Surveillance vidéo sur réseaux de capteurs sans-fils: ordonnancement adaptatif avec prise en compte de la criticité

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CFIP 2009

Mardi 13 octobre, 2009

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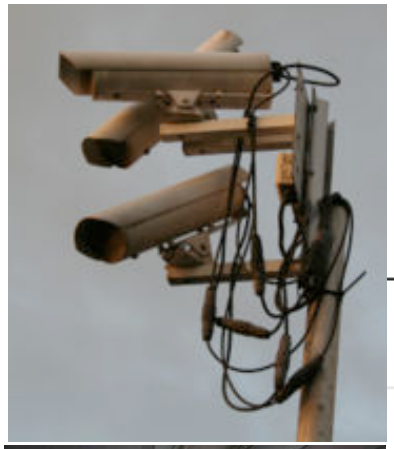
Université de Pau, France

TCAP project (2006-2009)

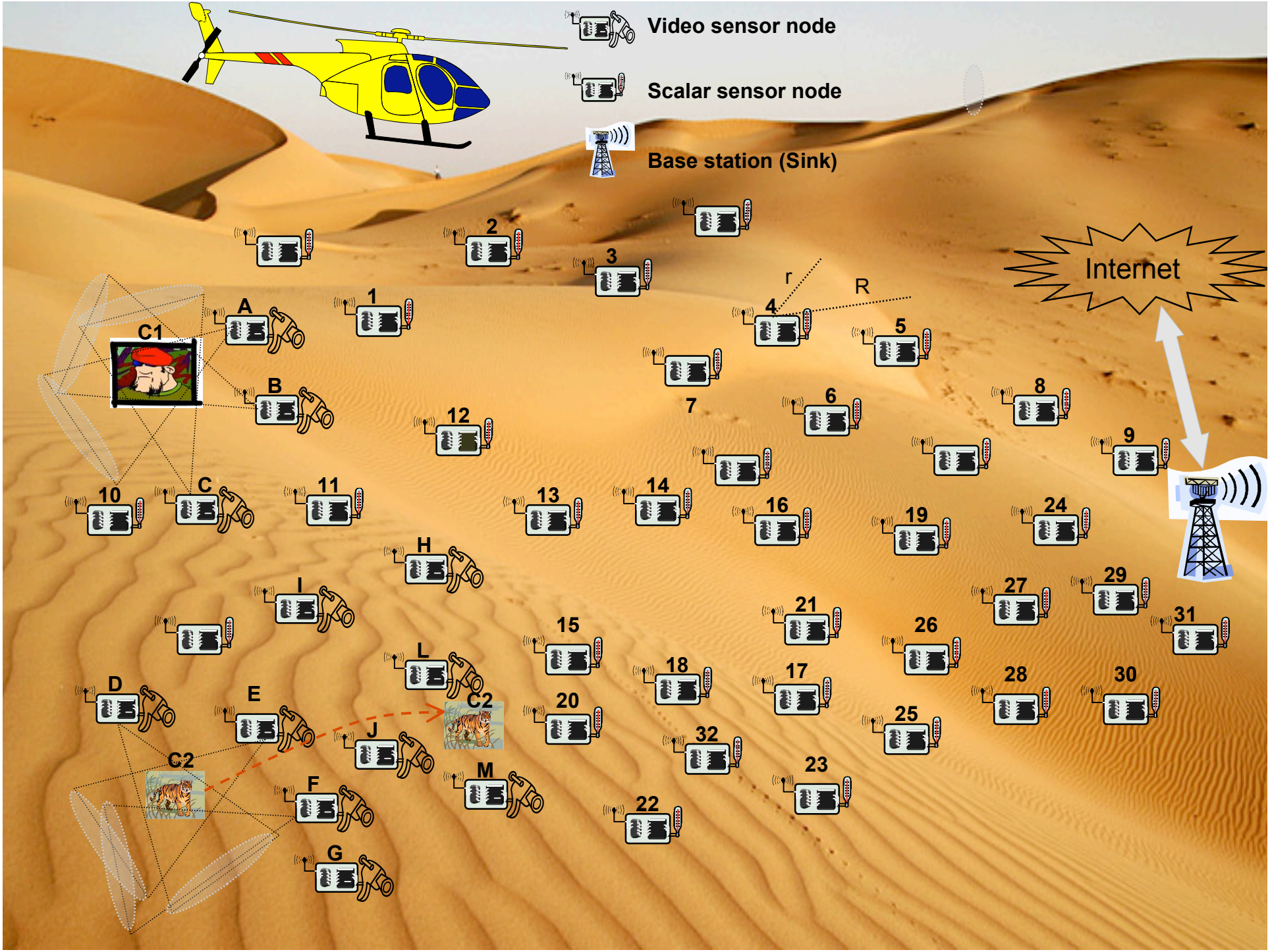
Agence Nationale de la Recherche
ANR

- « Video Flows Transport for Surveillance Application »
- LIUPPA
  - Software architecture for multimedia integration, supervision plateform, transport protocols & congestion control
- CRAN (Nancy)
  - Video coding techniques, multi-path routing, interference-free routing

Traditionnal surveillance infrastructure



Vitracom®
Advanced Videosensor Technologies


Video sensor node
Scalar sensor node
Base station (Sink)
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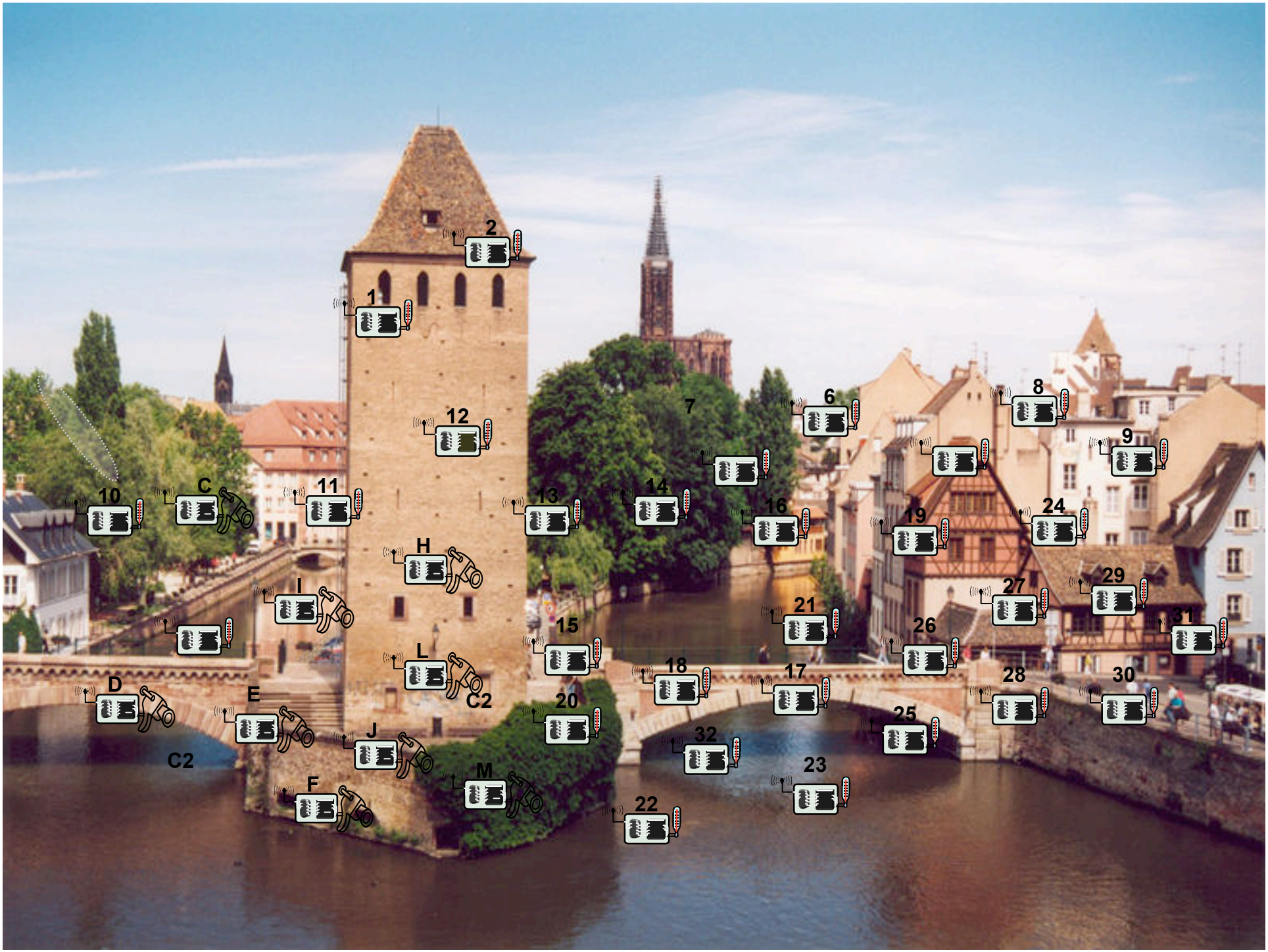
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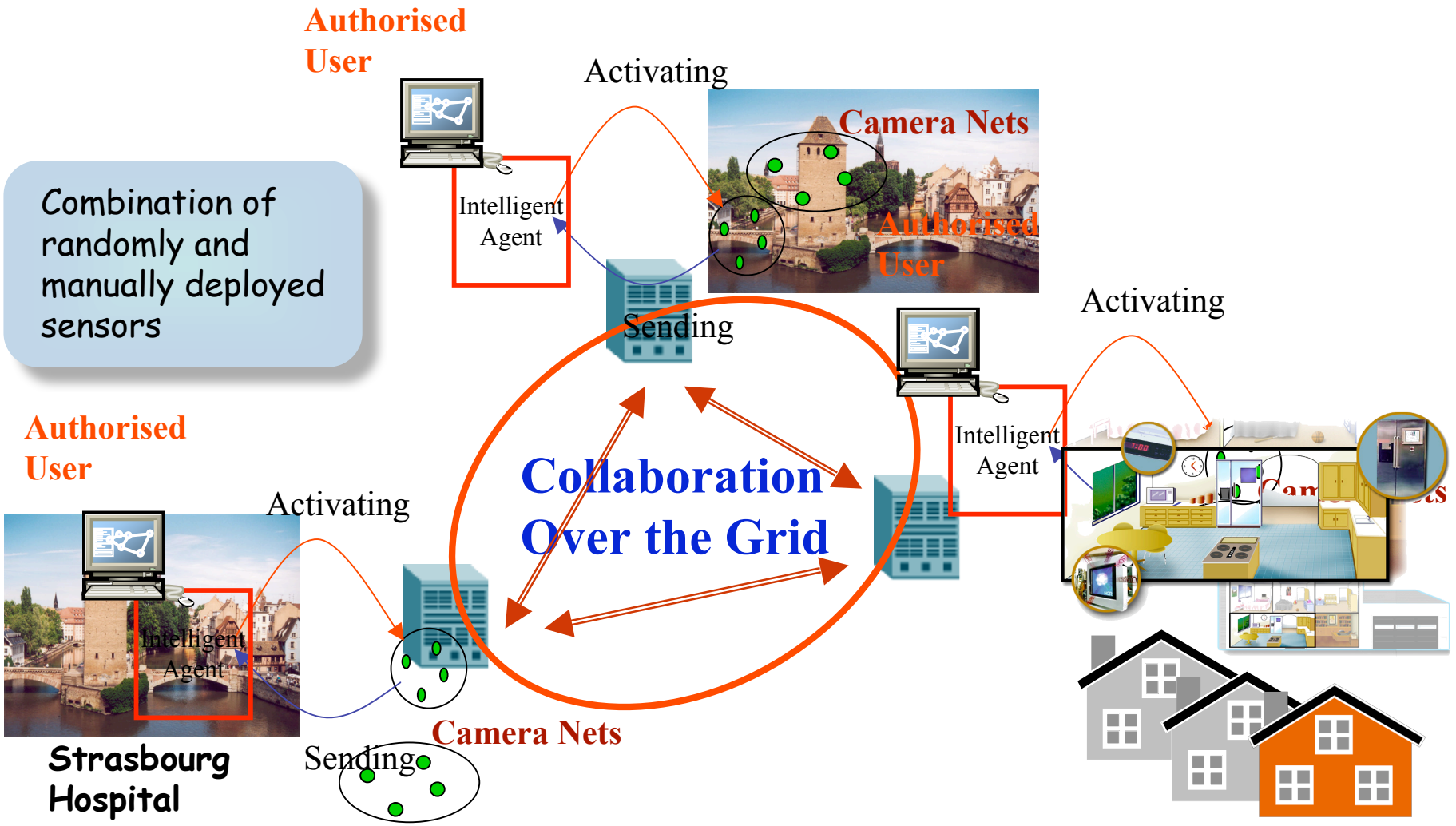
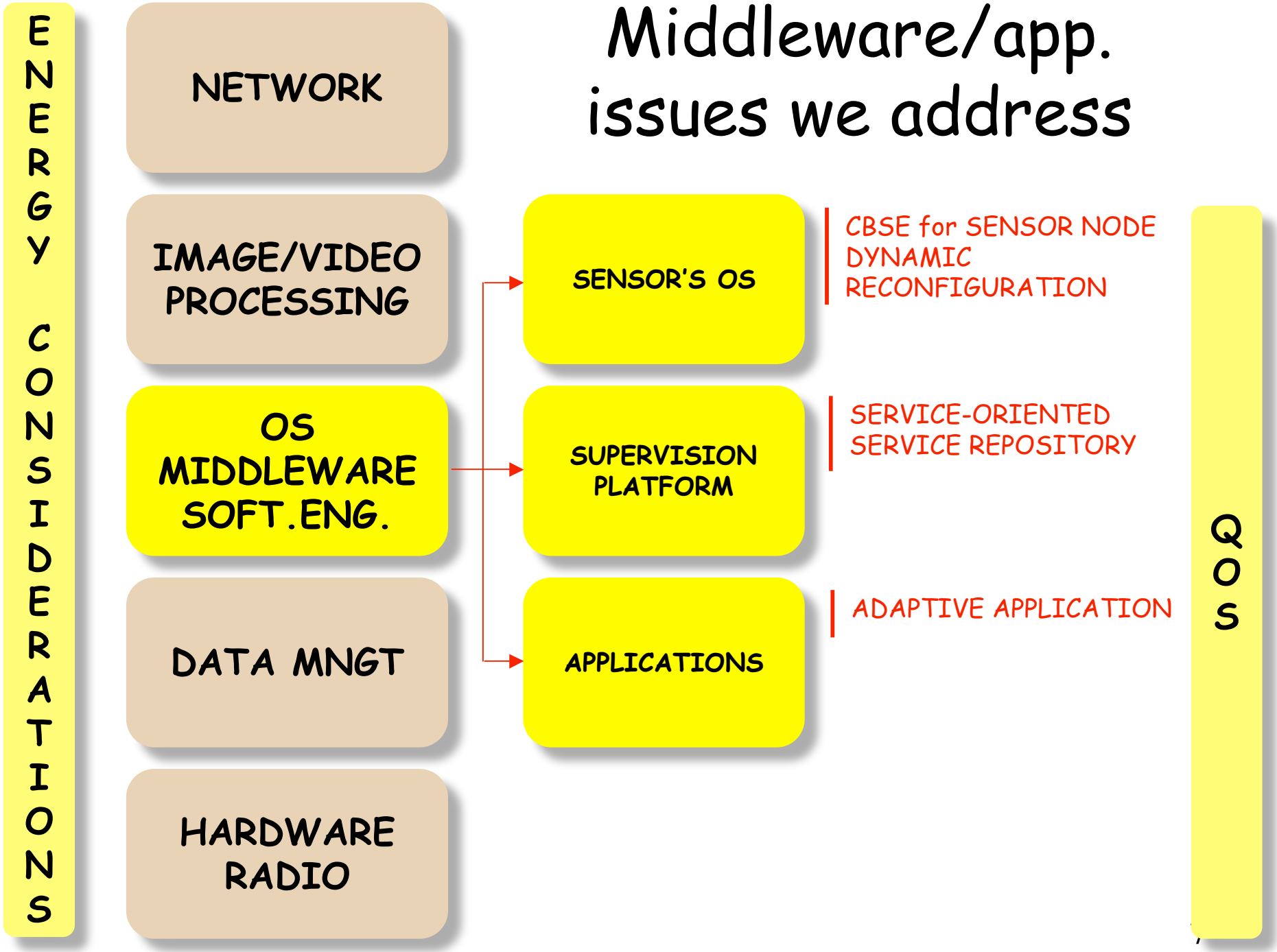
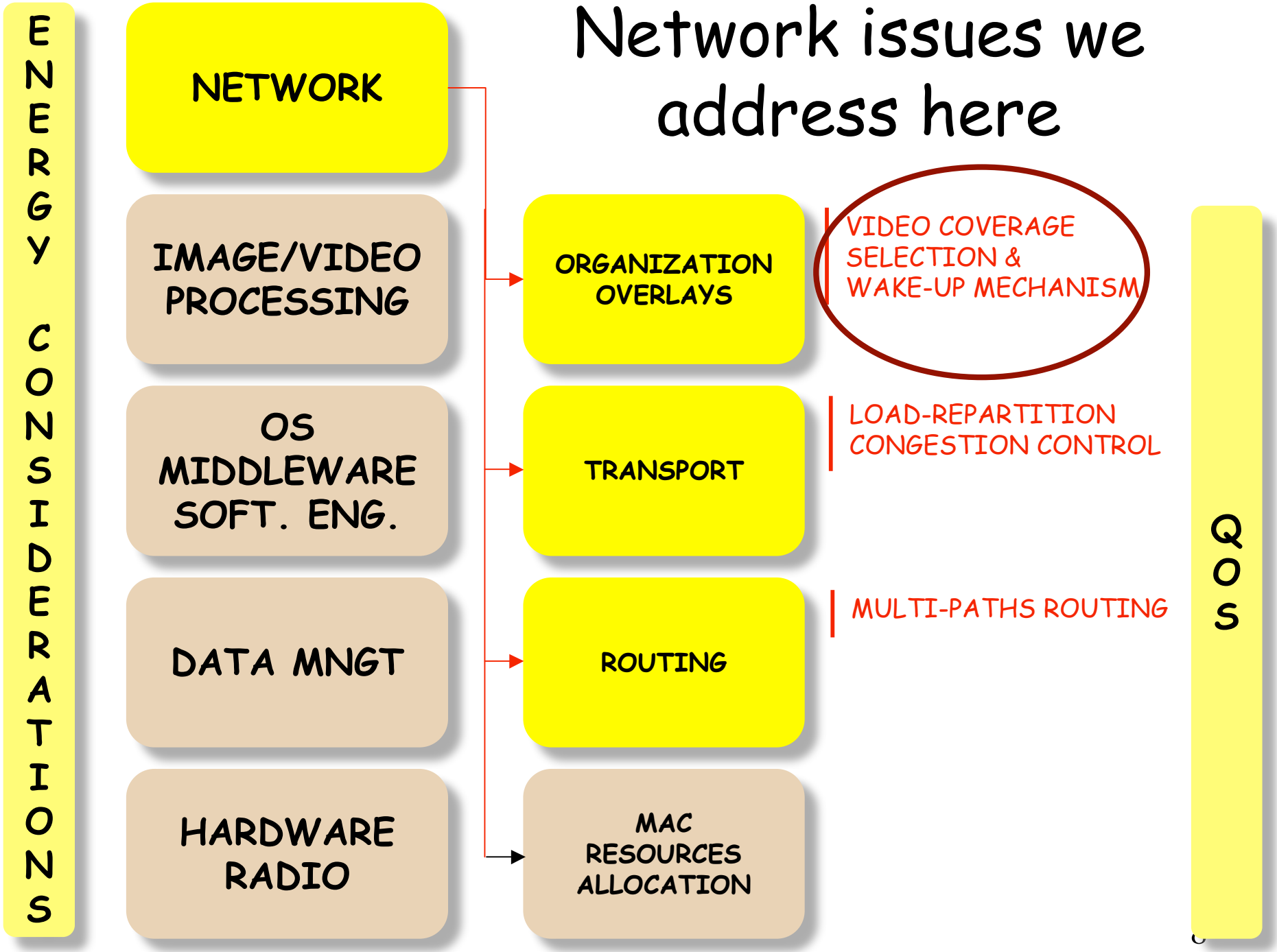
Towards large-scale pervasive environments



Middleware/app. issues we address

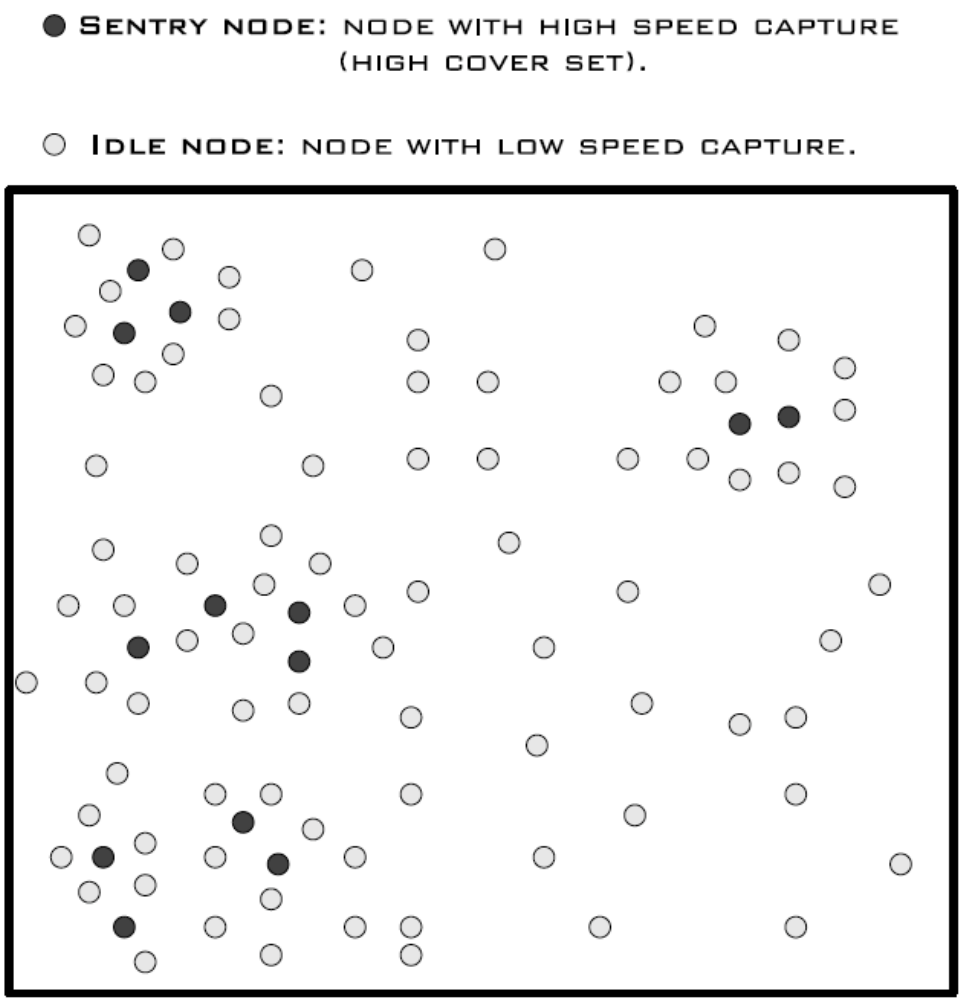


Network issues we address here



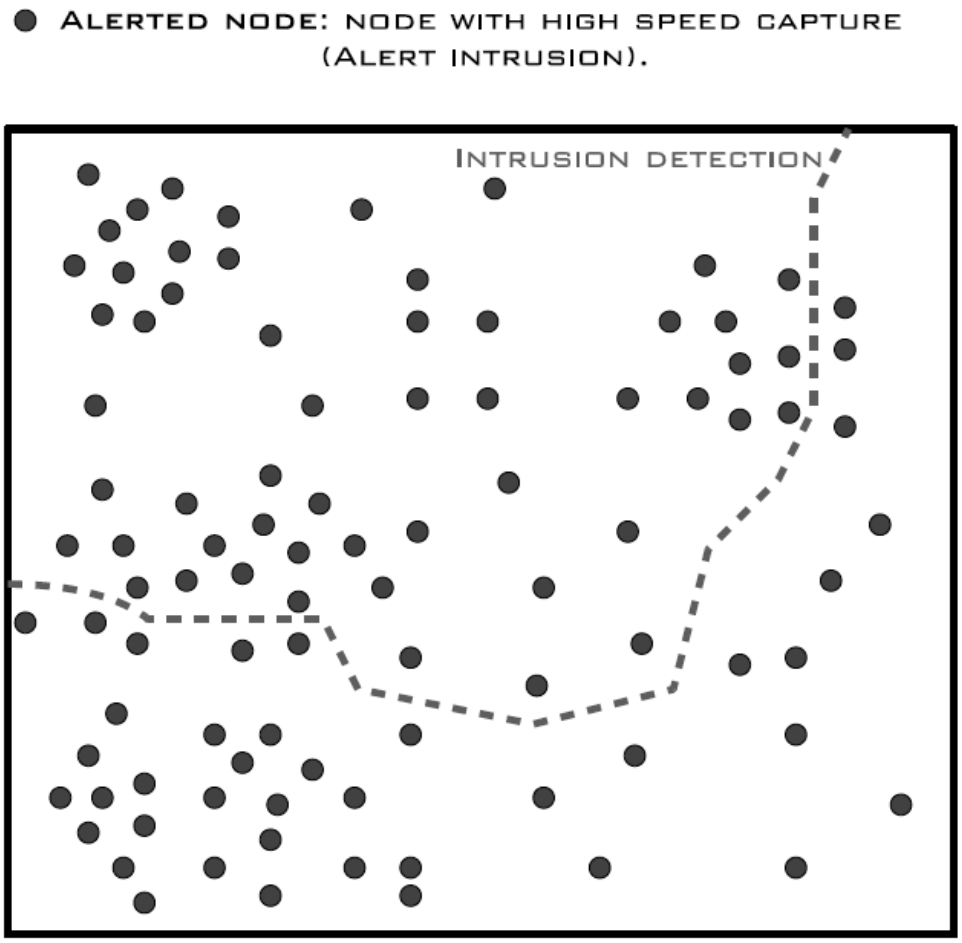
Surveillance scenario (1)

- Randomly deployed video sensors
- Not only barrier coverage but general intrusion detection
- Most of the time, network in so-called *hibernate mode*
- Most of active sensor nodes in *idle mode* with low capture speed
- Sentry nodes with higher capture speed to quickly detect intrusions



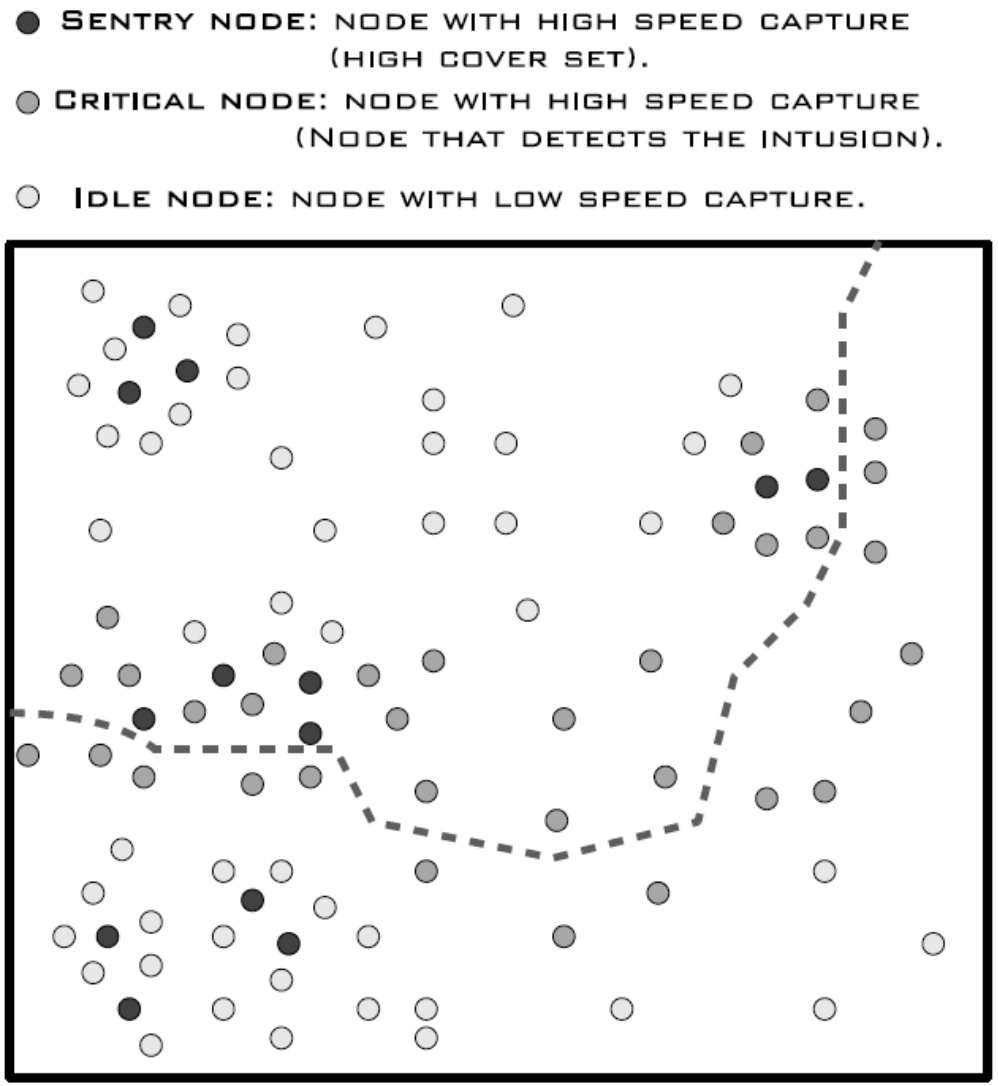
Surveillance scenario (2)

- Nodes detecting intrusion must alert the rest of the network
- 1-hop to k-hop alert
- Network in so-called *alerted mode*
- Capture speed must be increased
- Ressources should be focused on making tracking of intruders easier



Surveillance scenario (3)

- Network should go back to *hibernate mode*
- Nodes on the intrusion path must keep a high capture speed
- Sentry nodes with higher capture speed to quickly detect intrusions



Application's criticality

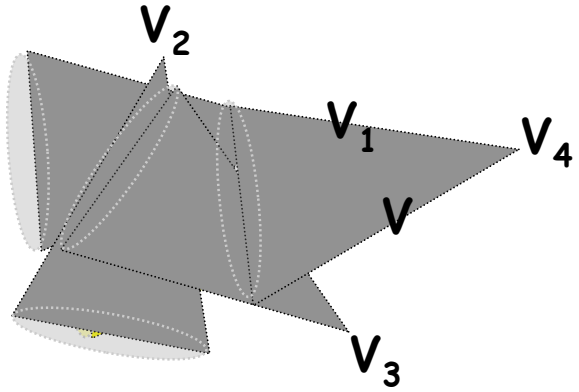
- All surveillance applications may not have the same criticality level, $r^0 \in [0,1]$
  - Environmental, security, healthcare,…
- Capture speed should decrease when r^0 decreases
- Sensor nodes could be initialized with a given r^0 prior to deployment

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 redundancy for node v
- V's capture speed can increase when as V has more nodes covering its own FoV - cover set

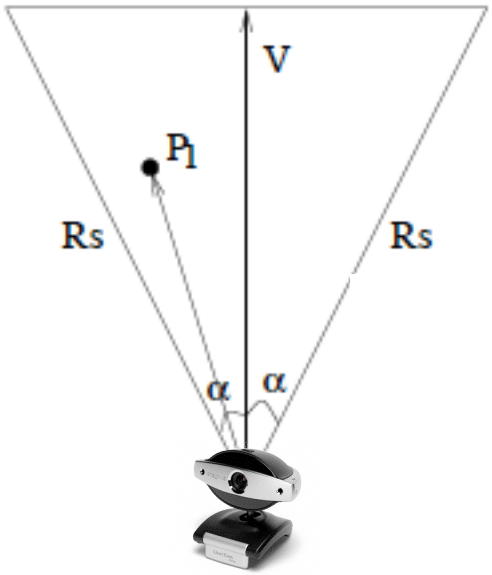
Node's cover set

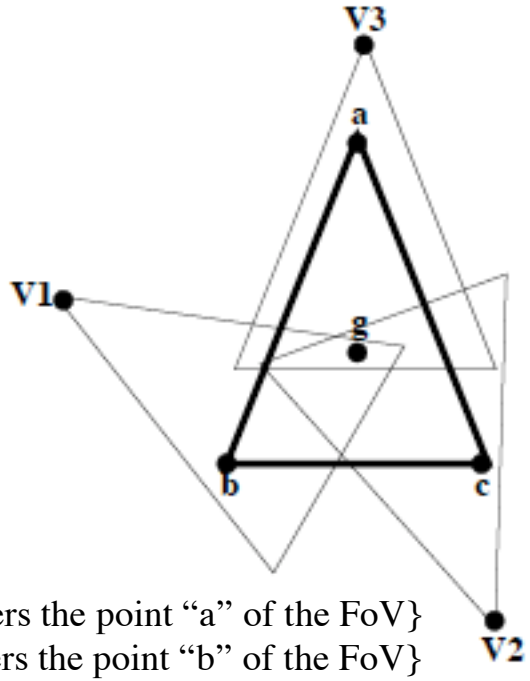
- Each node v has a Field of View, FoV_v
- $Co_i(v)$ = set of nodes v' such as $\bigcup_{v' \in Coi(v)} FoV_{v'}$ covers FoV_v
- $Co(v)$= set of $Co_i(v)$



$Co(v)=\{V_1,V_2,V_3,V_4\}$

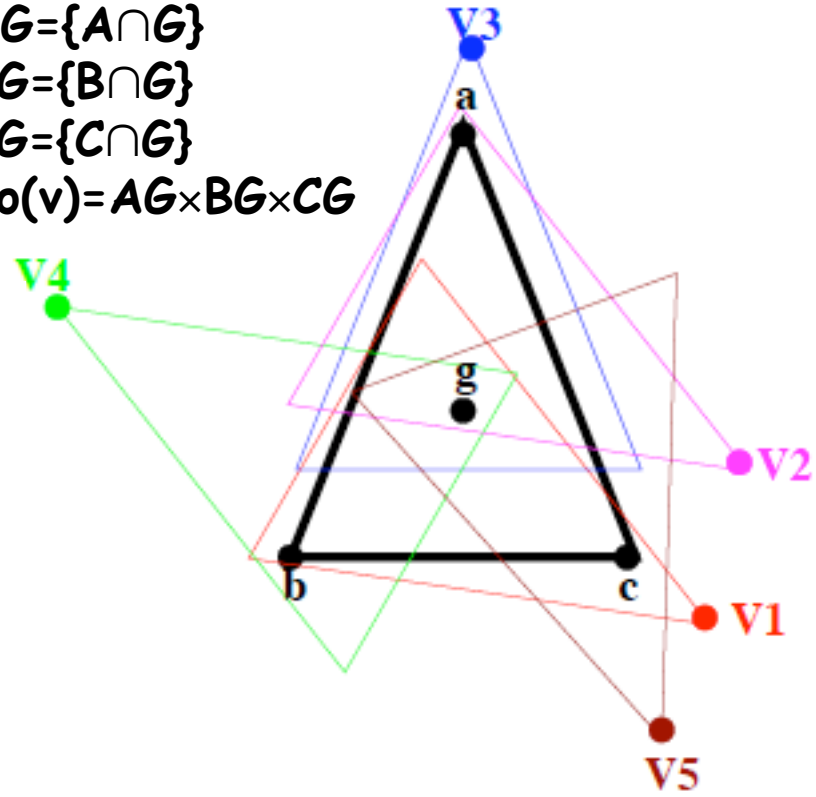
Finding v's cover set





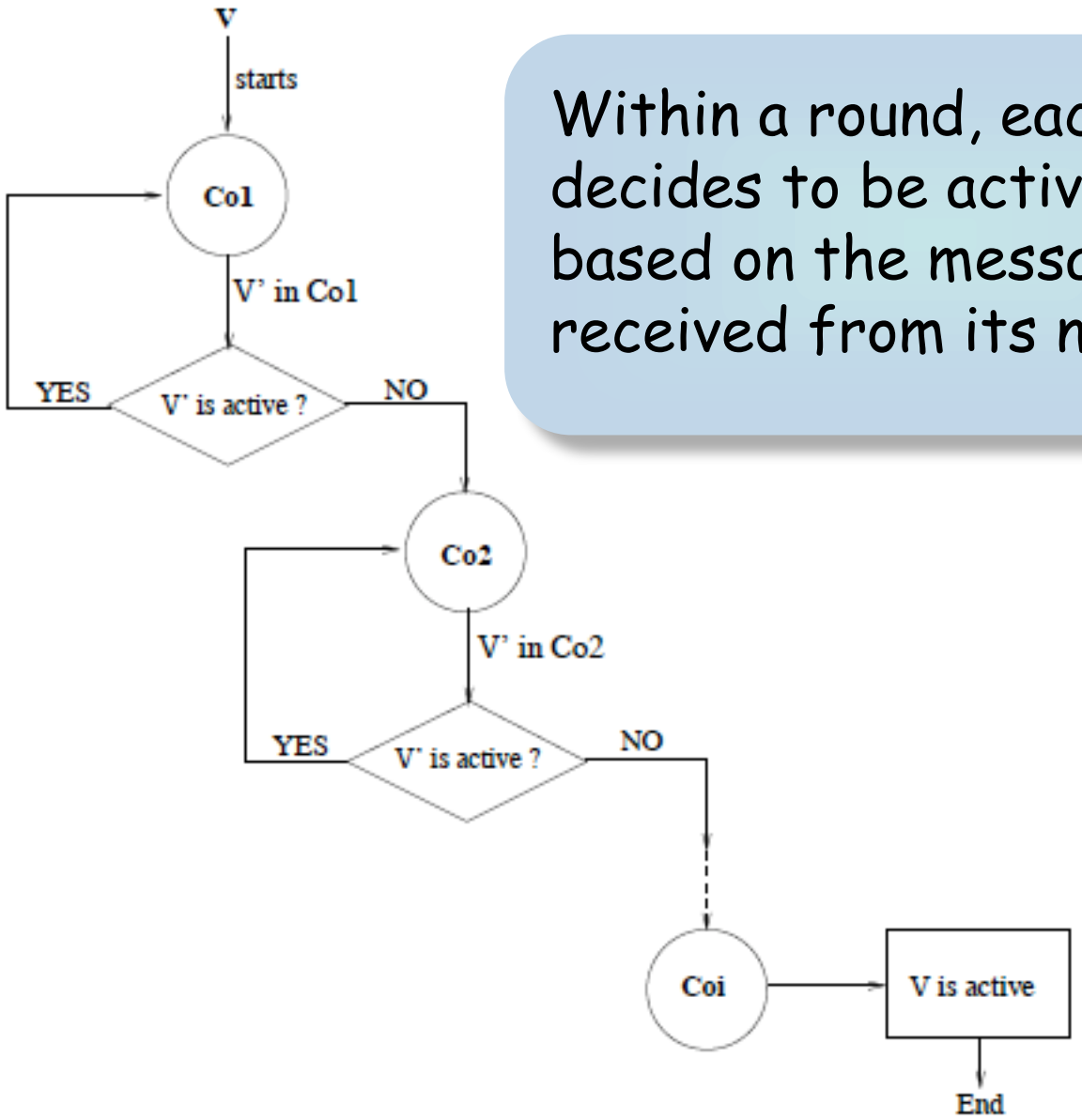
A = {v ∈ N(V) : v covers the point "a" of the FoV}
B = {v ∈ N(V) : v covers the point "b" of the FoV}
C = {v ∈ N(V) : v covers the point "c" of the FoV}
G = {v ∈ N(V) : v covers the point "g" of the FoV}

AG={A∩G}
BG={B∩G}
CG={C∩G}
Co(v)=AG×BG×CG



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

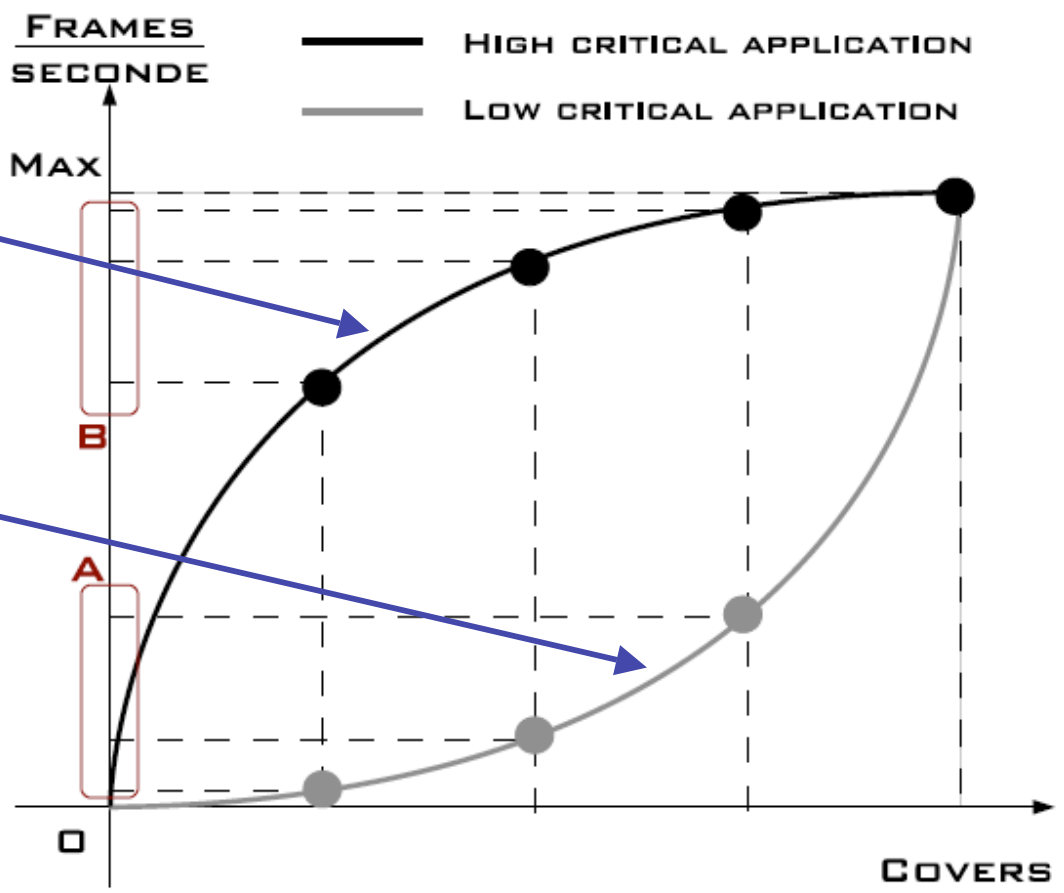
Active node selection



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

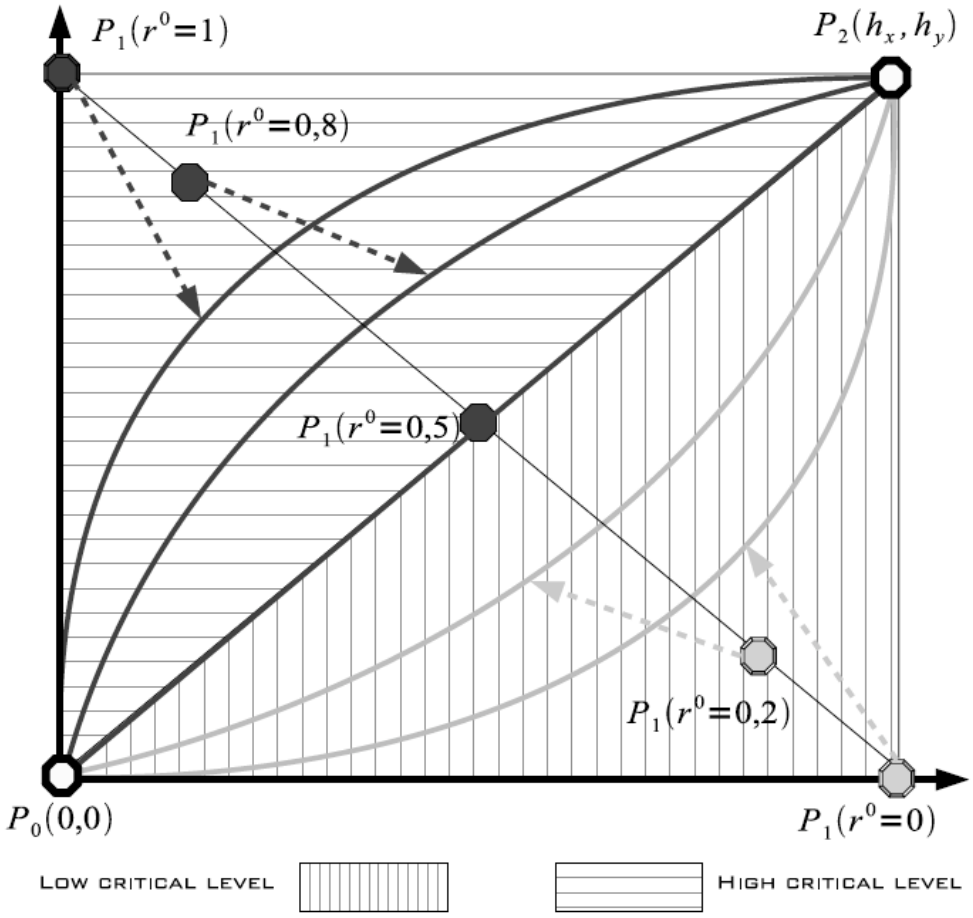
Criticality model (1)

- 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
- Concave and convex shapes automatically define sentry nodes in the network



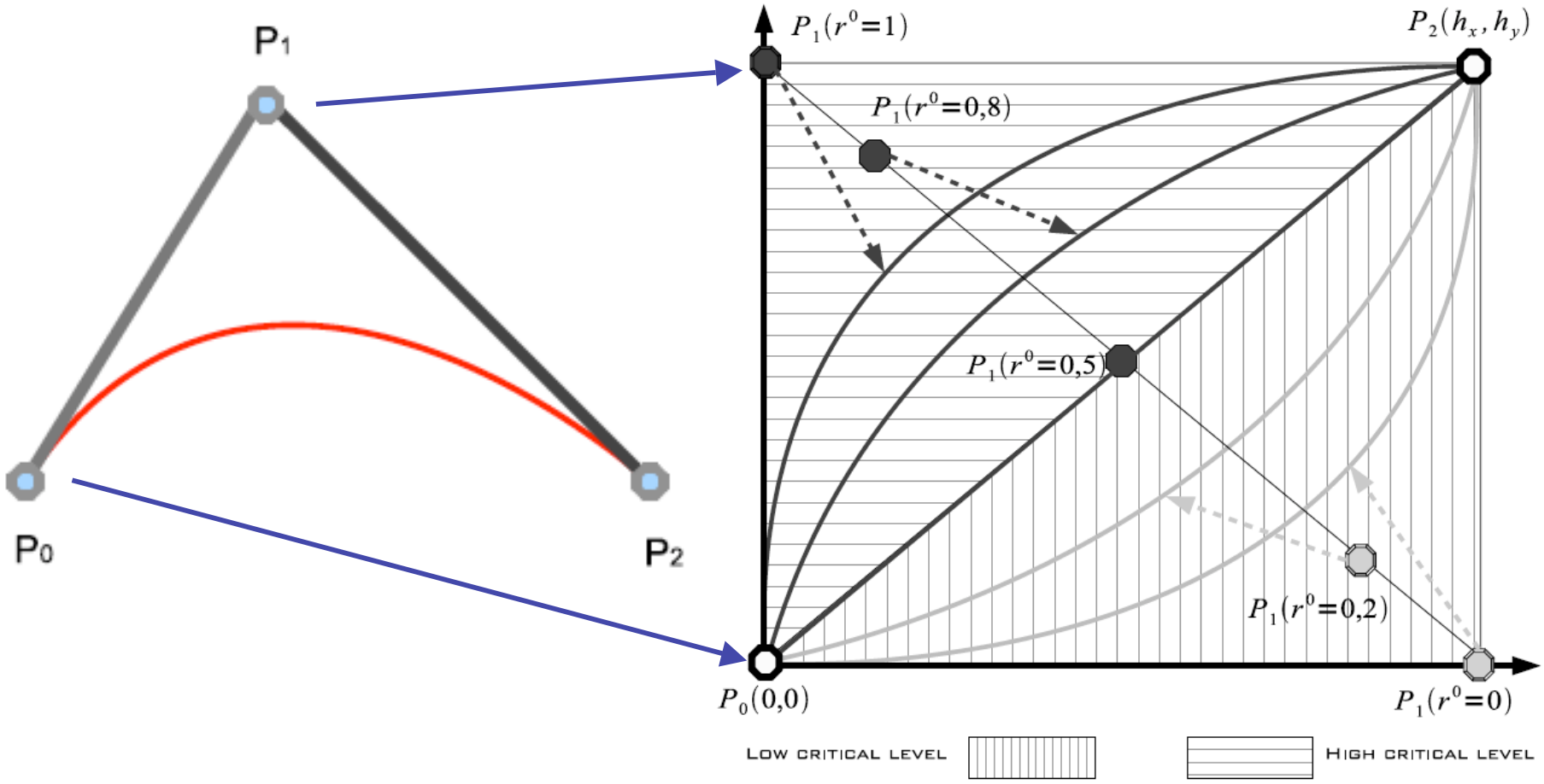
Criticality model (2)

- r^0 can vary in [0,1]
- BehaVior functions (BV) defines the capture speed according to r^0
- $R^0 < 0.5$
  - Concave shape BV
- $R^0 > 0.5$
  - 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

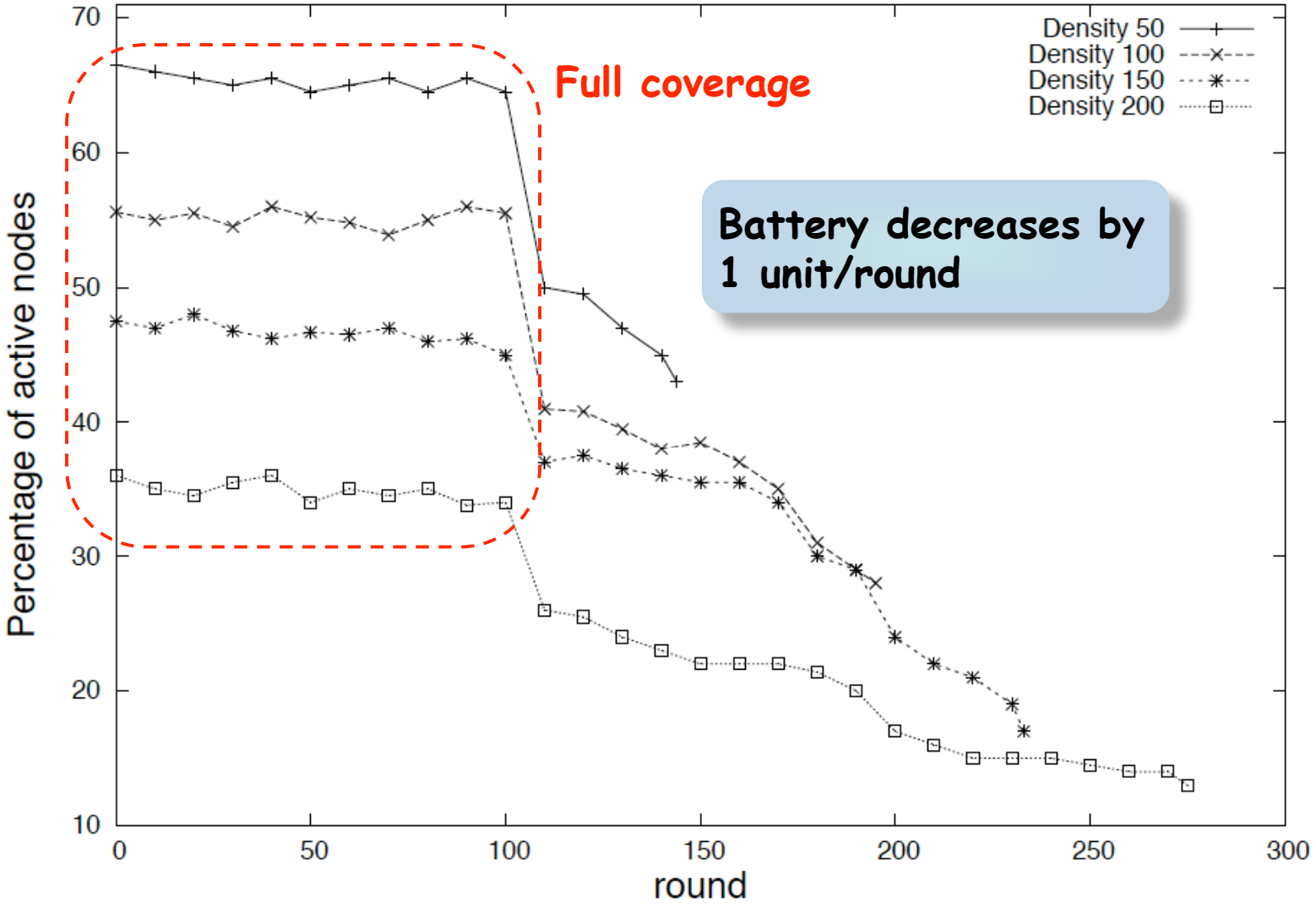
- Maximum capture speed is 6fps
- Nodes with size of cover set greater than 6 capture at the maximum speed

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

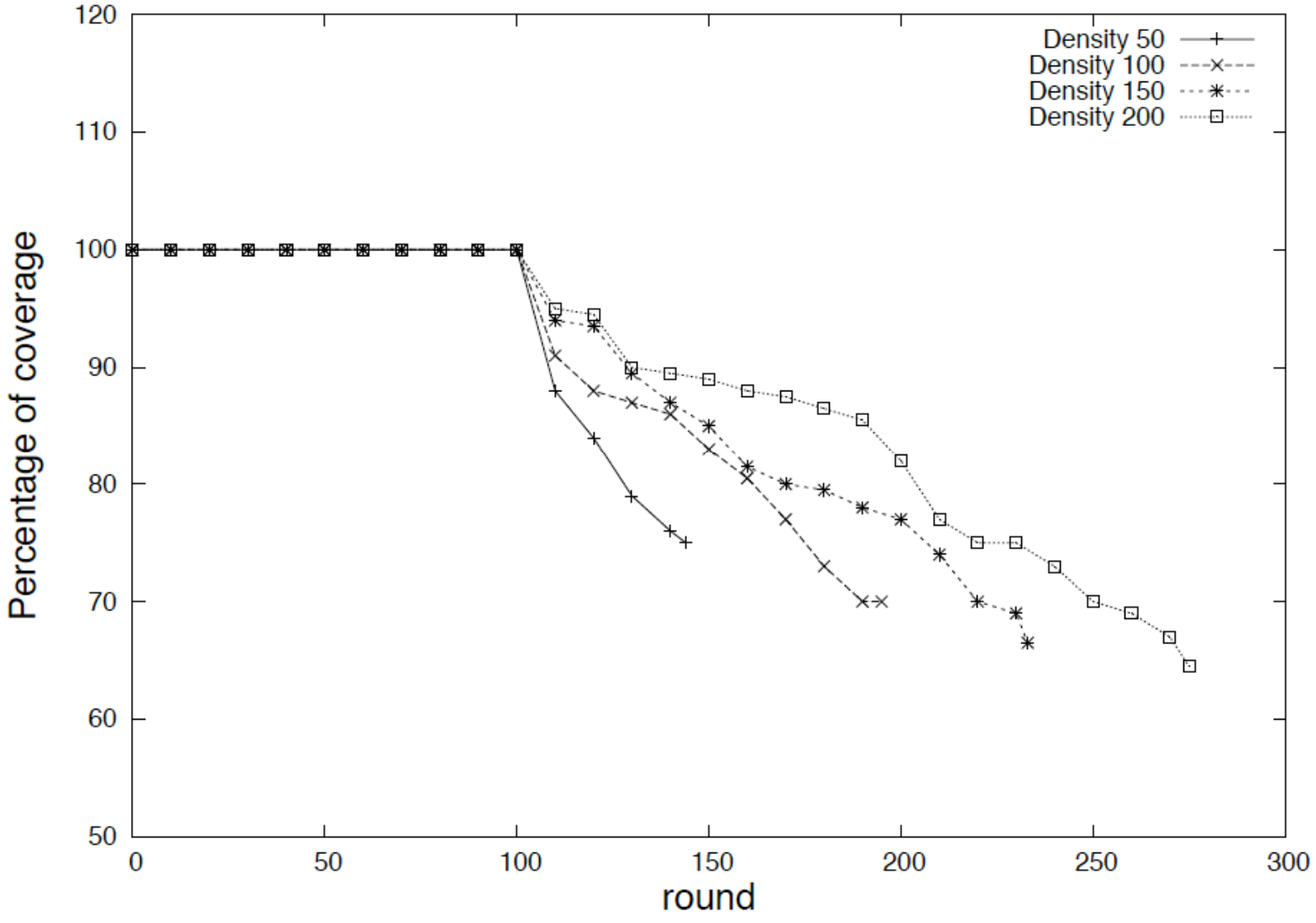
Simulation settings

- 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

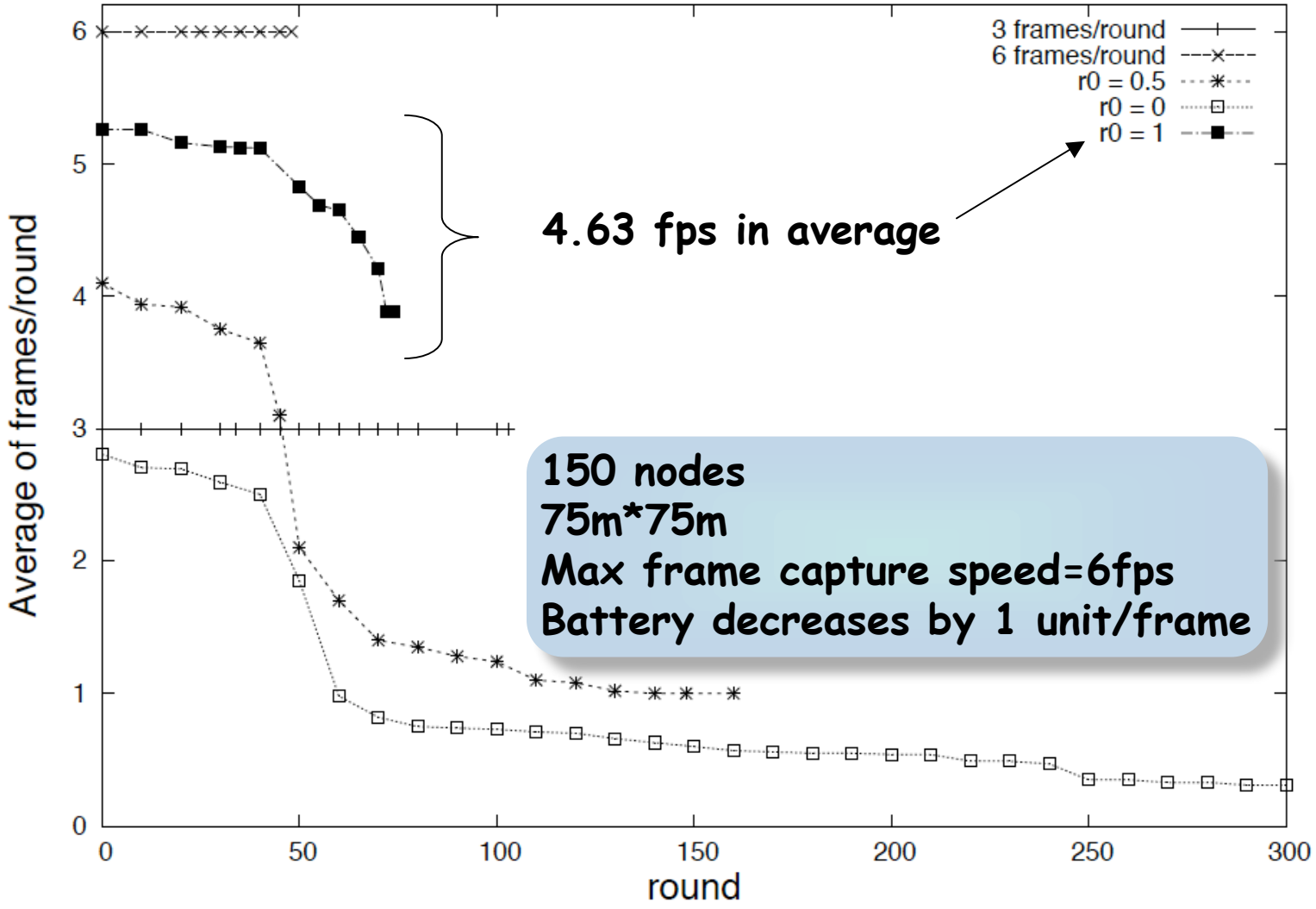
Percentage of active nodes



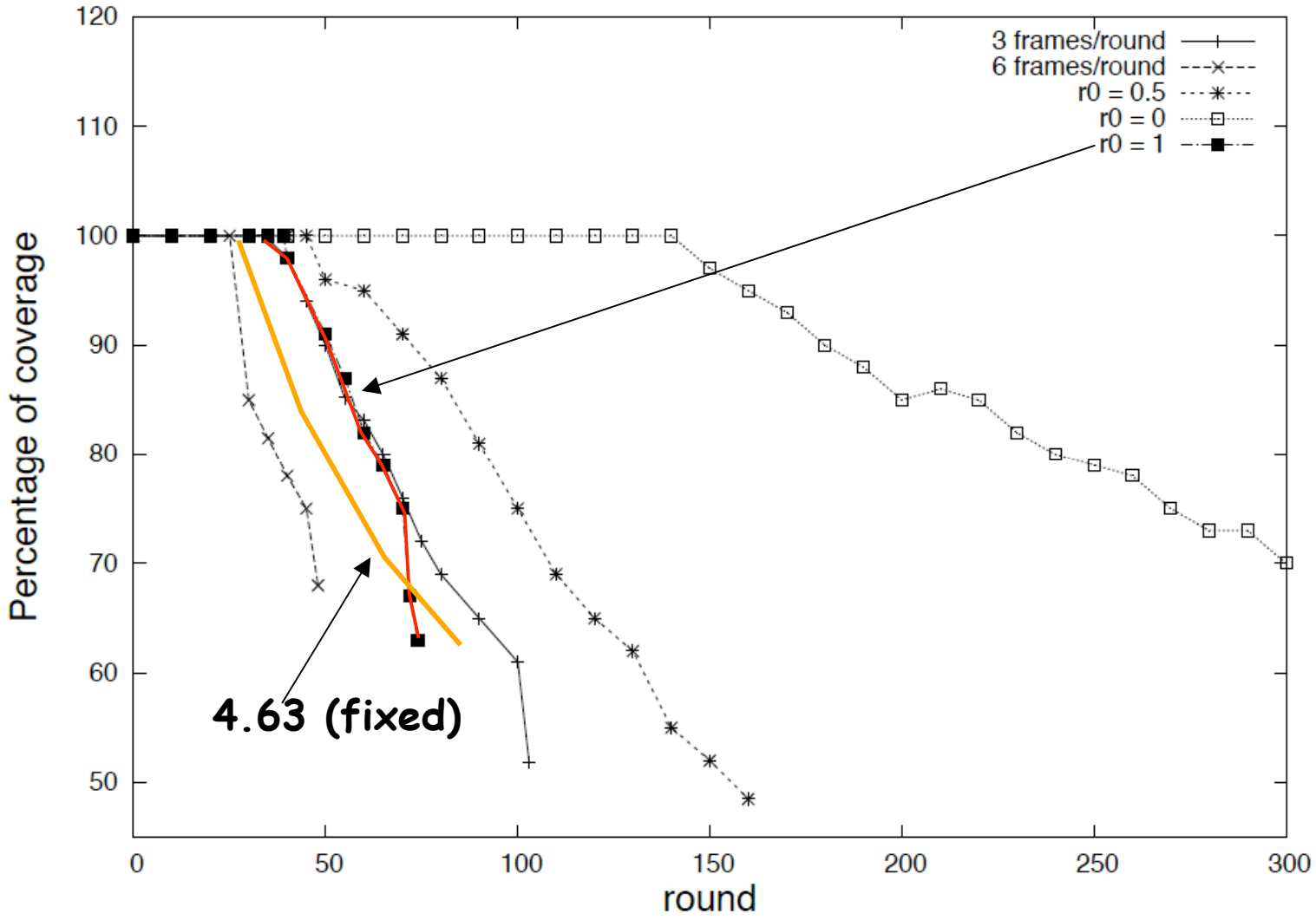
Percentage of coverage



Average capture speed



Fixed vs adaptive



Conclusions & future works

- Criticality model with adaptive scheduling of nodes
- Optimize the resource usage by dynamically adjusting the provided service level
- Extension for risk-based scheduling in intrusion detection systems