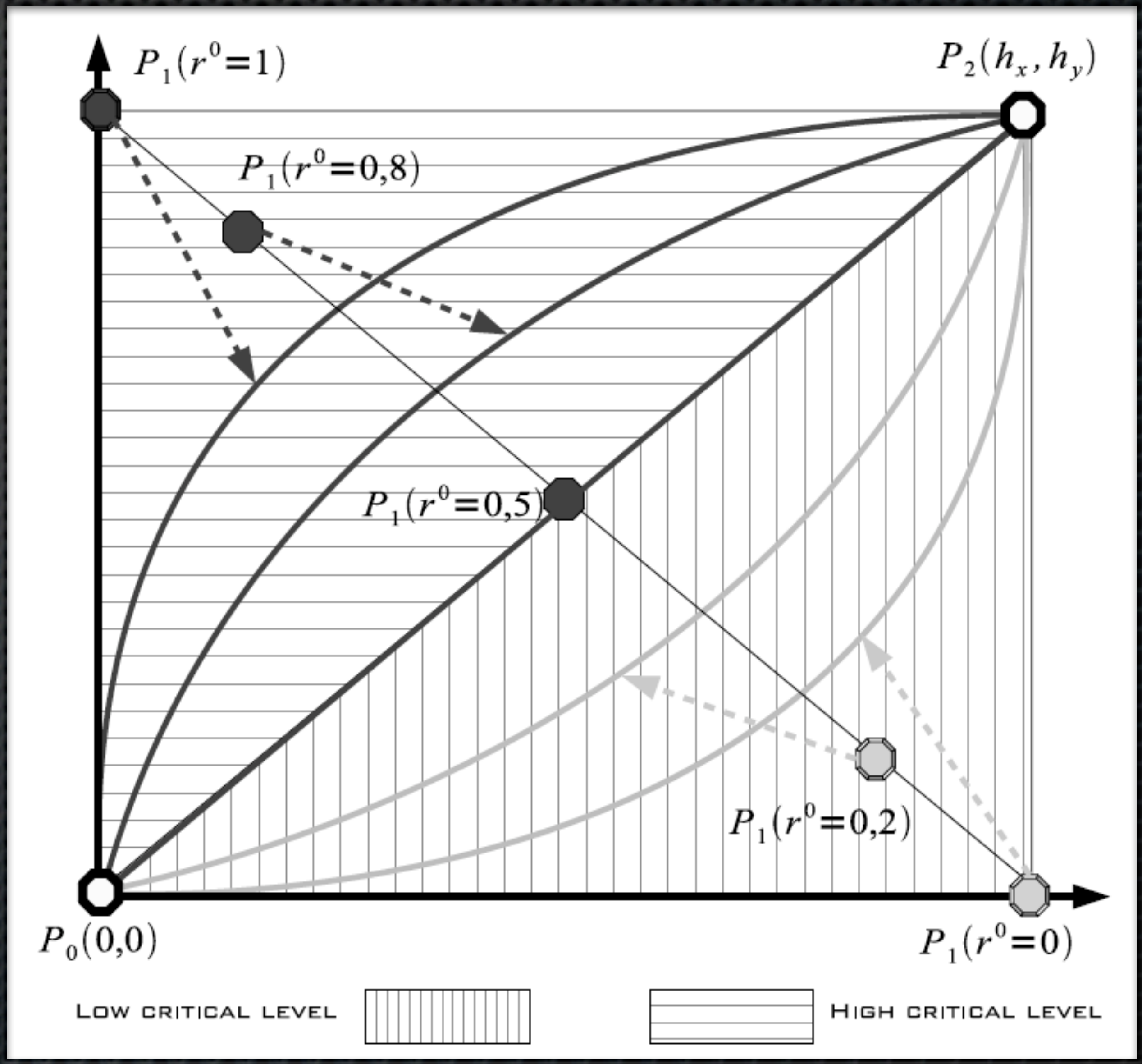
High criticality:
- Convex shape
- Most projections of x are close to the max capture speed

Low criticality:
- Concave shape
- Most projections of x are close to the min capture speed



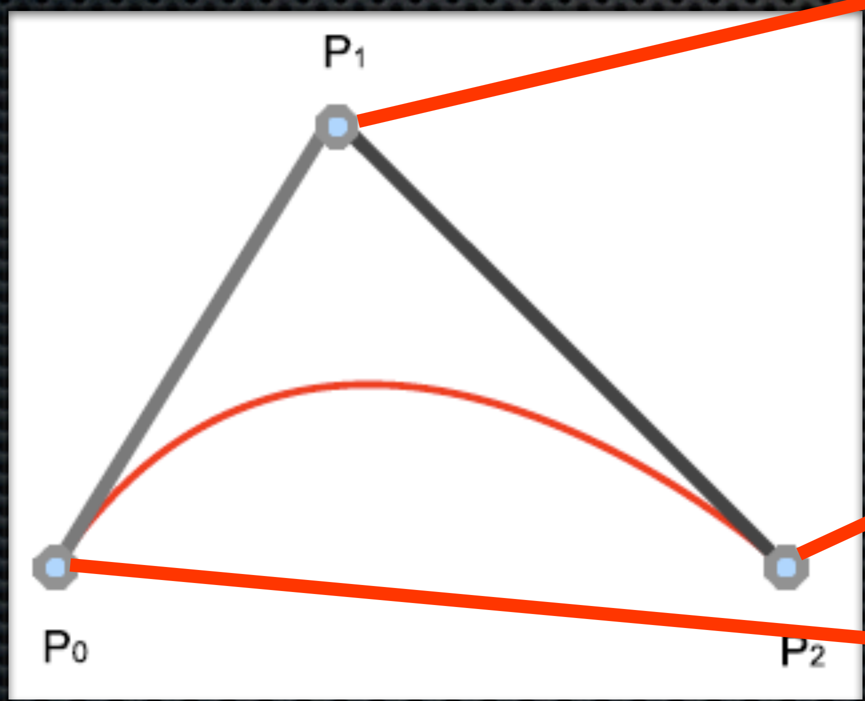
Criticality model (2)

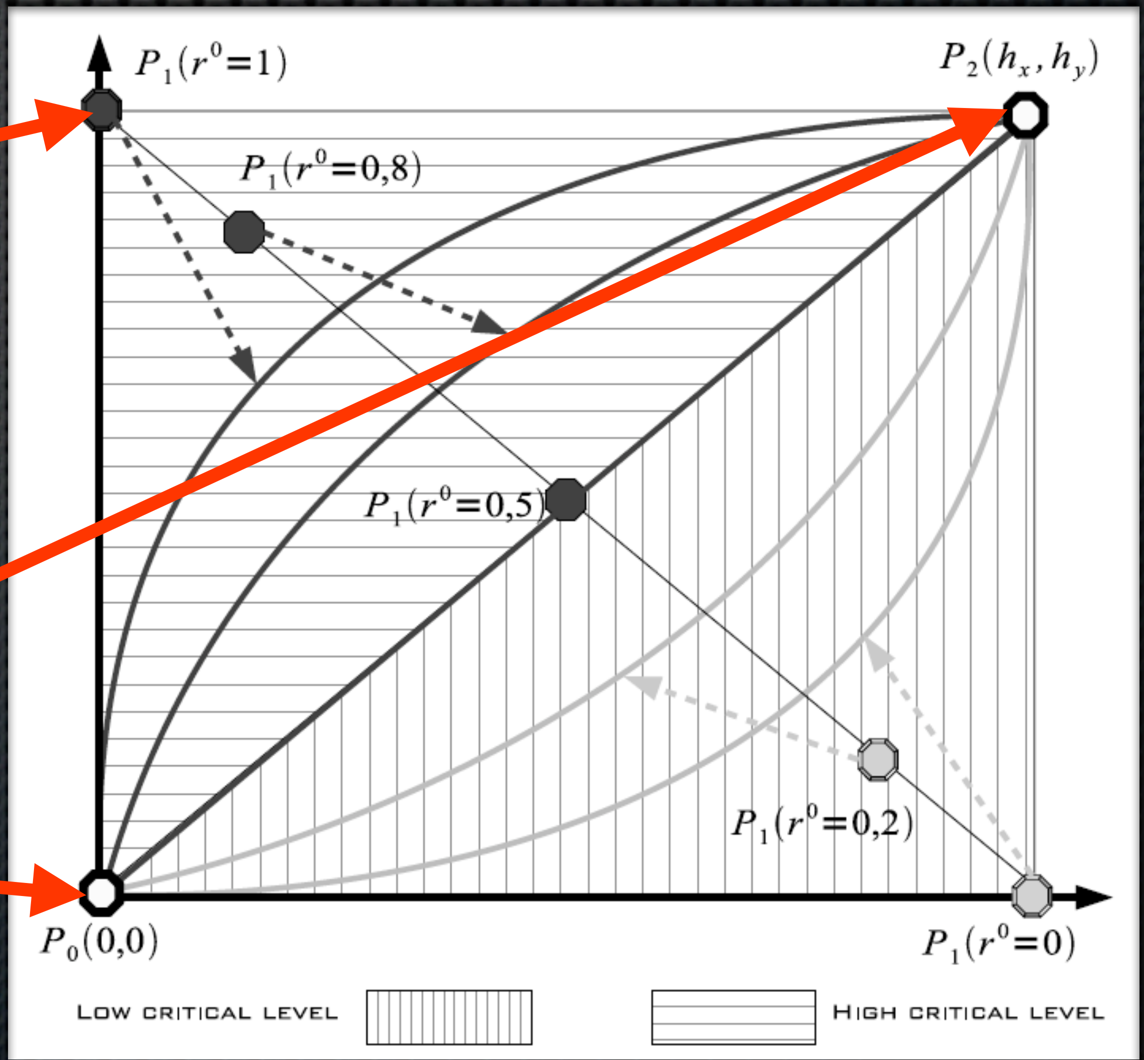
- r° can vary in [0,1]
- BehaVior functions (BV) defines the capture speed according to r°
- r° < 0.5 => Concave shape BV
- r° >= 0.5 => Convex shape BV
- **We propose to use Bézier curves to model BV functions**



BehaVior function

$$B(t) = (1-t)^2 * P_0 + 2t(1-t) * P_1 + t^2 * P_2$$





Some typical capture speed

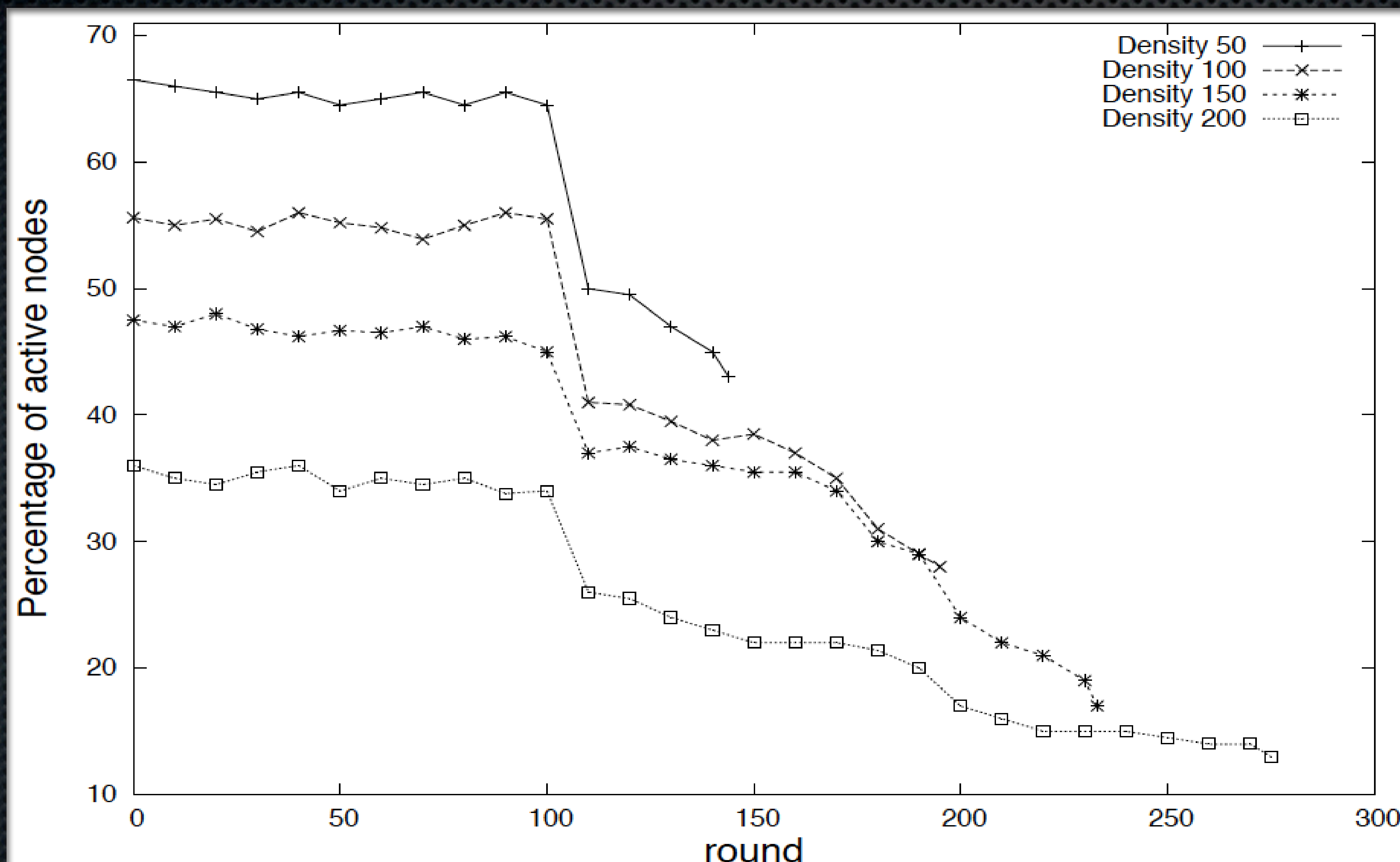
- Maximum capture speed is 6fps
- Nodes with size of cover set greater than 6 capture at the maximum speed

r^0 \ $\lvert Co(v)\rvert$	1	2	3	4	5	6
0.0	0.05	0.20	0.51	1.07	2.10	6.00
0.2	0.30	0.73	1.34	2.20	3.52	6.00
0.5	1.00	2.00	3.00	4.00	5.00	6.00
0.8	2.48	3.80	4.66	5.27	5.70	6.00
1.0	3.90	4.93	5.49	5.80	5.95	6.00

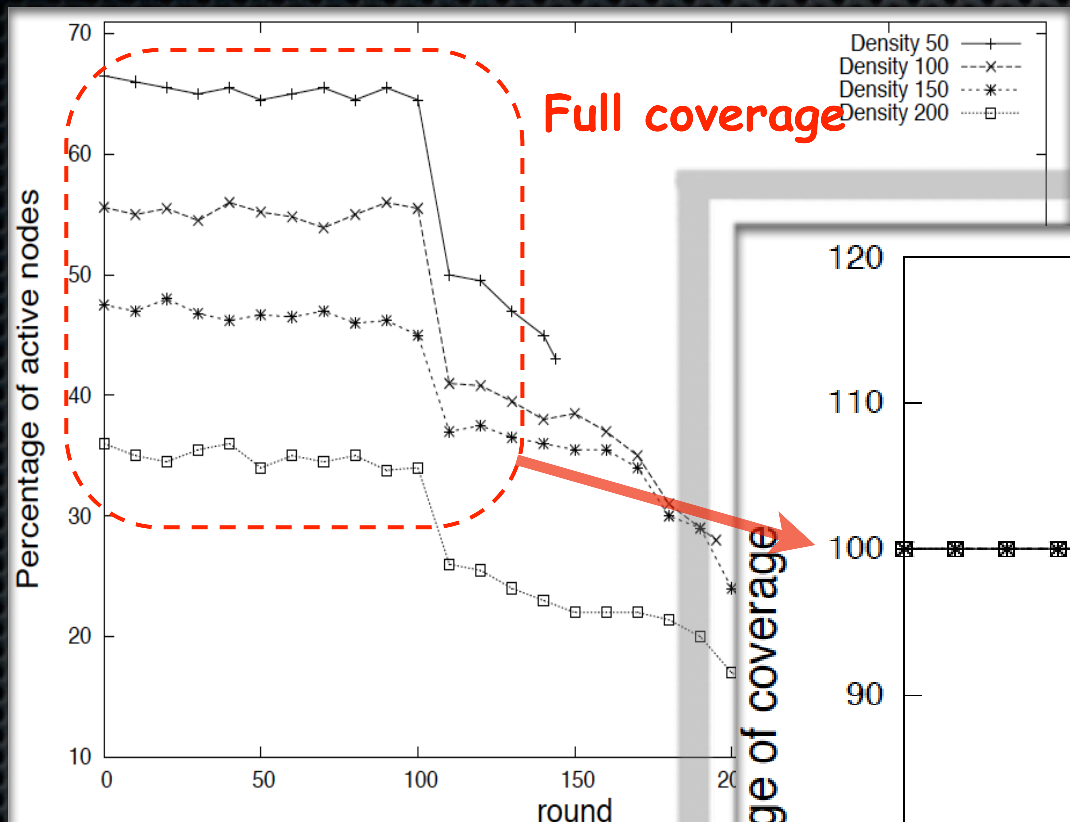
Simulation settings

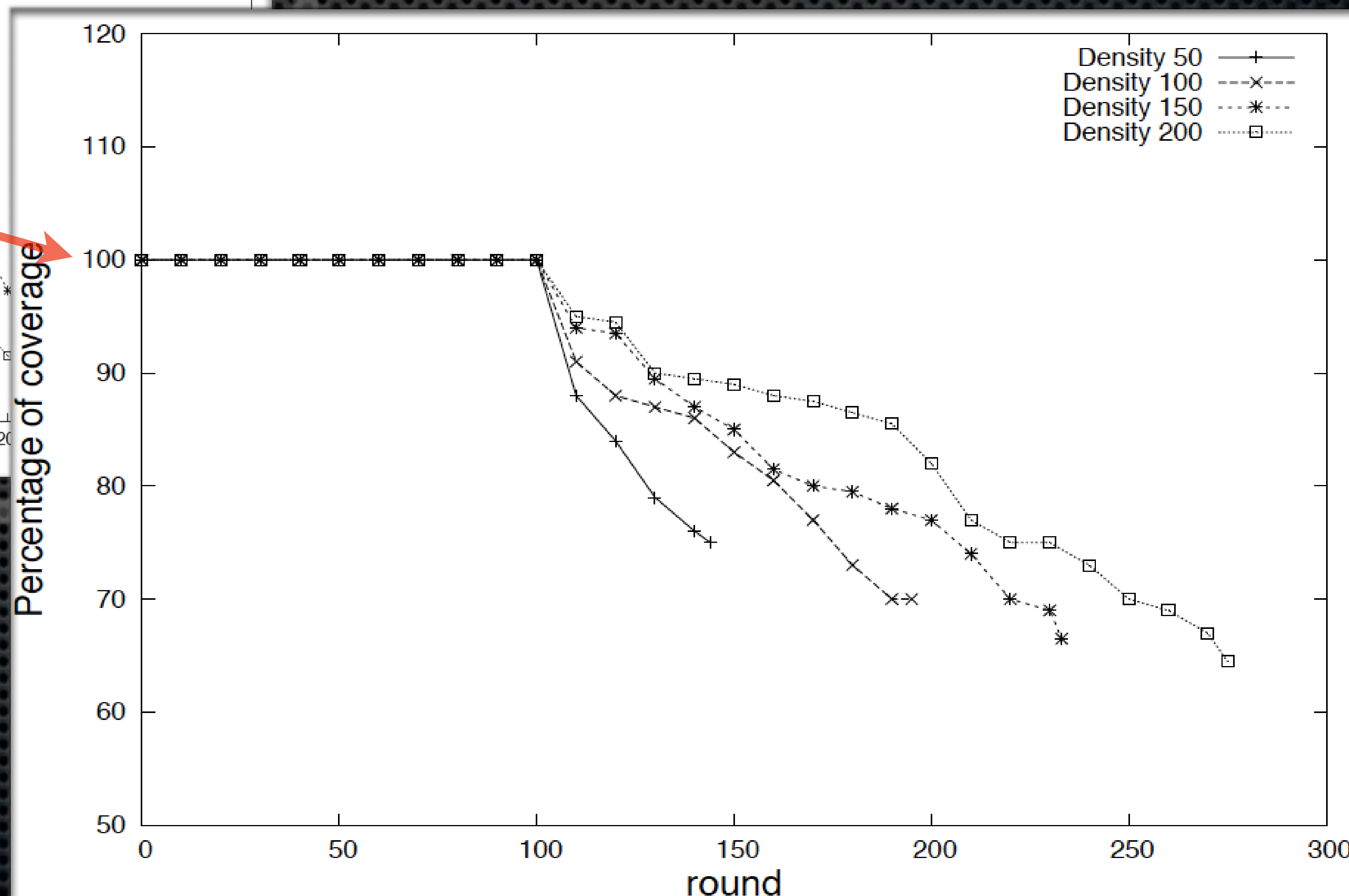
- OMNET++ simulation model
- Video nodes have communication range of 30m and video sensing range of 25m, FoV is a sector of 60°
- Battery has 100 units
- Full coverage is defined as the region initially covered when all nodes are active

Percentage of active nodes

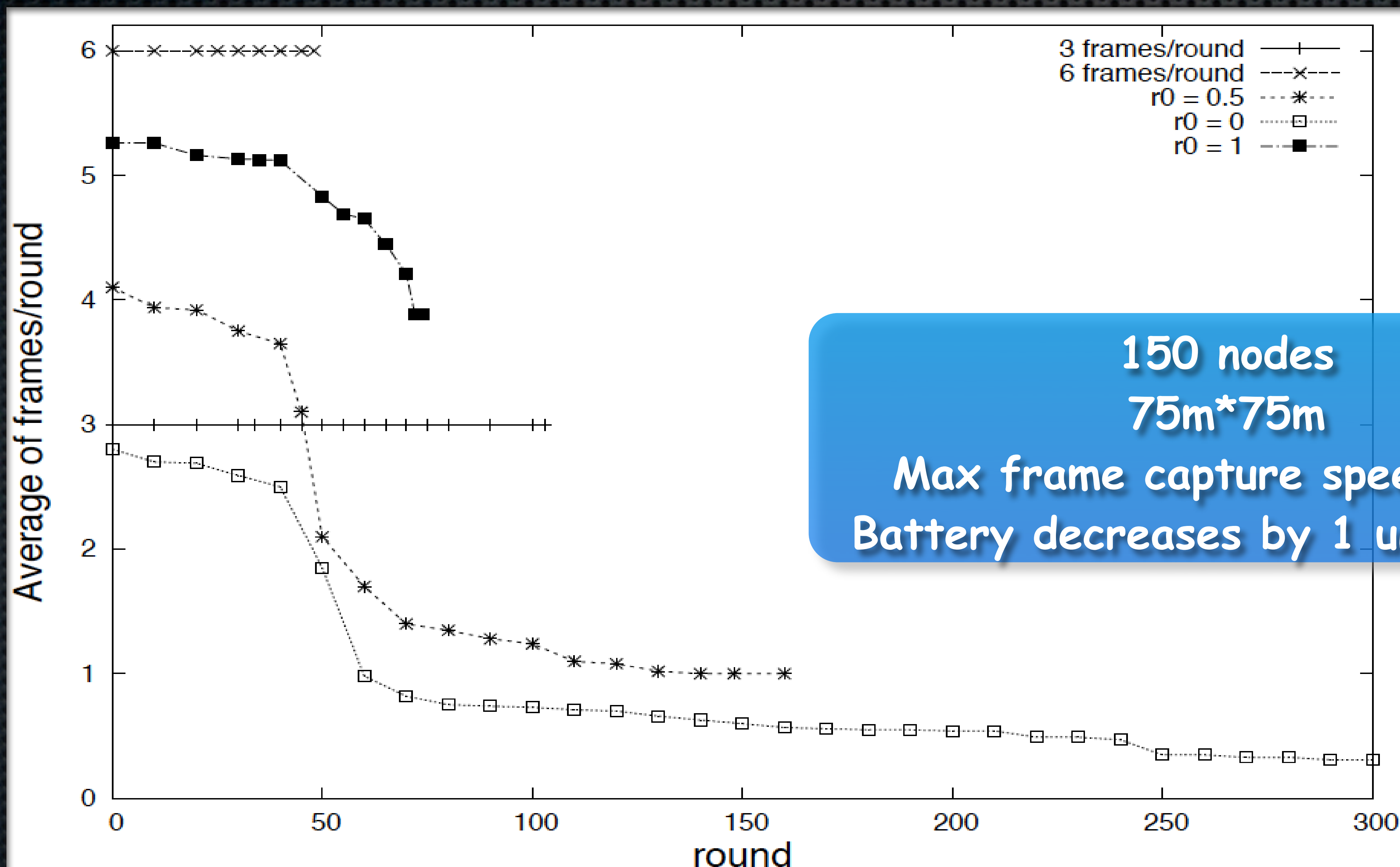


Percentage of active nodes



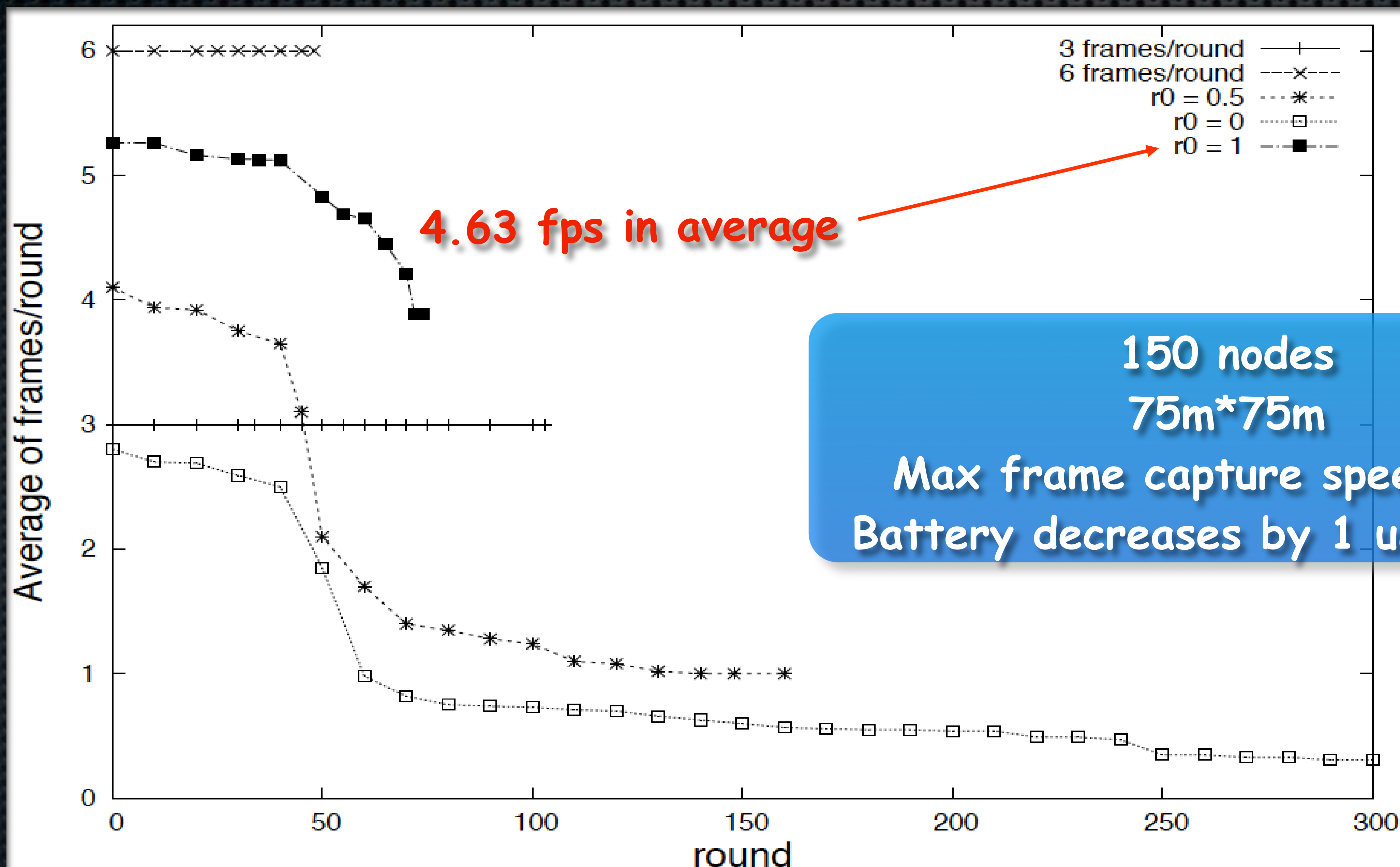


Average capture speed



150 nodes
75m*75m
Max frame capture speed=6fps
Battery decreases by 1 unit/frame

Average capture speed



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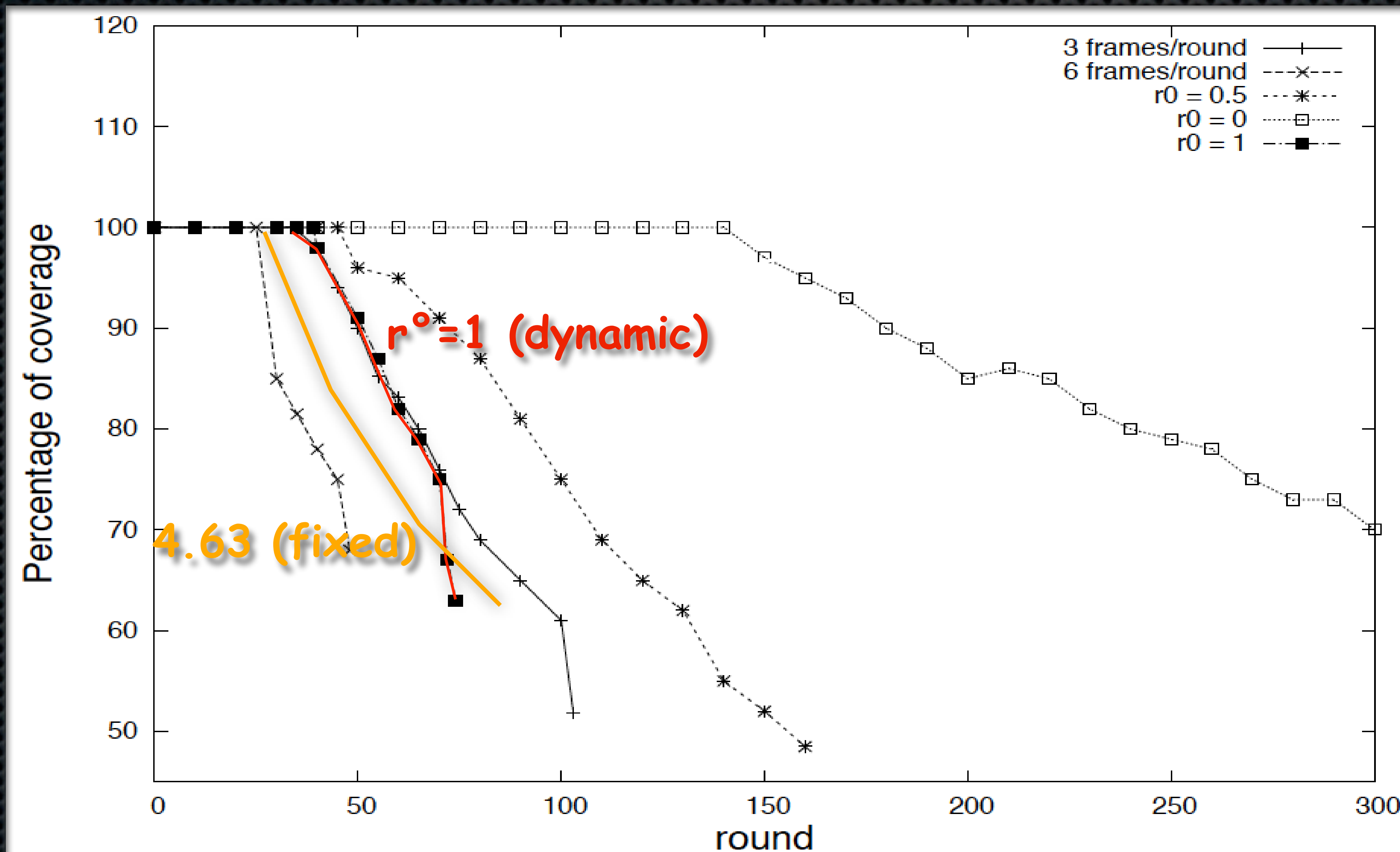
Fixed vs adaptive

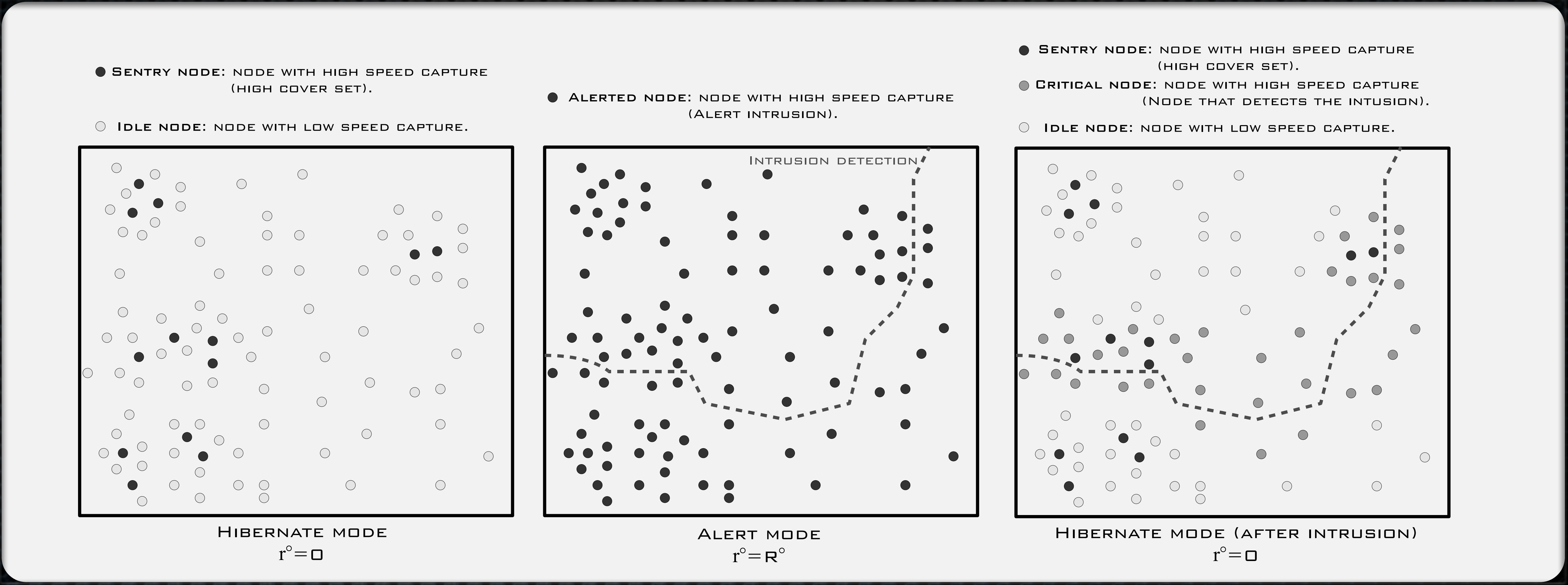


Conclusions

- Criticality model with adaptive scheduling of nodes
- Optimize the resource usage by dynamically adjusting the provided service level

Perspective

Extension for risk-based scheduling in intrusion detection systems



Thanks for your attention