Towards Self-organising Smart Camera Systems

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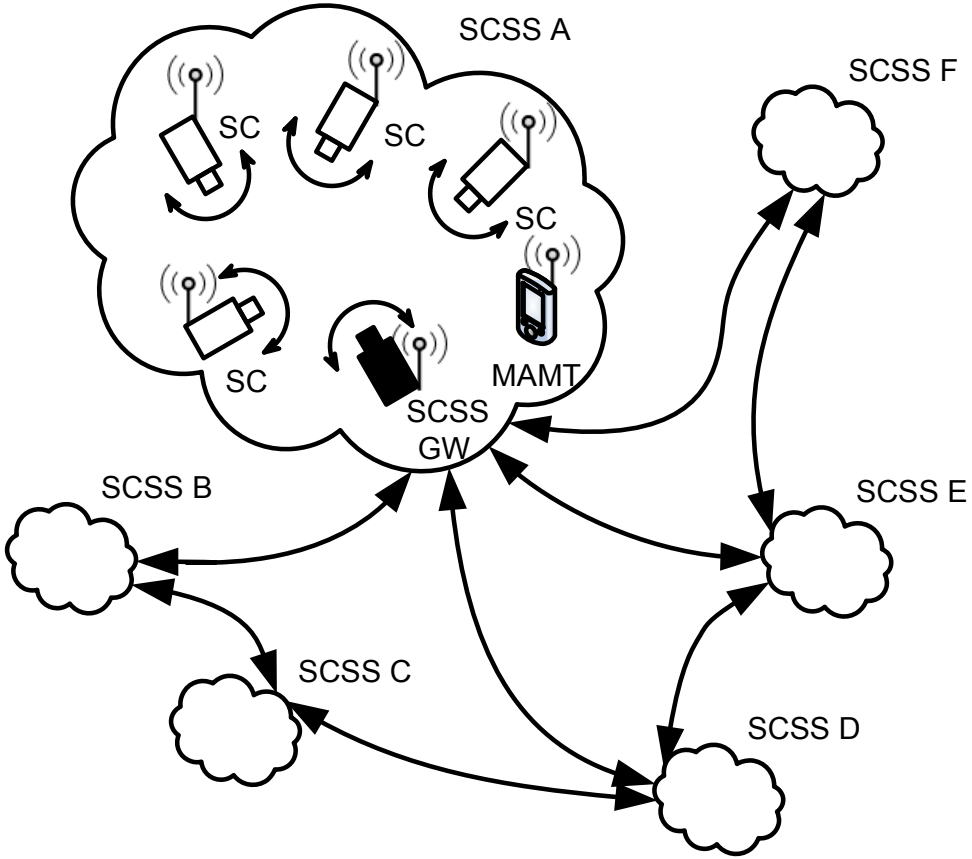
Outline

- Smart Cameras at a glance
- System Architecture
- Node Architecture
- Cooperative Tasks
  - Spatial partitioning problem
- Conclusion

- Each Smart Camera Node:
  - Obviously includes a (PTZ) camera
  - Local processing resources
    (CPU, memory, etc.)
  - Communication interface to exchange information
    with other Smart Camera Nodes
    (e.g. wireless ad-hoc or wired network)
- What is it good for?
  - Unburden human operators from trivial tasks
  - Help to preserve individuals privacy

- Networked Smart Camera Nodes
  - Cameras can cooperatively solve surveillance tasks
  - Achieve goals that cannot be achieved with a single camera, e.g. wide-area object tracking, multi-view observation
  - Efficient and robust coordination and management of (possibly large number of) cameras required

- Where can it be used?
  - Possible application scenario: apron of an airport
    - safety critical, wide area
    - Manual image analysis and camera adjustment is time and cost intensive



SC: Smart Camera

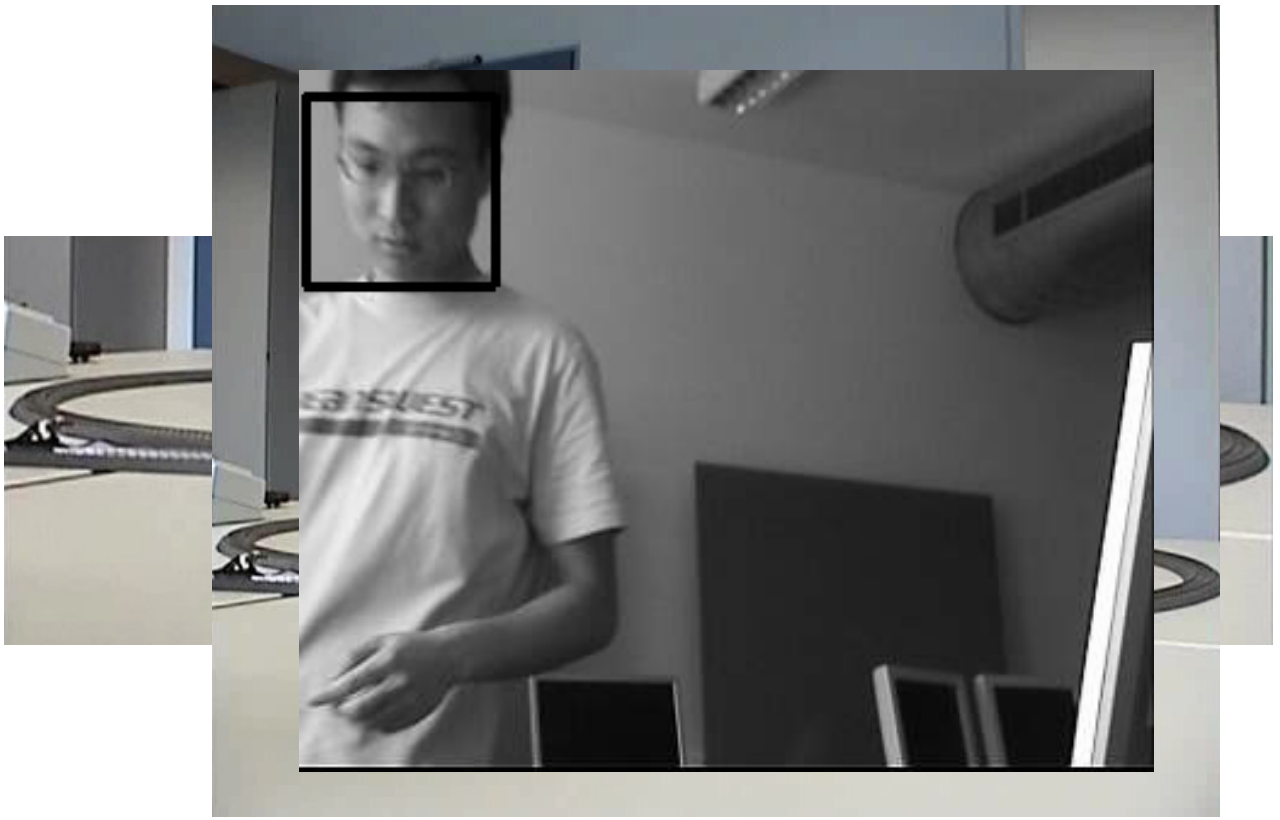
SCSS: SC Sub-System

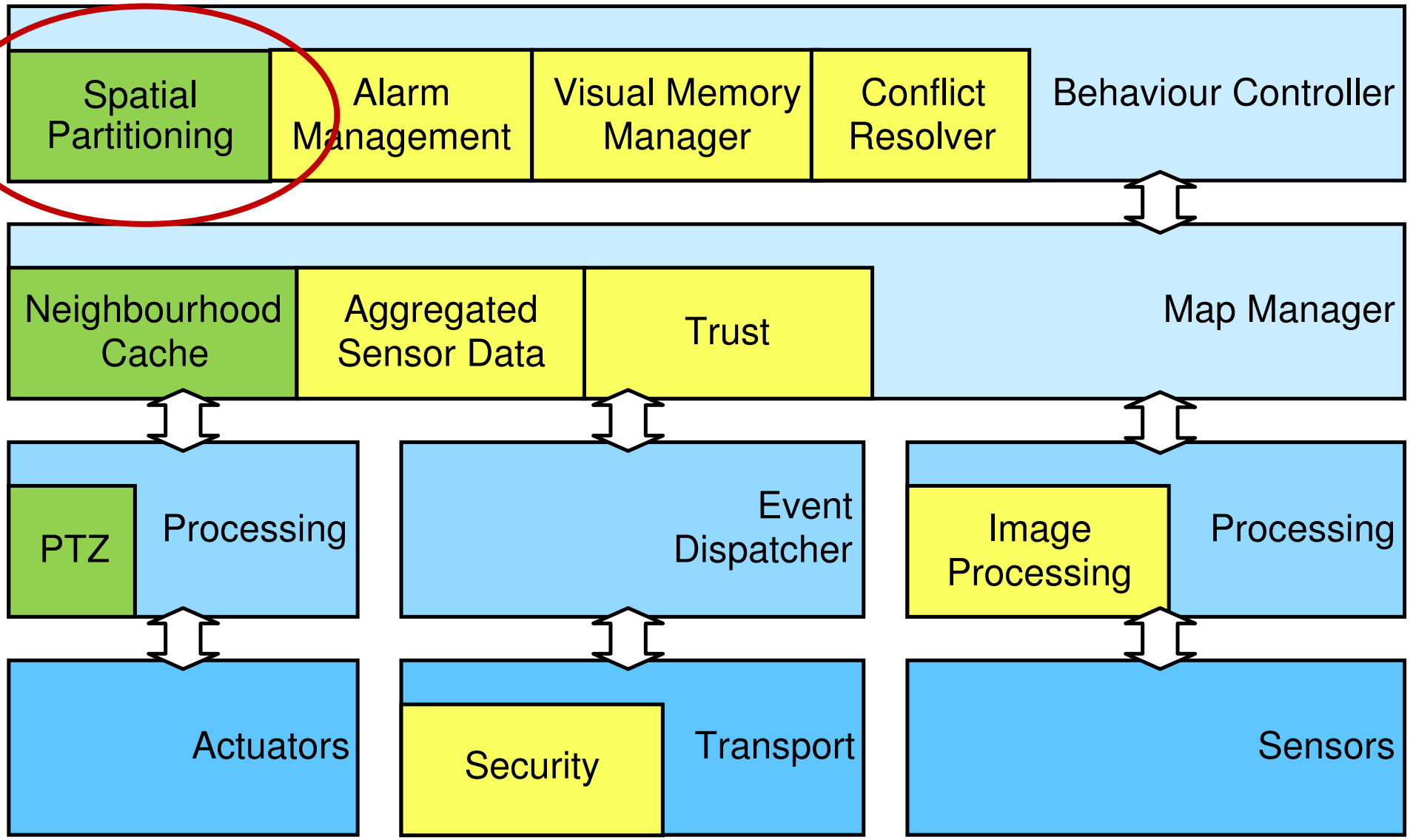
MAMT: Mobile Alarm Management Terminal

SCSS-GW: SCSS Gateway

- Smart Camera Sub-system (SCSS): spatially adjacent cameras
- Gateways in SCSS: interconnect individual SCSS
- Mobile alarm management terminals (MAMT): deliver information to the operator

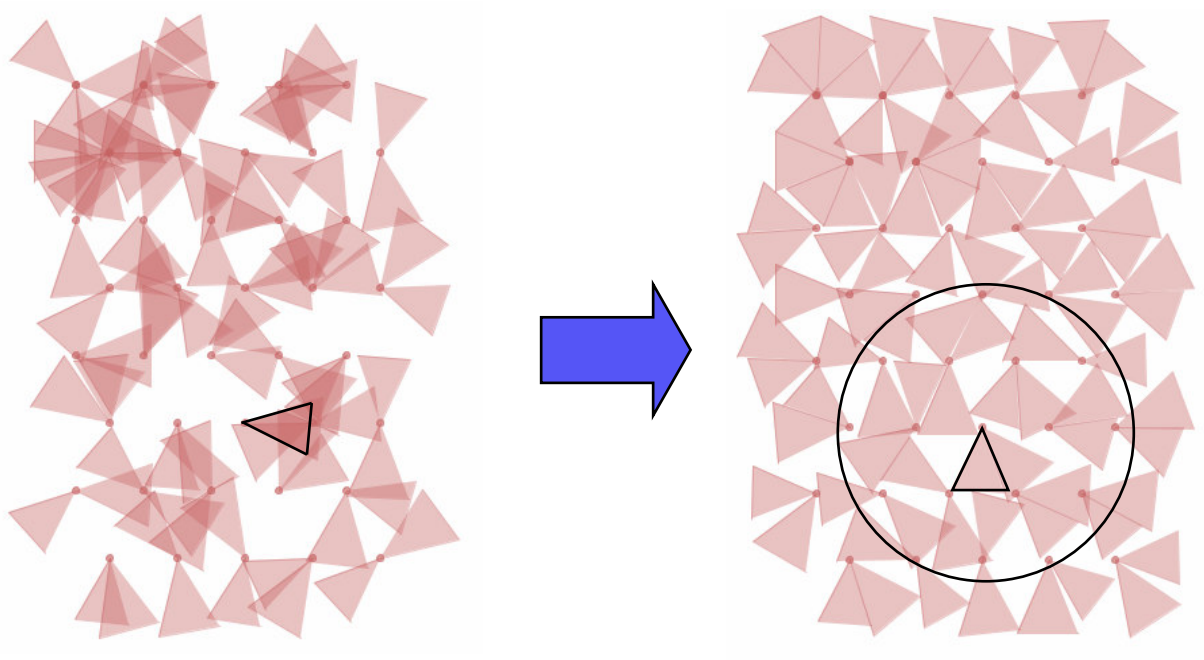
- PC based prototype
  - Use of well known computer vision library OpenCV
  - Face detection
  - Motion detection





A distributed algorithm for spatial partitioning: ROCAS

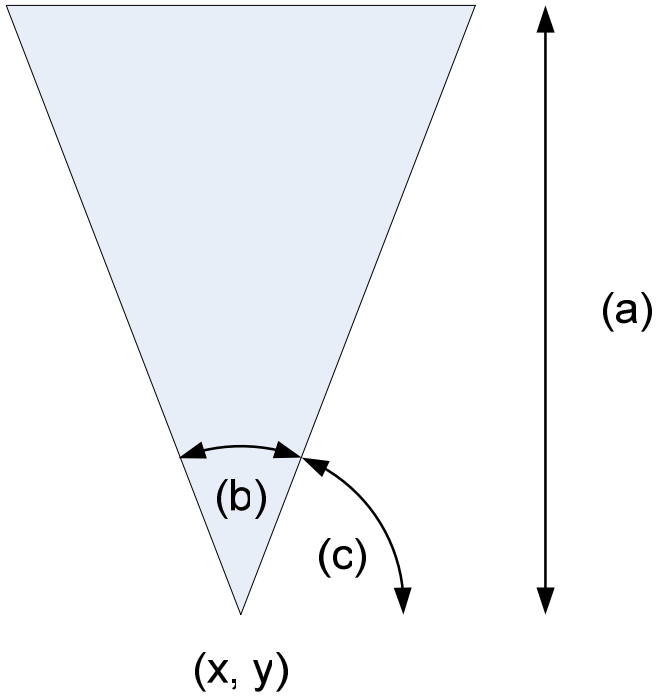
- Cooperative Task: Spatial Partitioning
- Robust Online Camera Alignment System (ROCAS)



- Computational Geometry problem:
  - How many guards are needed to fully observe an n-walled room?
  - Goal: find an optimal positioning for the guards
  - NP hard problem (Aggarwal, 1984)
  - Art Gallery Theorems and Algorithms (O'Rourke, 1987)

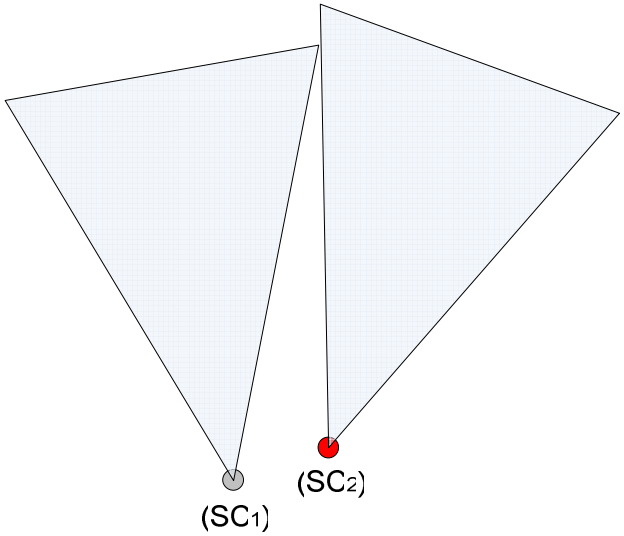
- SC partitioning problem is a derivative of the Art Gallery Problem
  - SCs have fixed positions (mobile nodes may be considered in future)
  - Degrees of freedom are limited to pan/tilt/zoom capabilities of SCs
  - Distributed, fault tolerant heuristics

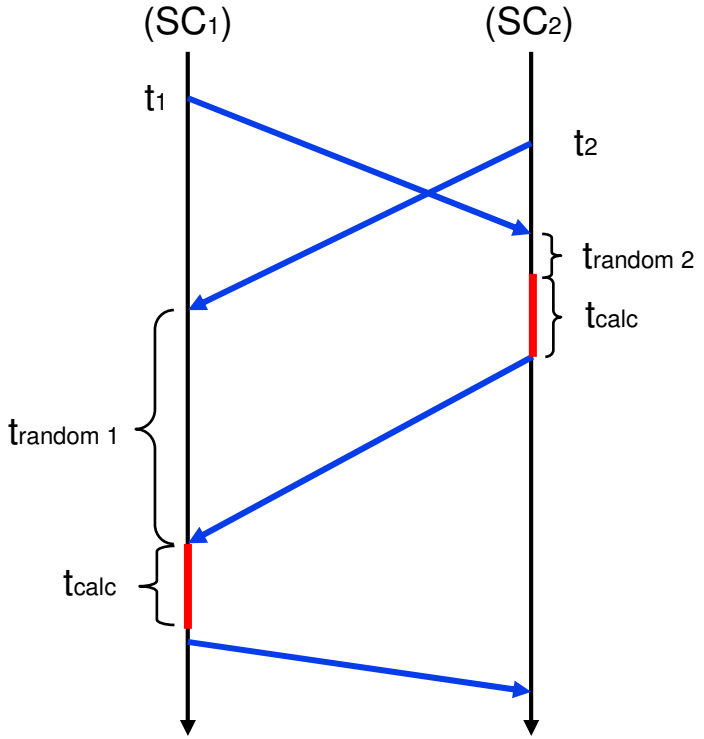
ROCAS: Simplified field of view of a SC



Message ID
Sender ID
X-Position (x)
Y-Position (y)
Viewing range (a)
Span angle (b)
Viewing angle (c)

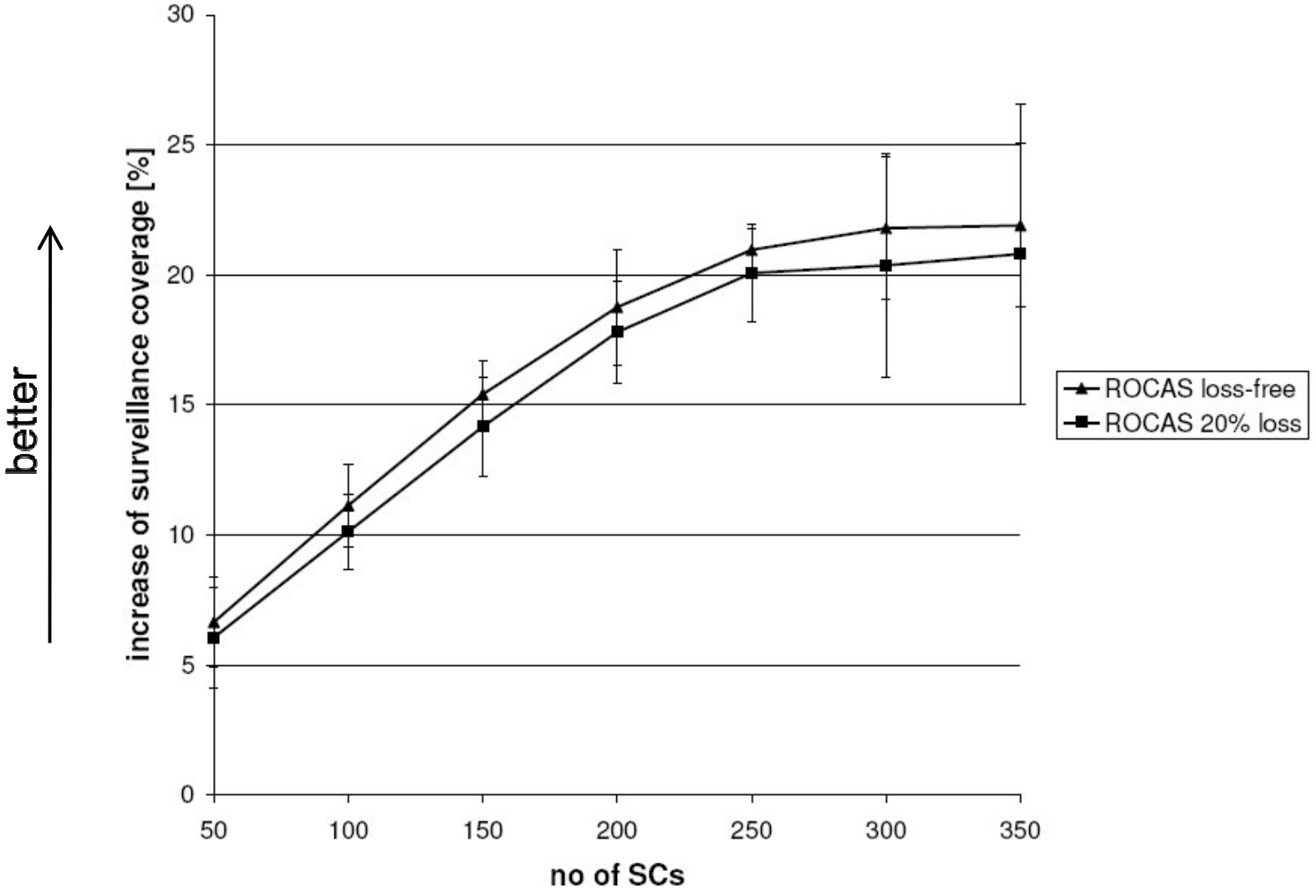
- A SC‘s field of view and ROCAS message format
  - each SC has a fixed position
  - ROCAS changes viewing angle to optimise surveillance coverage



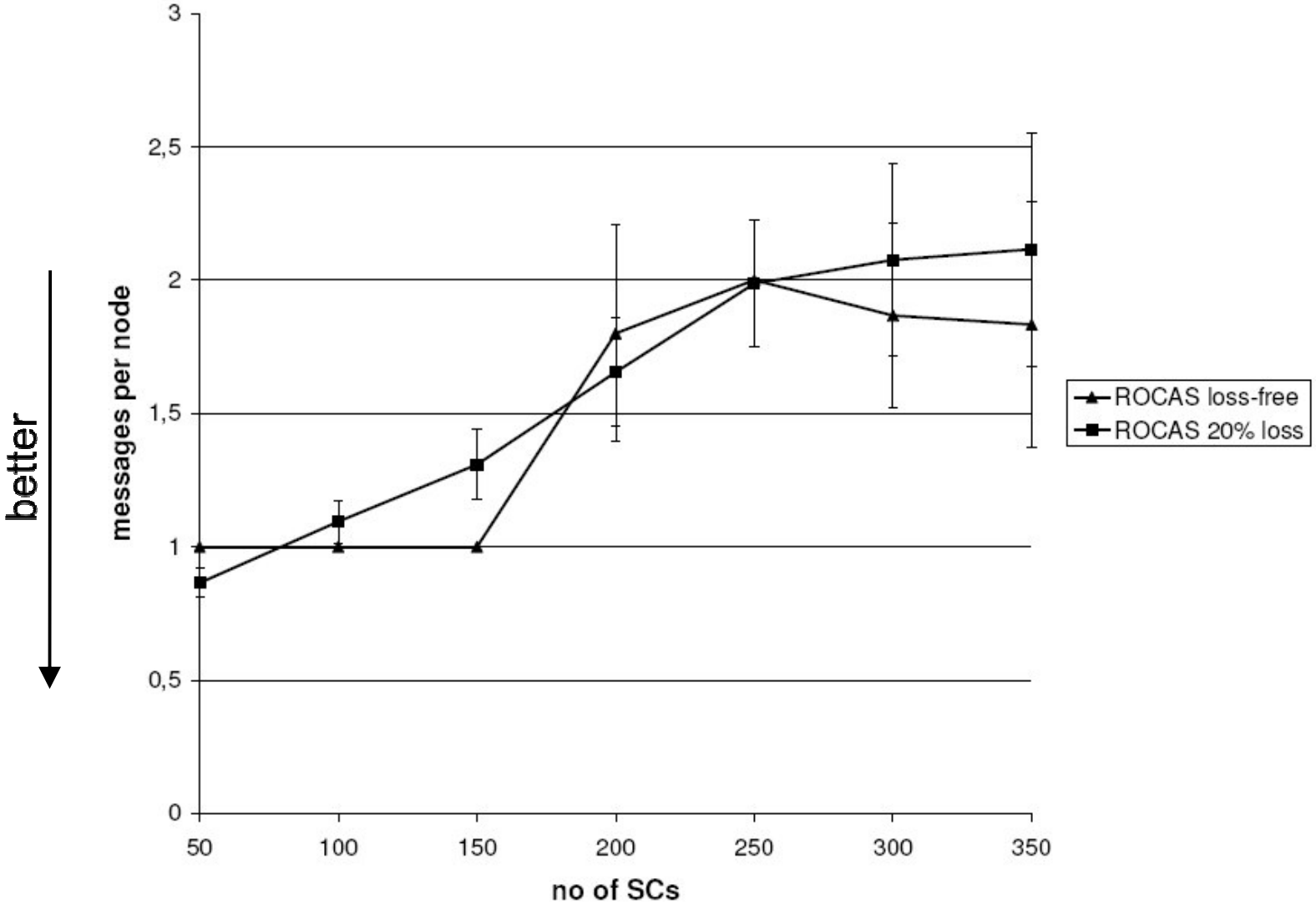


- Investigation of large-scale networks: simulation used
- Basis: Network simulator ns2 plus click modular router
- System parameters
  - 50 to 350 cameras
  - Area 600m x 600m
  - IEEE 802.11 ad-hoc (160m)
  - Field of view: span angle 45 degrees, max. viewing distance: 50m
  - Deployed randomly or on a regular grid
- Performance metrics
  - Surveillance coverage
  - Message overhead
  - Fault tolerance

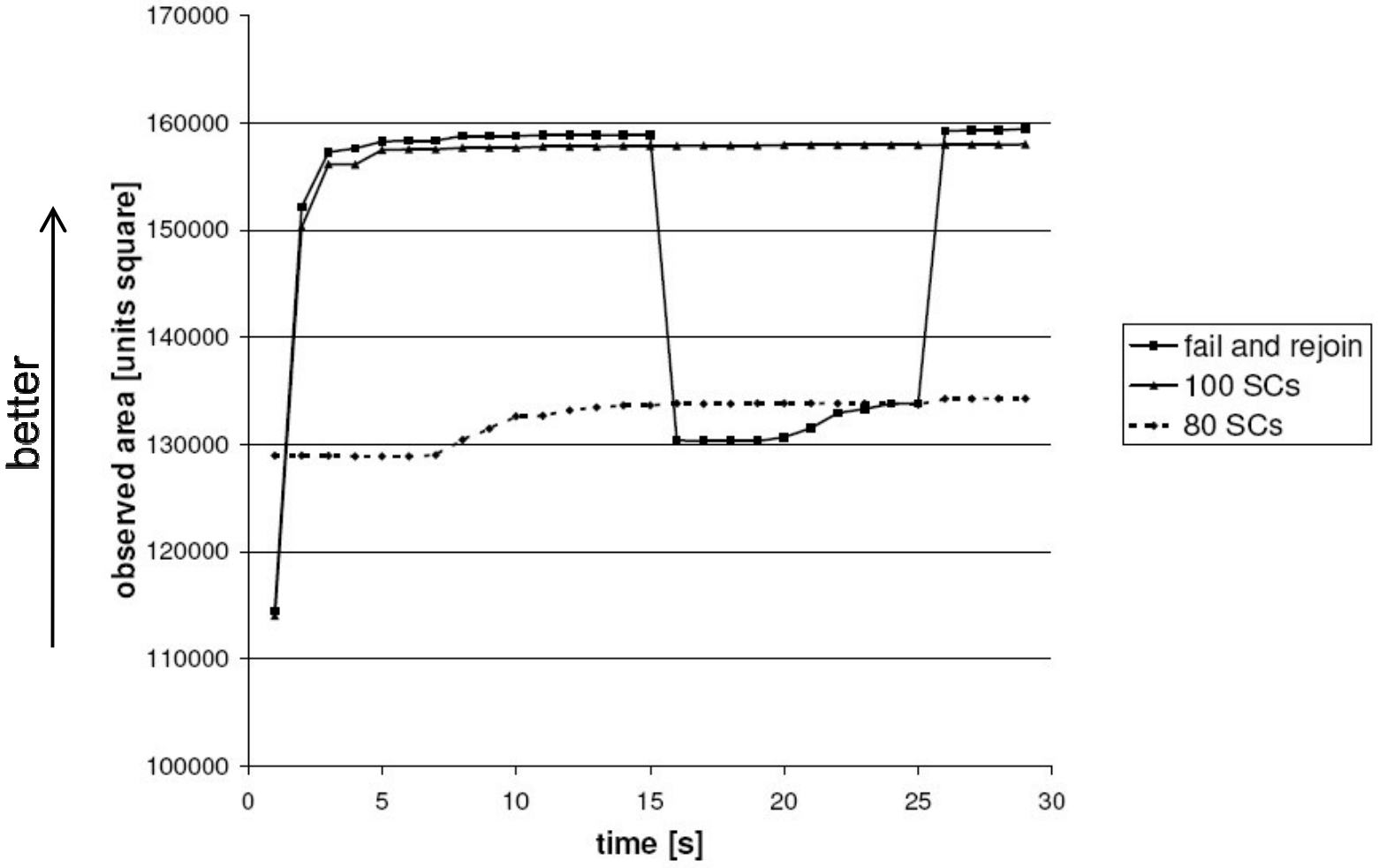
Experiment 1: Increase of Surveillance Coverage



Experiment 2: Message Complexity



Experiment 3: Fault Tolerance



Conclusion

- System and node architecture
- ROCAS enables SCs to partition an area under surveillance
  - Example for a distributed coordination algorithm in Smart Camera Systems
  - Scalable (up to 350 SCs per SCSS)
  - Lightweight (message complexity is low)
  - Robust and fault tolerant
- Future prospects: Cooperative tasks
  - Object Tracking
  - Camera Synchronisation
  - Scene understanding

Thank you for your attention!