A Congestion Control Framework for Handling Video Surveillance Traffics on WSN

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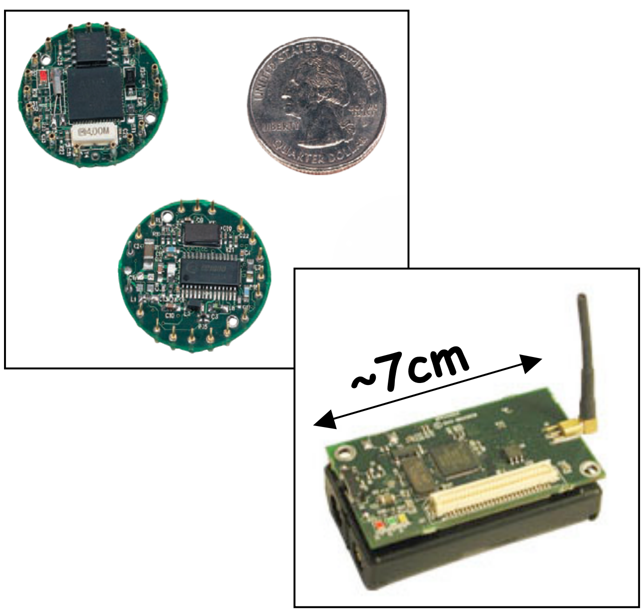
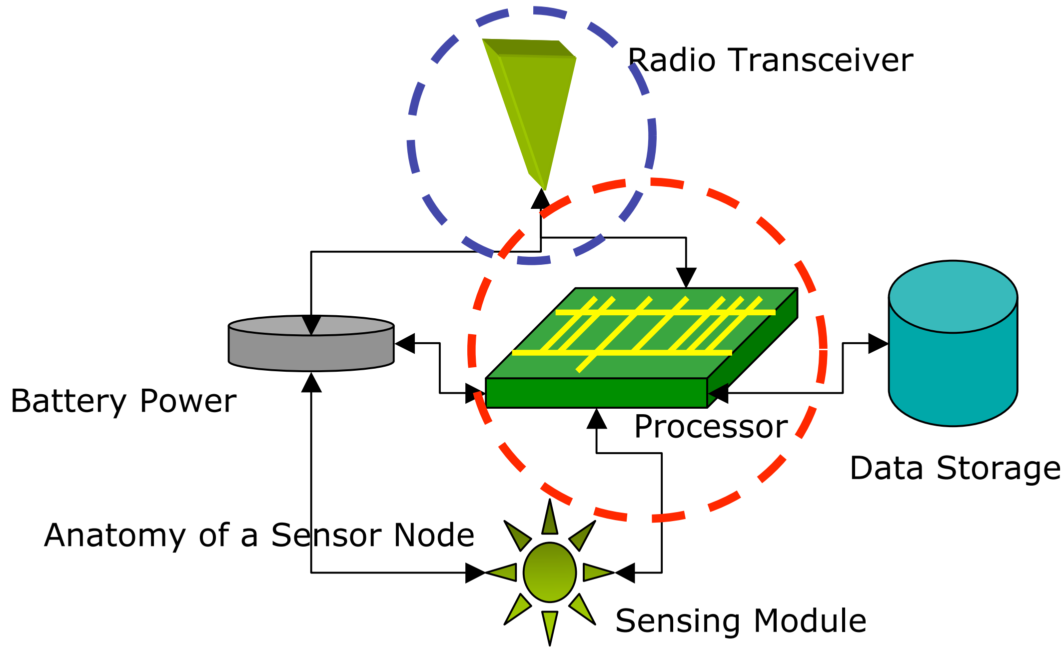
Wireless autonomous sensor

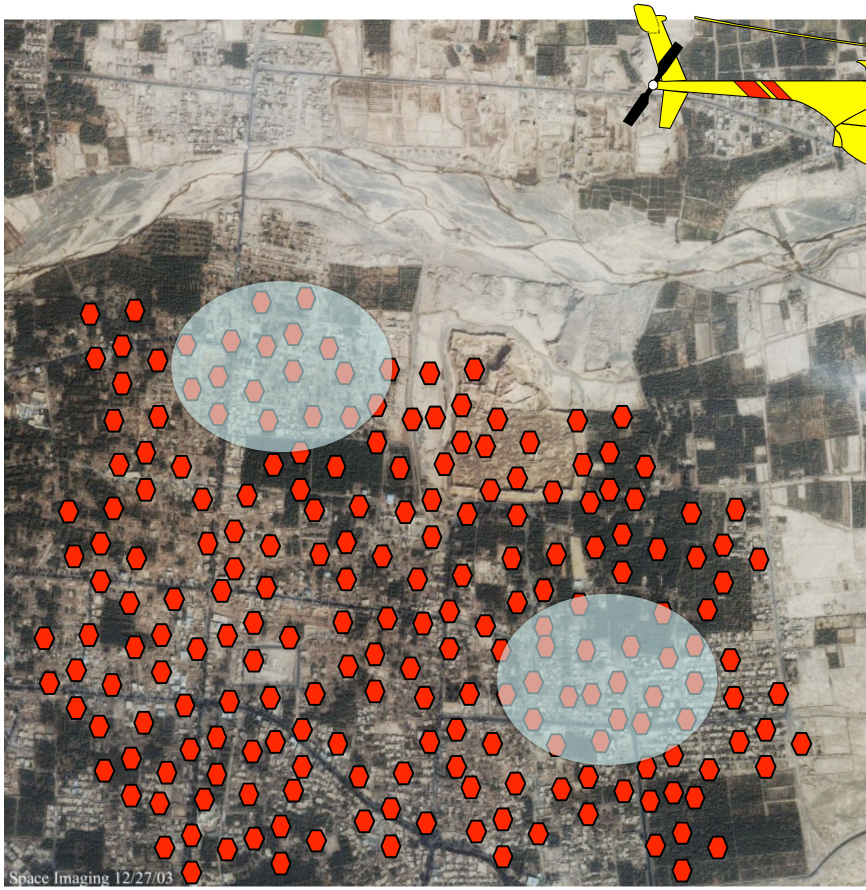
- In general: low cost, low power (the battery may not be replaceable), small size, prone to failure, possibly disposable
- Role: sensing, **data processing**, **communication**





New sensor applications

monitoring: disaster relief, surveillance



Real-time organization and optimization of rescue in large scale disasters

Rapid deployment of fire detection systems in high-risk places

New sensor applications
environmental

Environmental monitoring
- air
- water

Cell-phones with embedded CO sensor?

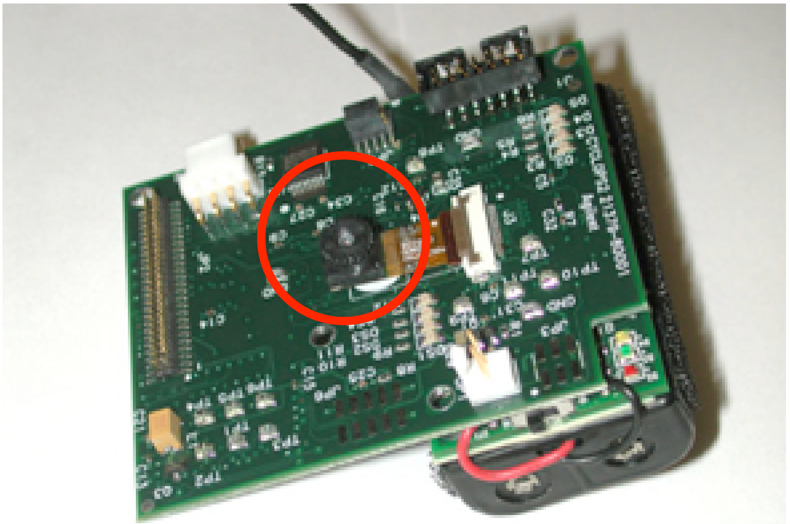
- most ubiquitous device (millions)
- not deployment cost
- high replacement rate
- no energy constraints
- see SocialCom-09/SCMPS-09

TCAP project (2006-2009)

Agence Nationale de la Recherche ANR

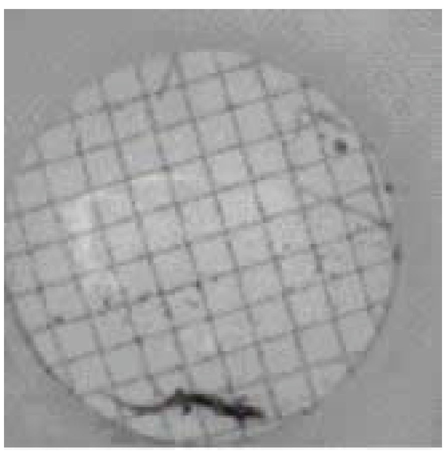
- « Video Flows Transport for Surveillance Application »
- LIUPPA
  - Software architecture for multimedia integration, supervision plateform, transport protocols & congestion control
- CRAN (Nancy)
  - Video coding techniques, multi-path routing, interference-free routing

Wireless Video Sensors

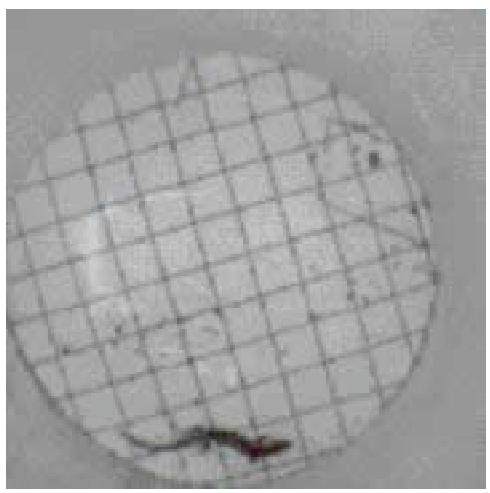


Cyclops video board on Mica motes

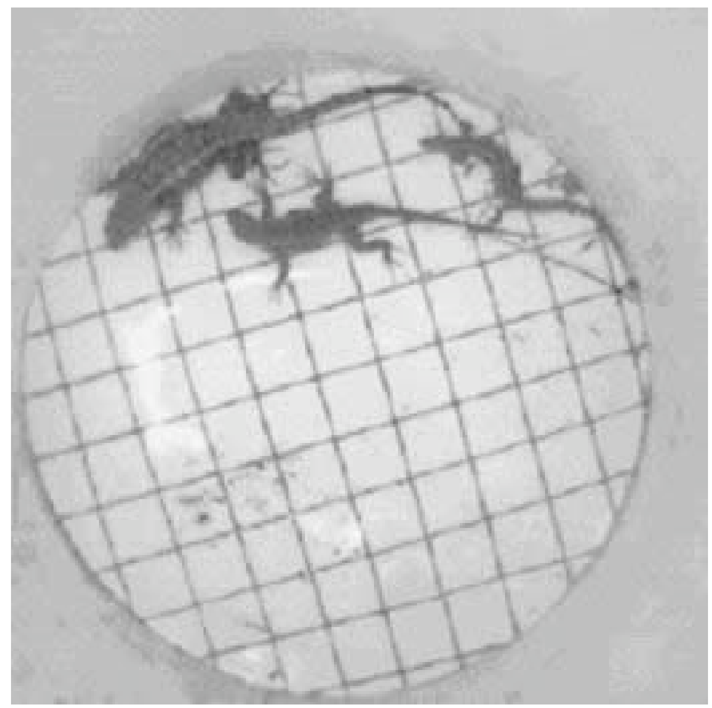
115200 bits, 2 bits/pixels



128x128

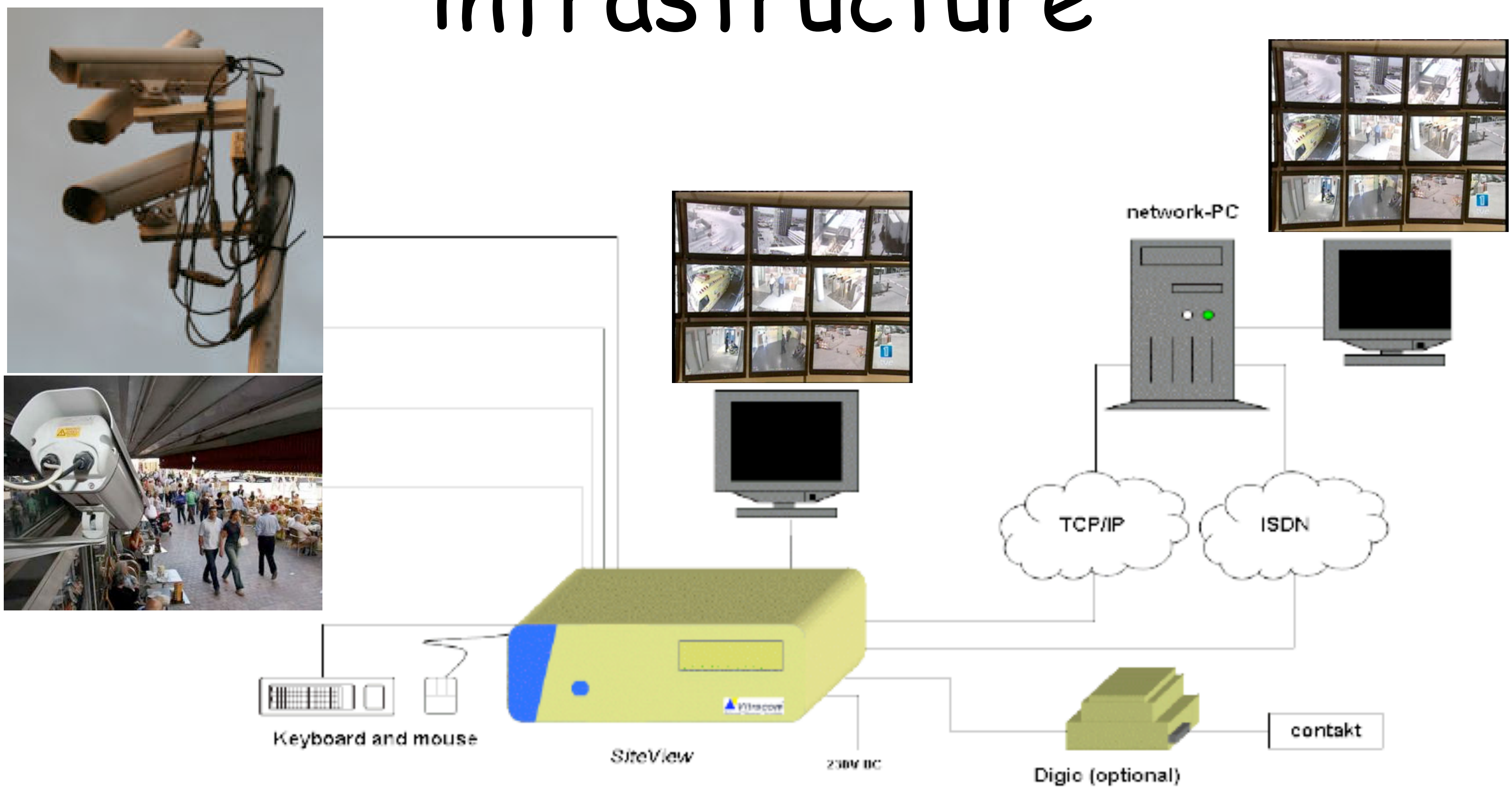


140x140

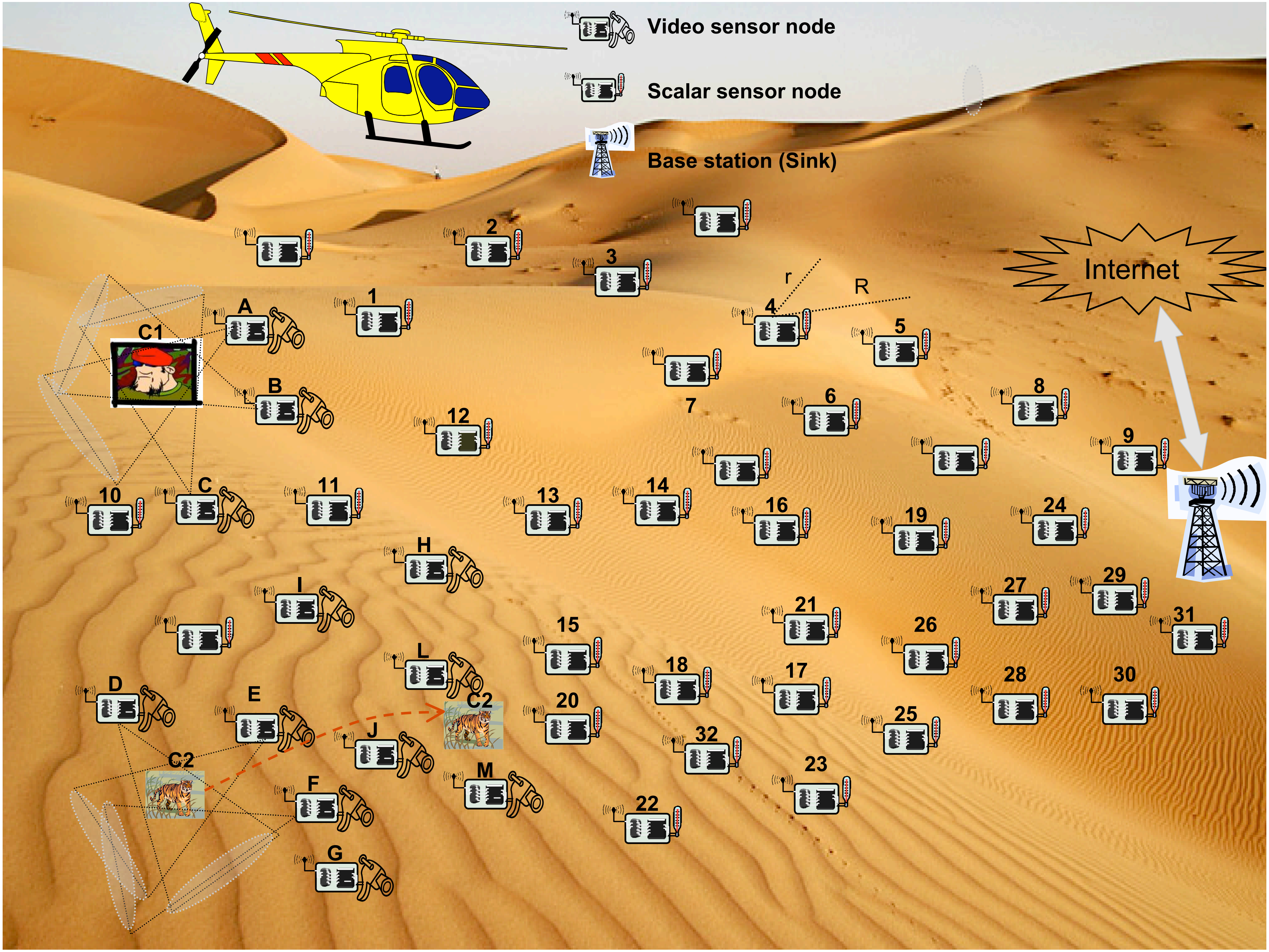


240x240

Traditionnal surveillance infrastructure



Vitracom®
Advanced Videosensor Technologies


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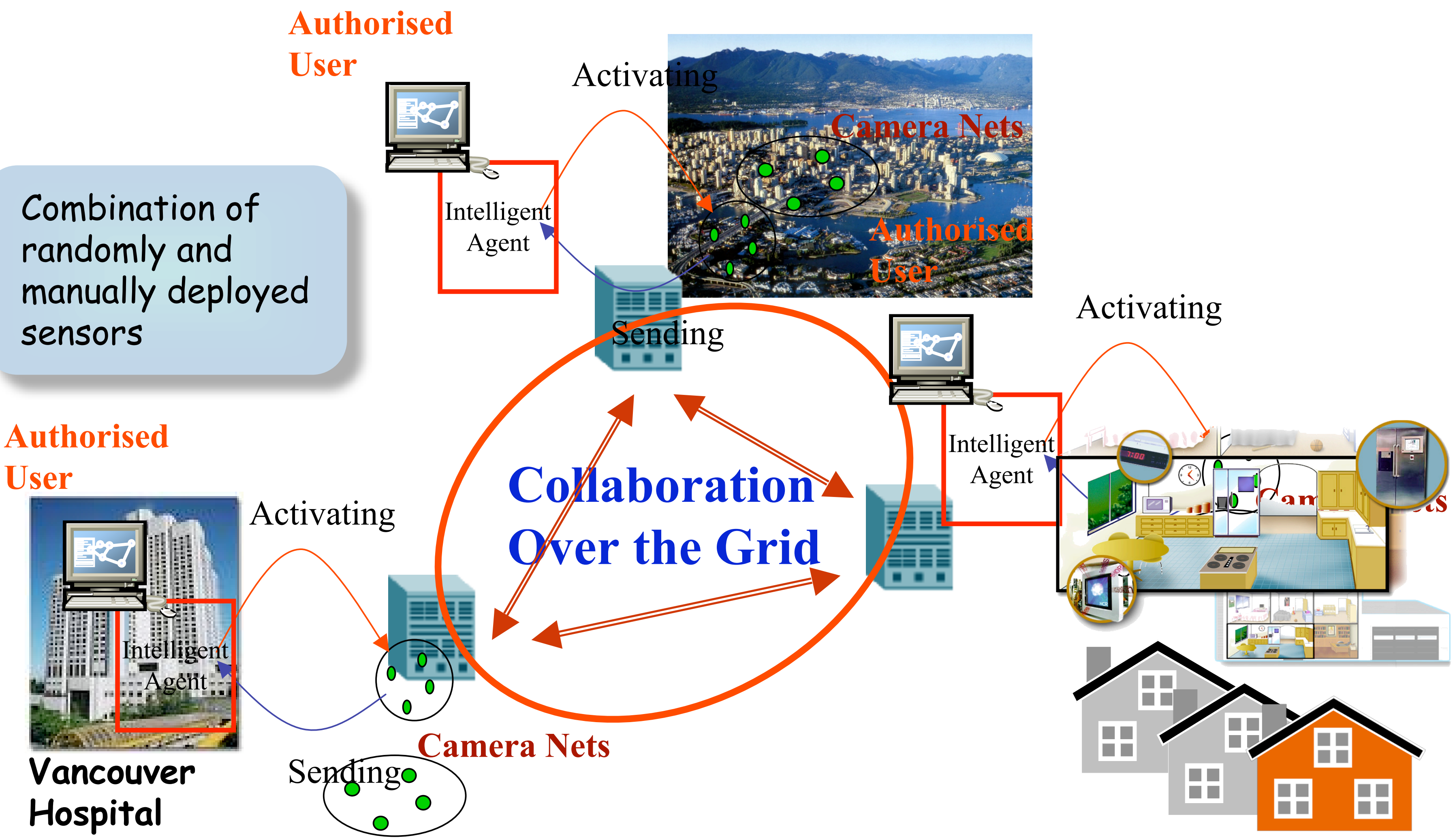
Towards large-scale pervasive environments

Combination of randomly and manually deployed sensors

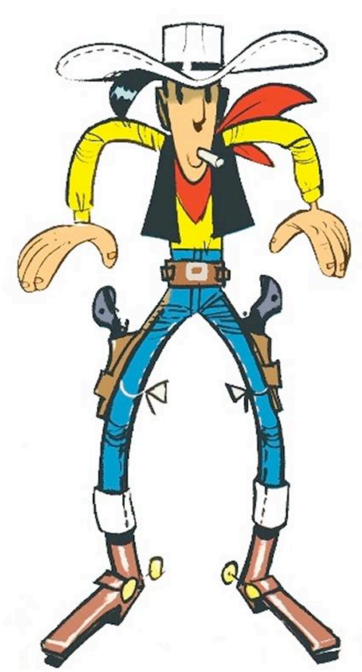


Challenges

- Wireless Scalar Sensor Networks
  - Small size of events (°C, pressure,...)
  - Usually no mobility
  - Data fusion, localization, routing, congestion control
- Wireless Video Sensor Networks
  - Video needs much higher data rate
  - Cheap mobility with camera rotation
- WVSN for Surveillance
  - What's new?
  - Where are the challenges?

Surveillance applications (1)

- Lesson 1: don't miss important events



What is captured

Whole understanding of the scene is wrong!!!

Surveillance applications (2)

- Lesson 2: high-quality not necessarily good

333x358 16M colors, no light

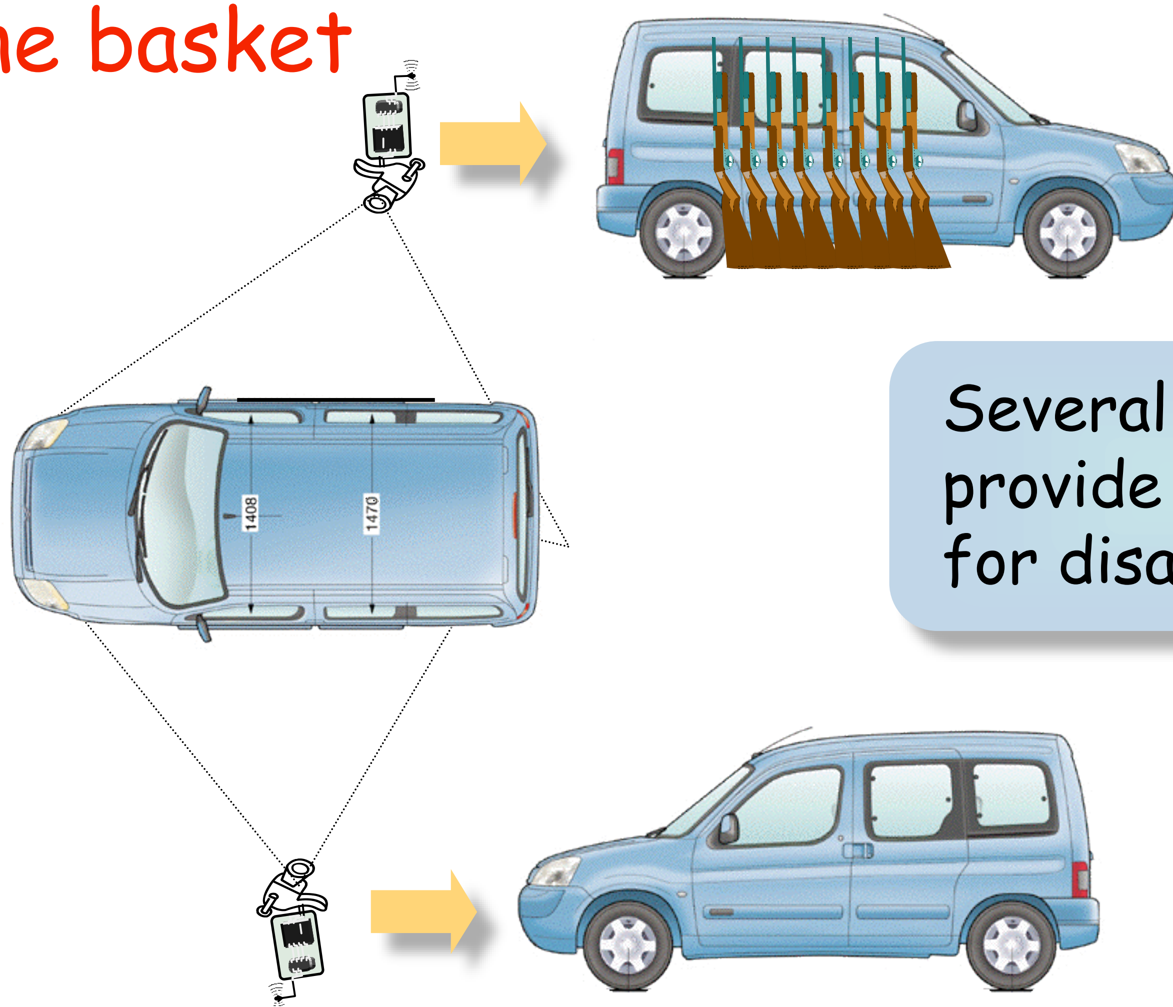
167x180 16 colors, light

Keep in mind the goal of the application!

167x180 BW (2 colors), light

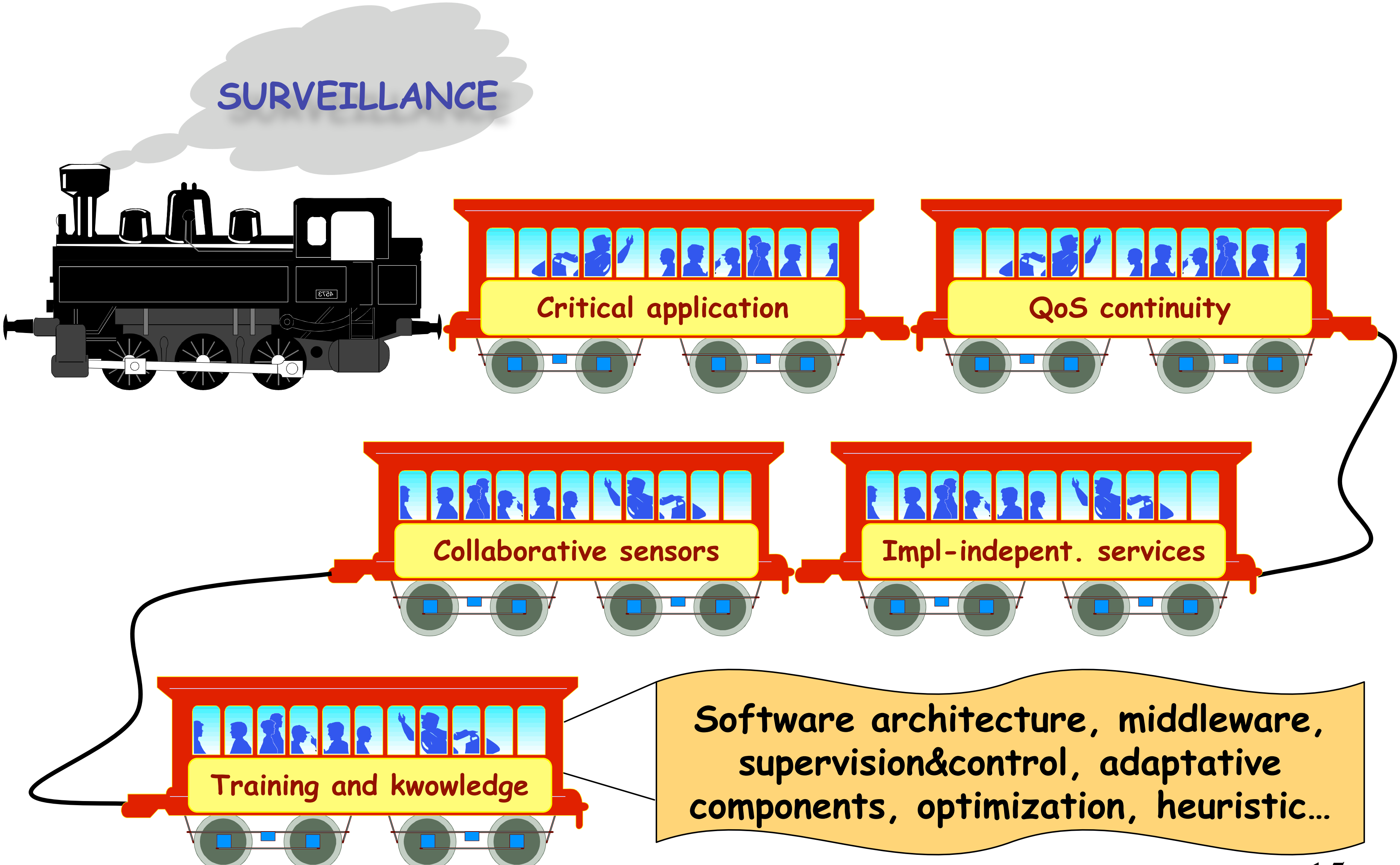
Surveillance applications (3)

- Lesson 3: don't put all your eggs in one basket



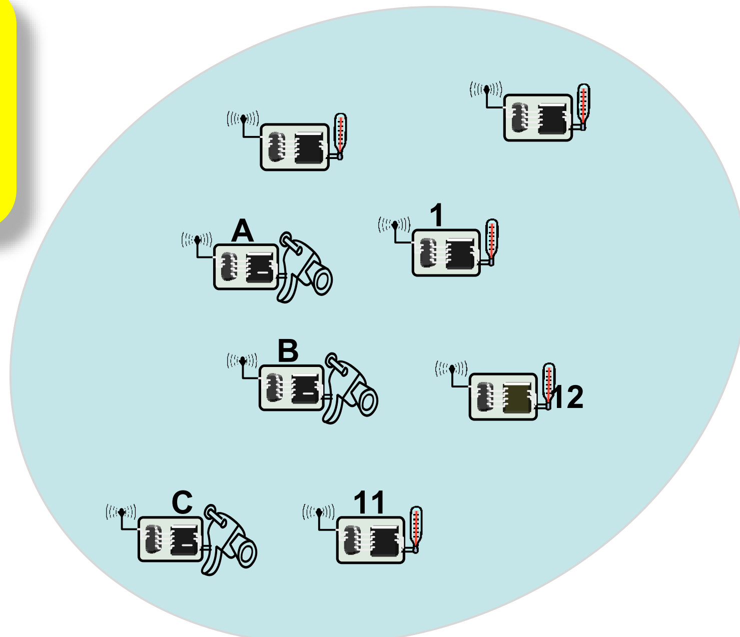
Several camera provide multi-view for disambiguation

Impacts of QoS



The overall surveillance system: the wishes

Heterogeneous sensor hardware



Best coverage Highest net. lifetime

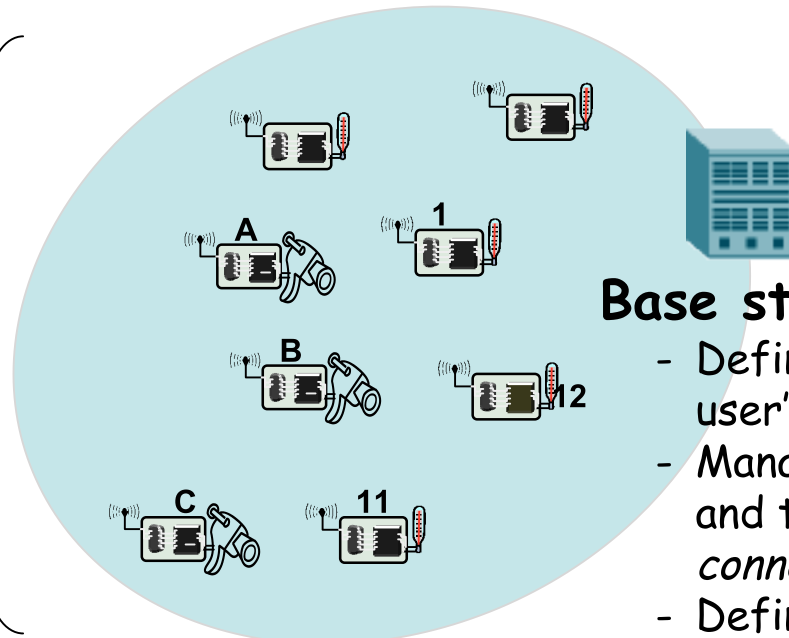
Operate 24/24

SLA for surveillance service

The overall surveillance system: the answers

Sensors must be able to

- Define best way to insure coverage
- Schedule themself to increase network lifetime
- Able to reconfigure themselves
- Communicate to collaborate



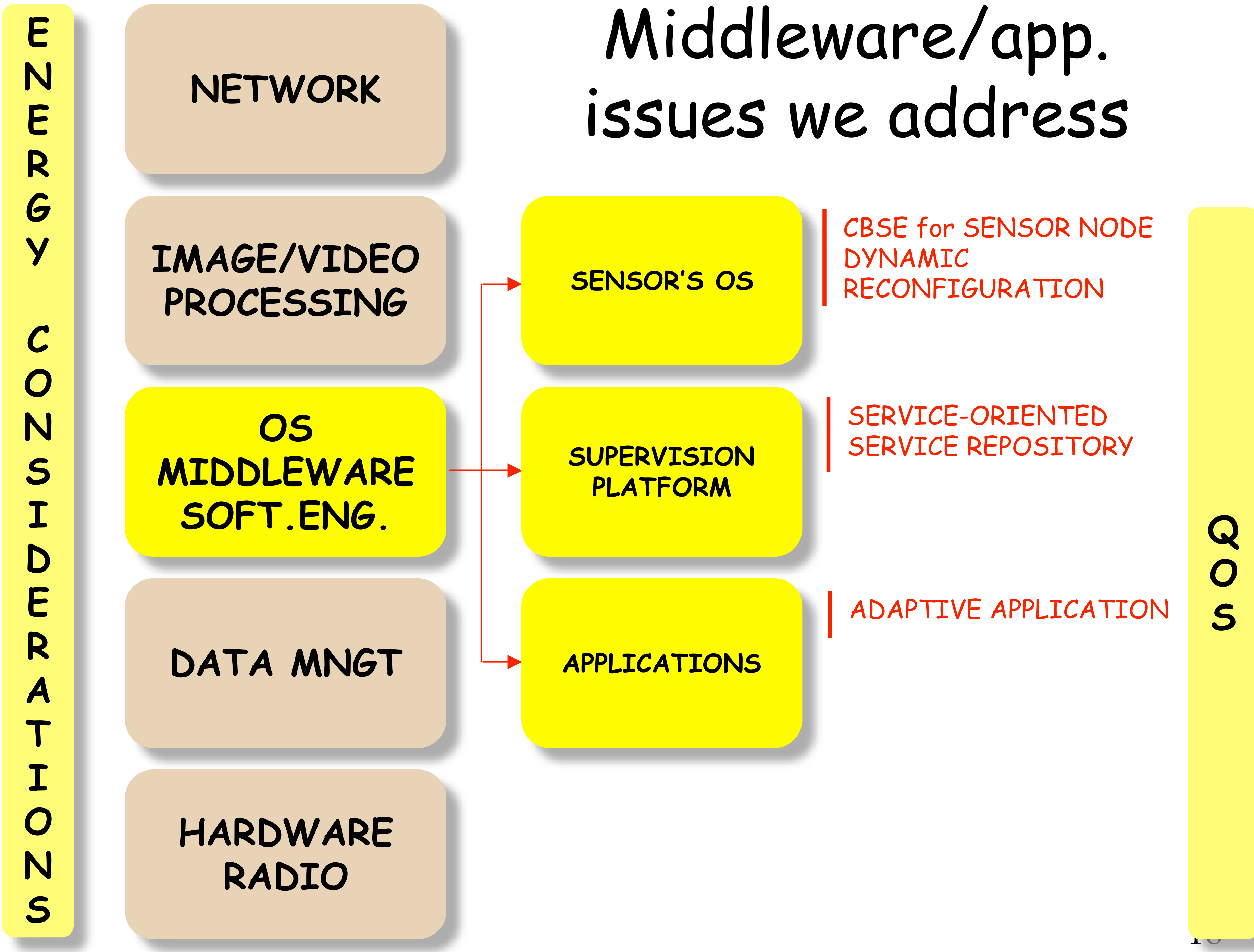
Base station

- Define & monitor user's QoS
- Manage soft. Components and traffic flows through *connectors*
- Define best configuration according to context
- Supervise the set of sensors, manage failures

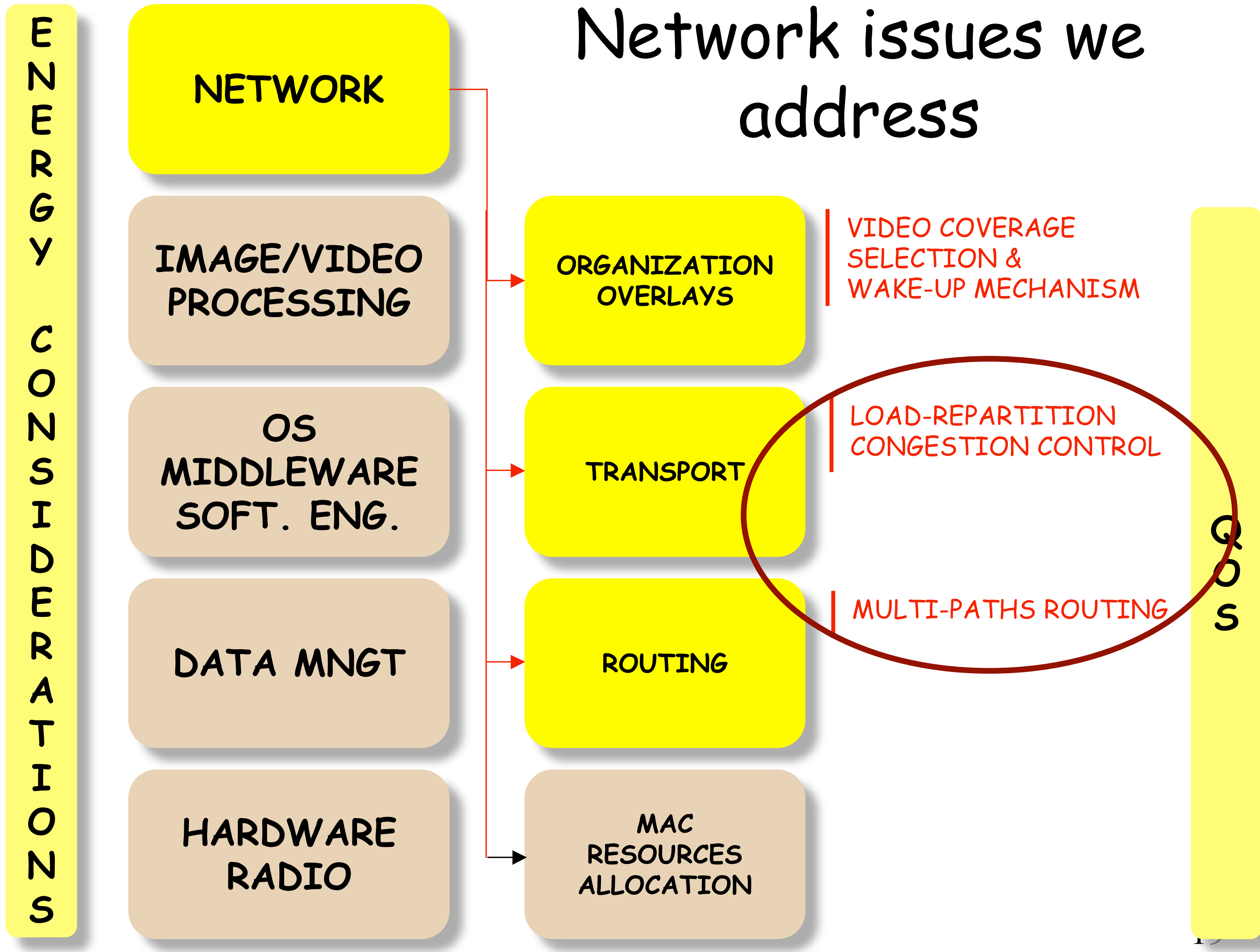
Communication protocols must

- Provide efficient connectivity, multi-hop, multi-path routing
- Handle information-intensive traffic

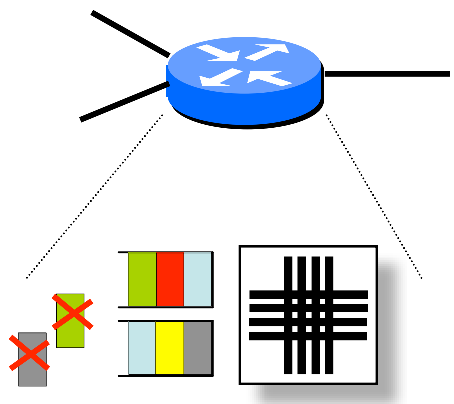
Middleware/app. issues we address

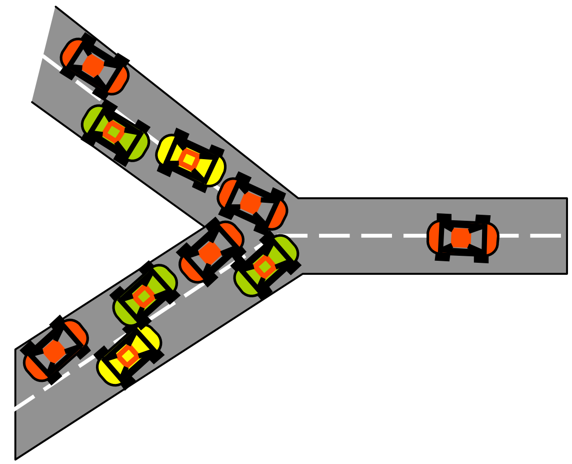


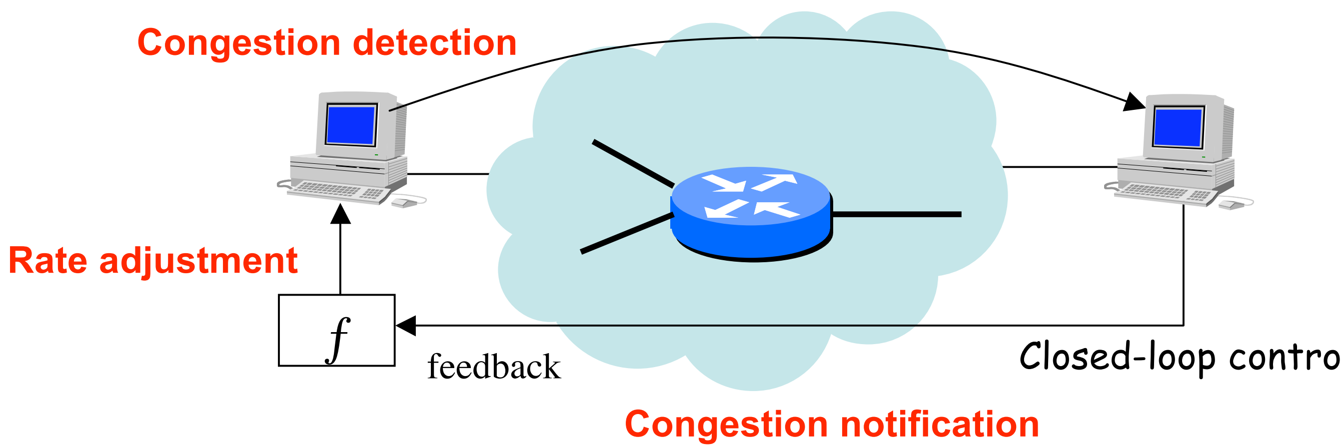
Network issues we address



Congestion Control



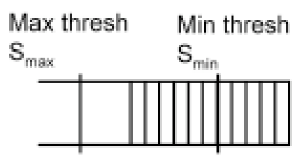




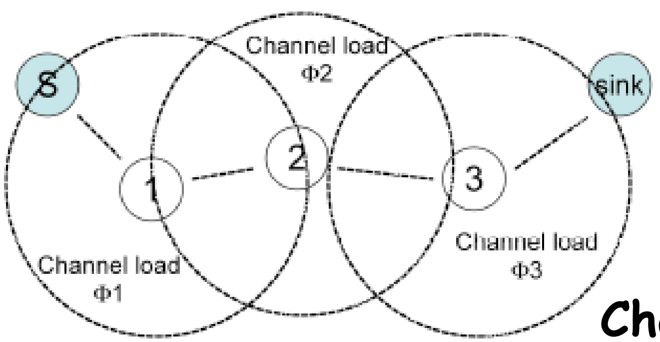
Feedback should be frequent, but not too much otherwise there will be oscillations
Can not control the behavior with a time granularity less than the feedback period

Congestion Control Framework

- Efficient Congestion Detection



Queue occupancy



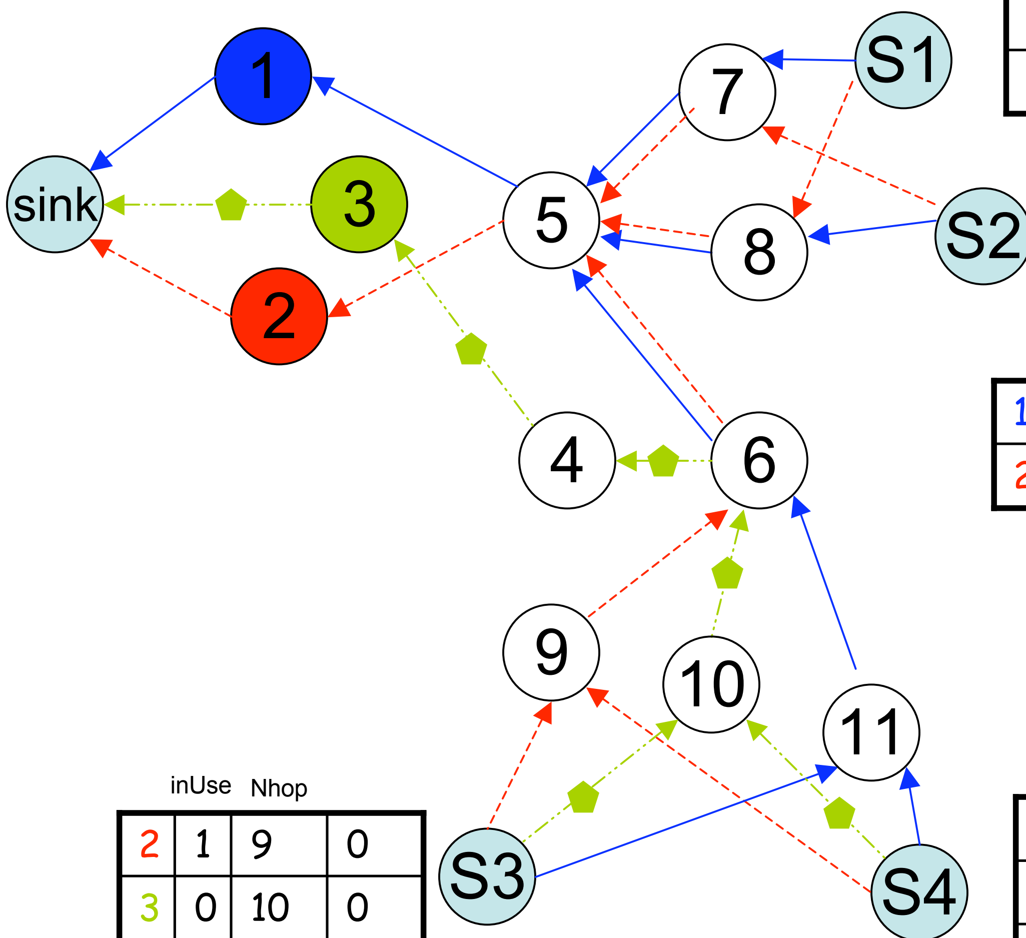
Channel load

	$Q > S_{max}$ $T > \tau$	$T < \tau$	$Q < S_{min}$	$S_{min} < Q < S_{max}$
$\Phi > \phi$	CN	CN	CN	CN
$\Phi < \phi$	CN	ok	ok	ok

Persistency criterion: T, τ

- Multi-path routing
- Fast Load Repartition

Path diversity



	inUse	Nhop	
1	1	7	0
2	0	8	0

No-disjoint paths

	inUse	Nhop	
1	1	8	0
2	0	7	0

	inUse	Nhop	
2	1	9	0
3	0	10	0
1	0	11	0

	inUse	Nhop	
2	1	9	0
3	0	10	0
1	0	11	0

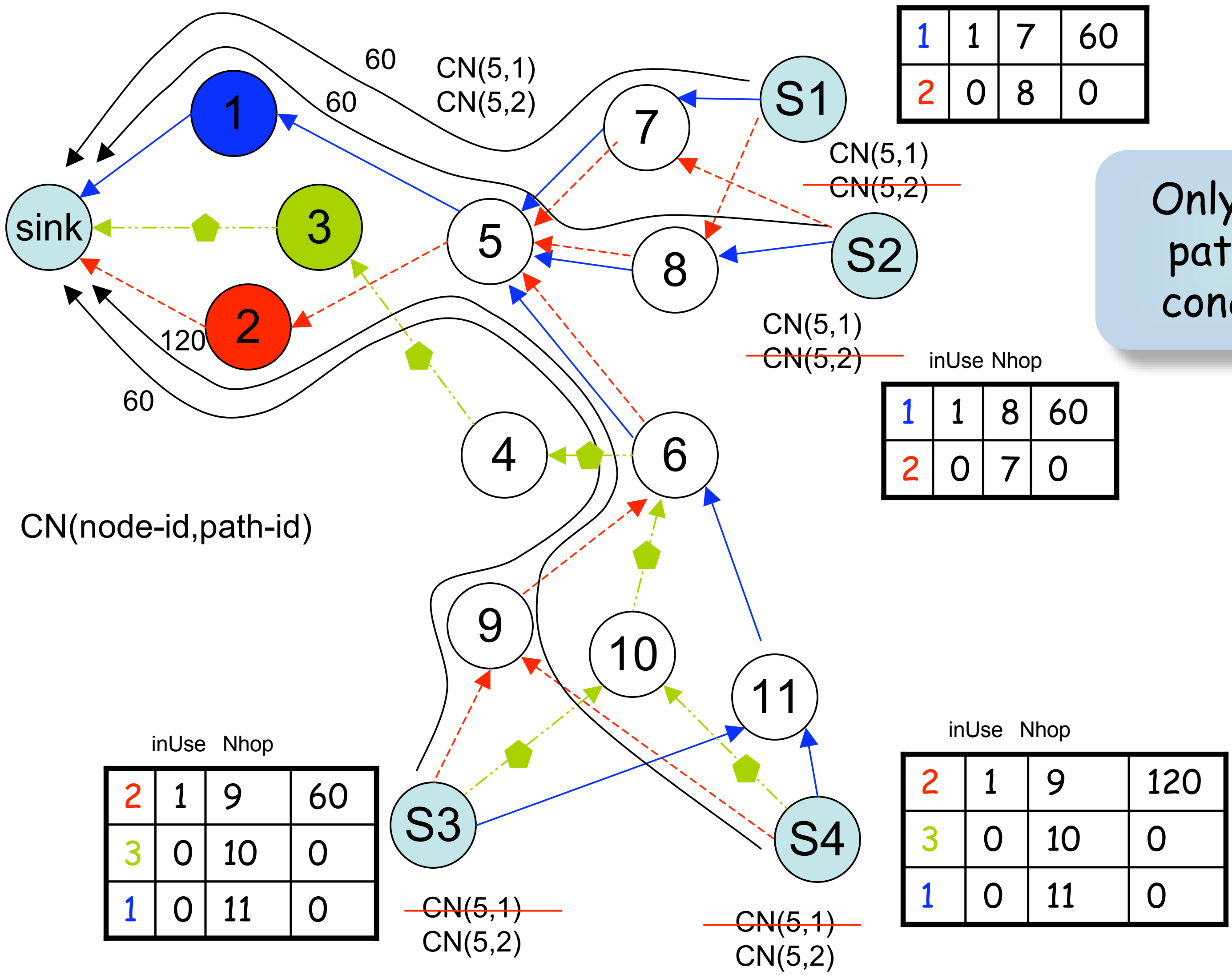
Fast Load Repartition

- Approaches that reduce the reporting rate may impact on detection efficiency
- Keep sending rate, thus video quality, constant: surveillance & critical applications
- Suppose
  - path diversity: path-id
  - Congestion notifications from network: CN(node-id, path-id)
- Load repartition of video traffic on multiple paths

Load repartition modes

- Mode 0
  - no load-balancing
- Mode 1
  - uses all available paths from the beginning
- Mode 2
  - starts with 1 path, for each CN(nid,pid) adds a new path, distribute load uniformly
- Mode 3
  - starts wih 1 path, for each CN(nid,pid) balance uniformly trafic load of path pid on all available paths (including path pid to avoid oscillation)

Initial configuration, then node 5 is congested



	inUse	Nhop	
1	1	7	60
2	0	8	0

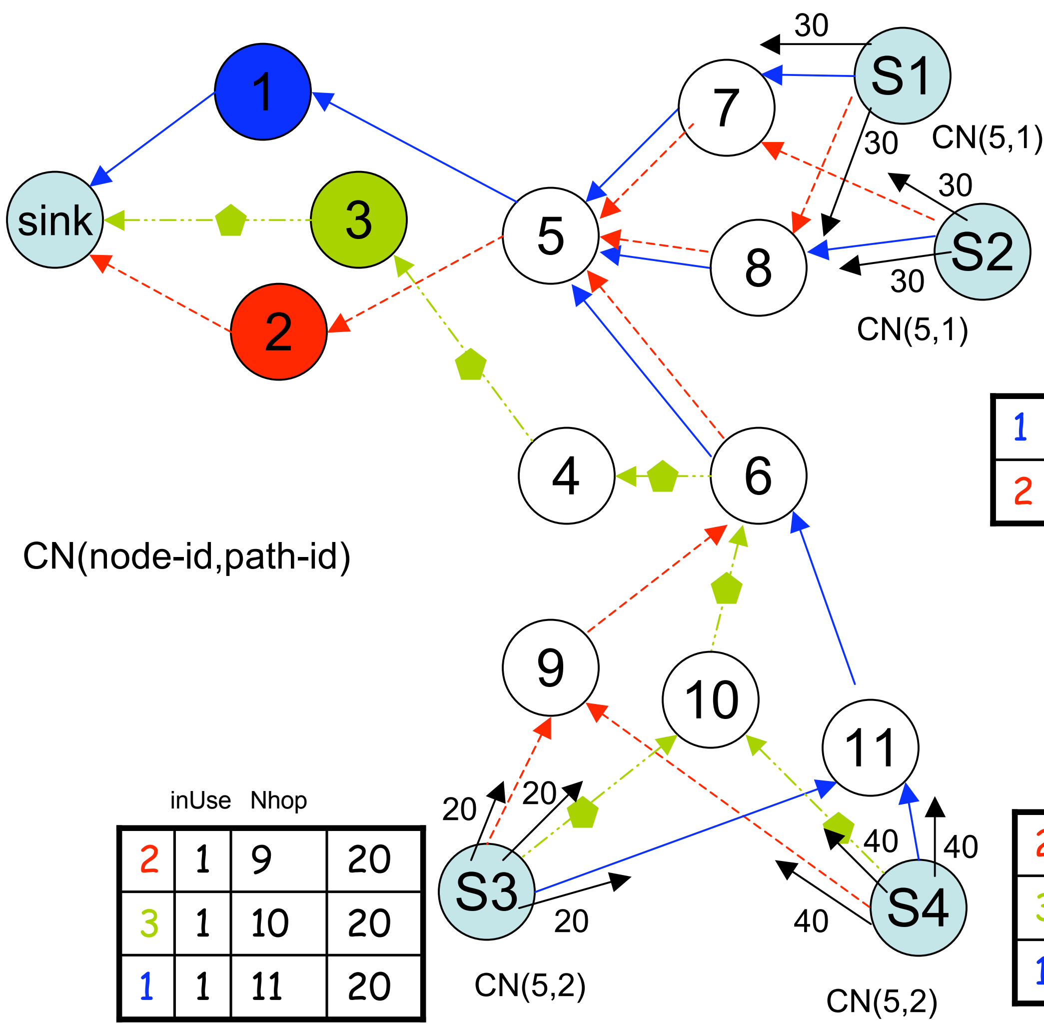
	inUse	Nhop	
1	1	8	60
2	0	7	0

	inUse	Nhop	
2	1	9	60
3	0	10	0
1	0	11	0

	inUse	Nhop	
2	1	9	120
3	0	10	0
1	0	11	0

Only active paths are concerned

Processing CN(5,*)



inUse Nhop

1	1	7	30
2	1	8	30

inUse Nhop

1	1	8	30
2	1	7	30

path id	S1	S2	S3	S4	total
path id 1	30	30	20	40	120
path id 2	30	30	20	40	120
path id 3			20	40	60
total	60	60	60	120	300

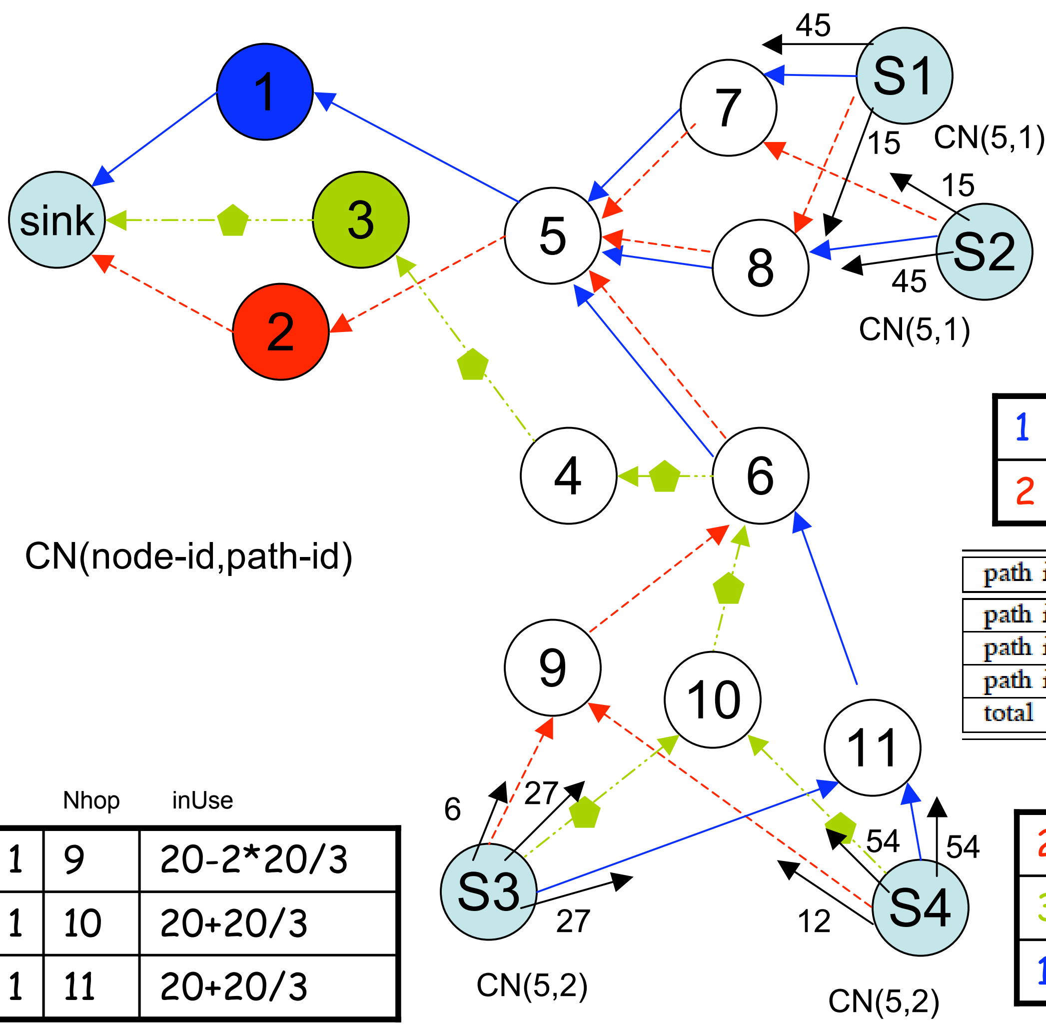
inUse Nhop

2	1	9	20
3	1	10	20
1	1	11	20

inUse Nhop

2	1	9	40
3	1	10	40
1	1	11	40

Congestion of node 2, processing CN(2,*)



	inUse	Nhop	
1	1	7	45
2	1	8	15

	inUse	Nhop	
1	1	8	45
2	1	7	15

path id	S1	S2	S3	S4	total
path id 1	30+15	30+15	20+20/3	40+40/3	170
path id 2	15	15	20-2*20/3	40-2*40/3	50
path id 3			20+20/3	40+40/3	80
total	60	60	60	120	300

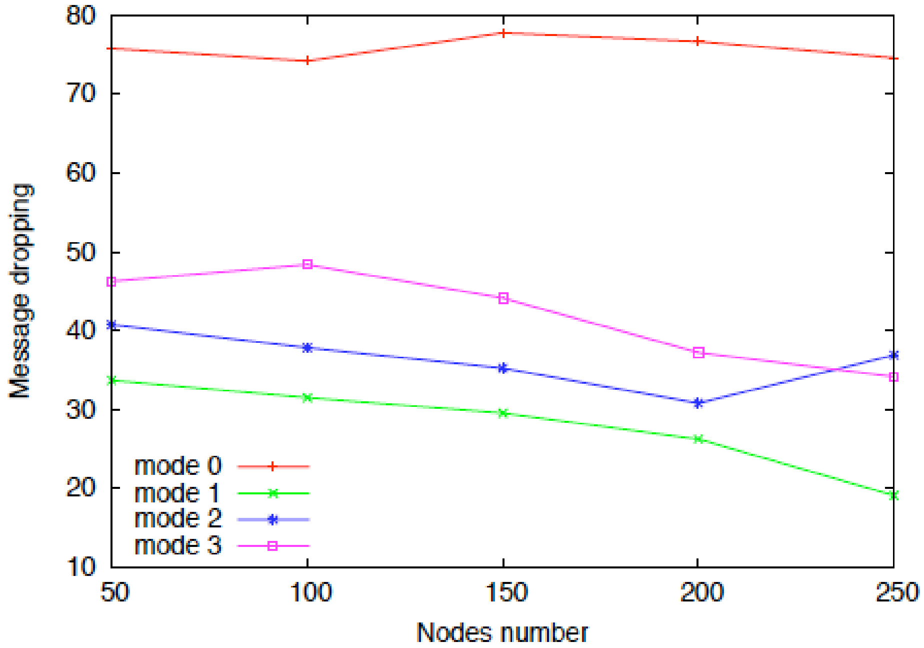
	Nhop	inUse	
2	1	9	20-2*20/3
3	1	10	20+20/3
1	1	11	20+20/3

	inUse	Nhop	
2	1	9	40-2*40/3
3	1	10	40+40/3
1	1	11	40+40/3

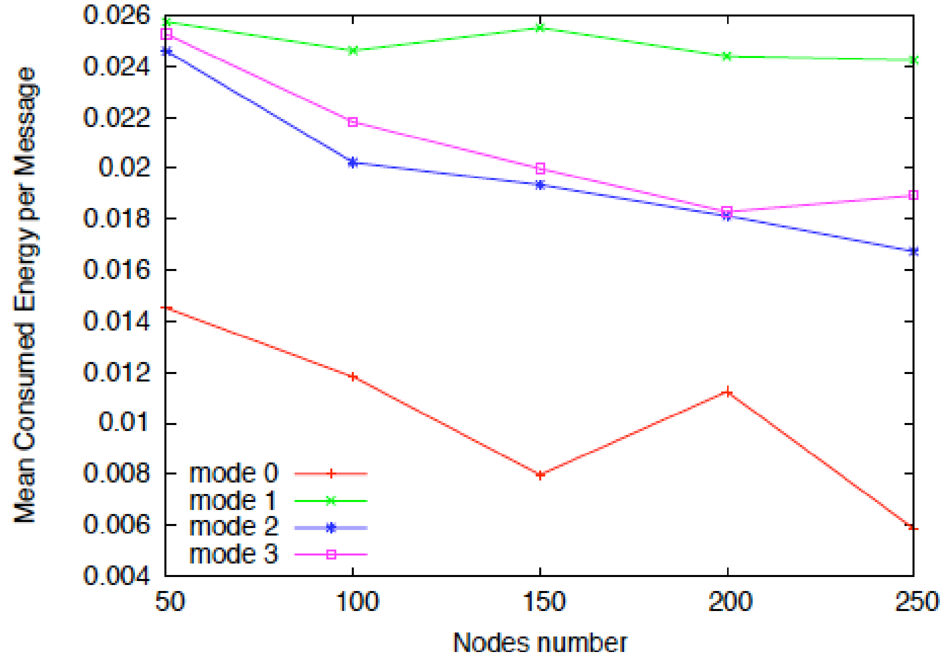
Simulation settings

- TOSSIM simulations (TinyOS)
- 50 to 250 randomly deployed sensors in a 1000mx1000m field
- Results are averaged over 100 simulations with different topologies
- 1 video flow = 60kbit
  - 120x125, 16 grayscale
- Links have 250kbps capacity

Some results (1)



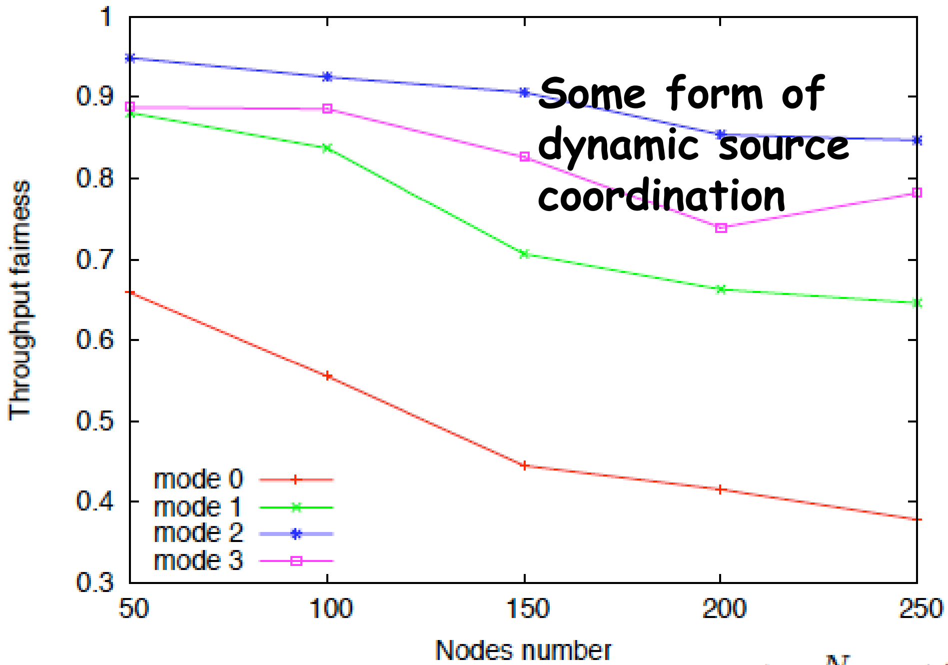
Message dropping rate at sensor queues



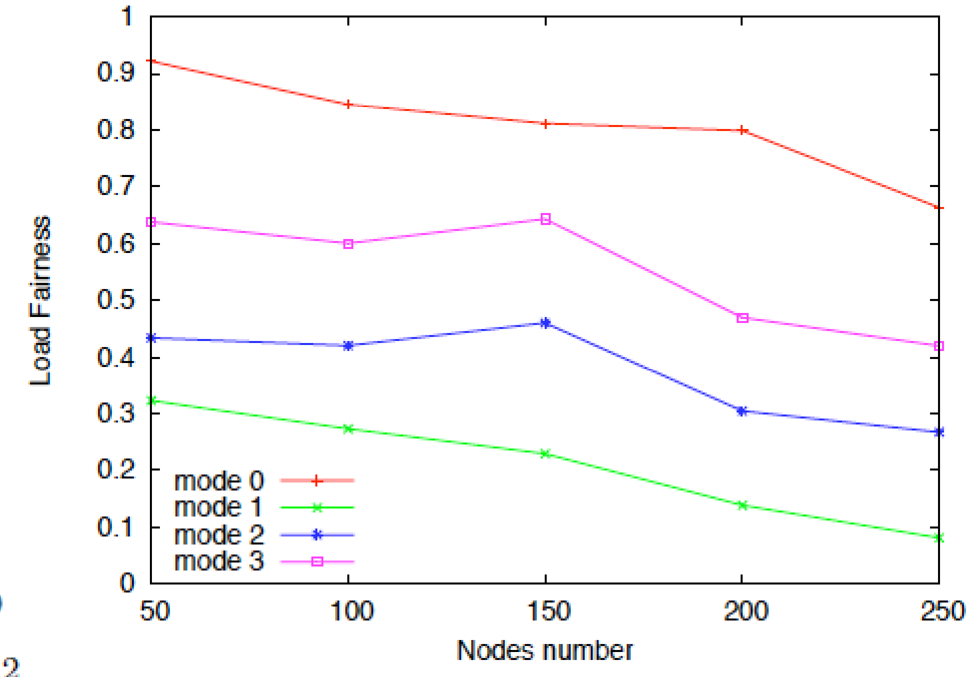
I Mean consumed energy per received packet

- Mode 0: no load-balancing
- Mode 1: uses all available paths from the beginning
- Mode 2: starts with 1 path, for each CN(nid,pid) adds a new path
- Mode 3: starts wih 1 path, for each CN(nid,pid) balance uniformly trafic load of path pid on all available paths (including path pid to avoid oscillation)

Some results (2)



Rate fairness among source $\frac{(\sum_{i=1}^{N_s} r_i)^2}{N_s \sum_{i=1}^{N_s} r_i^2}$



Load fairness among active sensors (belonging to the same path)

- Mode 0: no load-balancing
- Mode 1: uses all available paths from the beginning
- Mode 2: starts with 1 path, for each CN(nid,pid) adds a new path
- Mode 3: starts wih 1 path, for each CN(nid,pid) balance uniformly trafic load of path pid on all available paths (including path pid to avoid oscillation)

Conclusions

- Using all the paths right away is not that good (Mode 1)
- Mode 2 & mode 3 does have some form of source coordination which is a desirable feature
- Mode 3 introduces link unfairness but has better load fairness between active nodes

Future works

- Parameter sweeping study of congestion detection
- Study convergence & stability
- Optimize the load repartition computations
- Investigate congestion control & multiview support for disambiguation