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A Simulation Framework for Decentralized Data Fusion Networks

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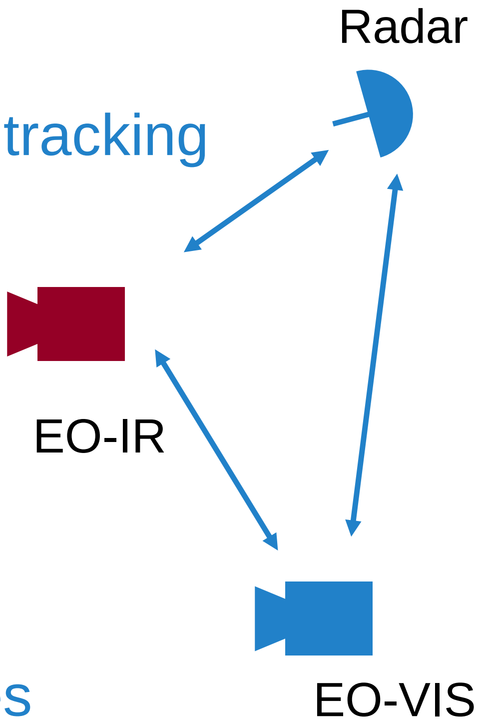
Outline

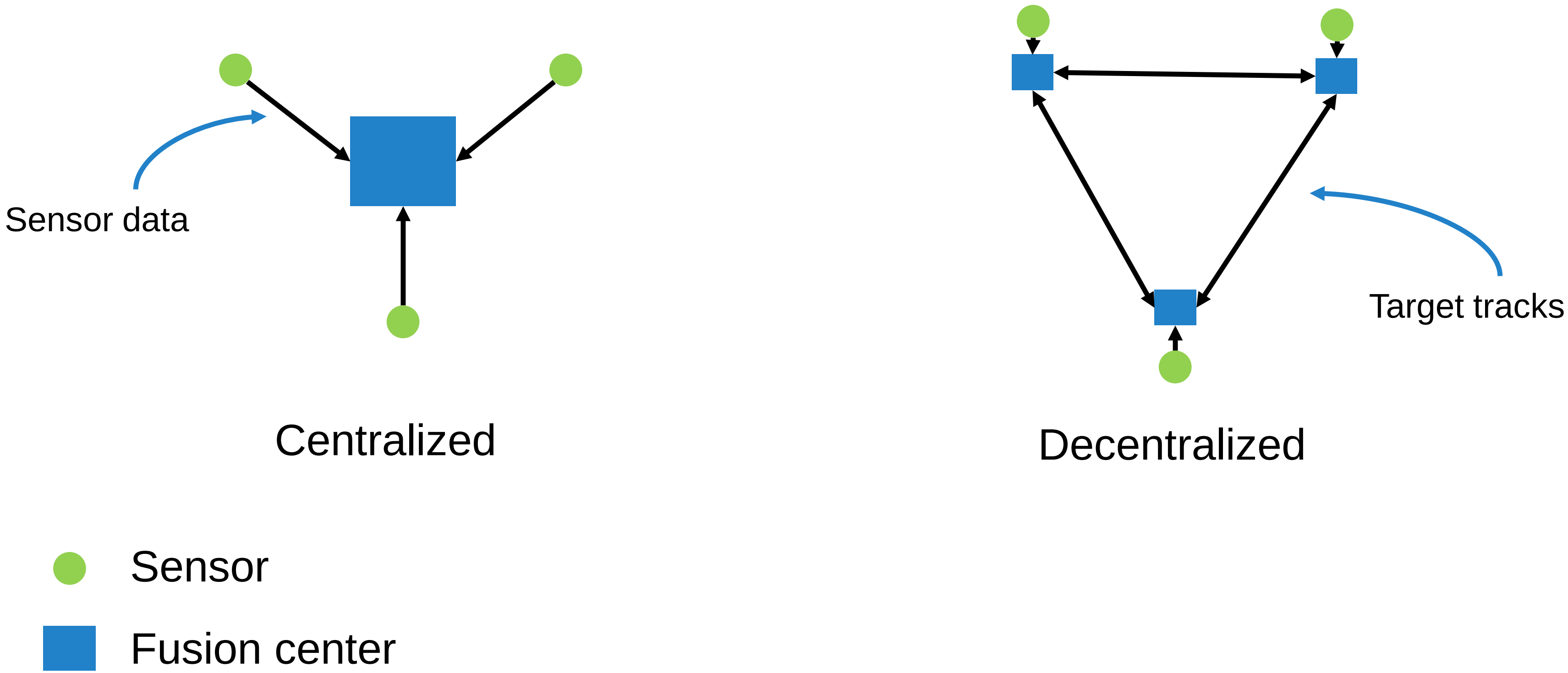
- Introduction
- The framework
- Case study
- Conclusions

Introduction

- Sensors for situational awareness using target tracking
- Increased number of sensors
  - Modalities
  - Stationary and mobile
- Communicate sensor data to a fusion center
  - Raw data
  - Processed data
- But, large networks imply communication issues

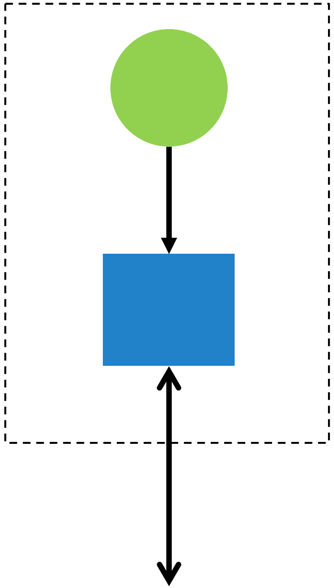


Fusion architectures



Decentralized architecture

- Local processing of sensor data
- Transmit target tracks instead of raw sensor data
- Benefits:
  - Compact and common representation
  - Reduce complexity
  - Scalability



Decentralized architecture

- New issues with decentralized architecture
- Track fusion
  - Correlations?
  - Target association?
- Communication
  - Which data?
  - Delayed data?
  - Out of sequence?

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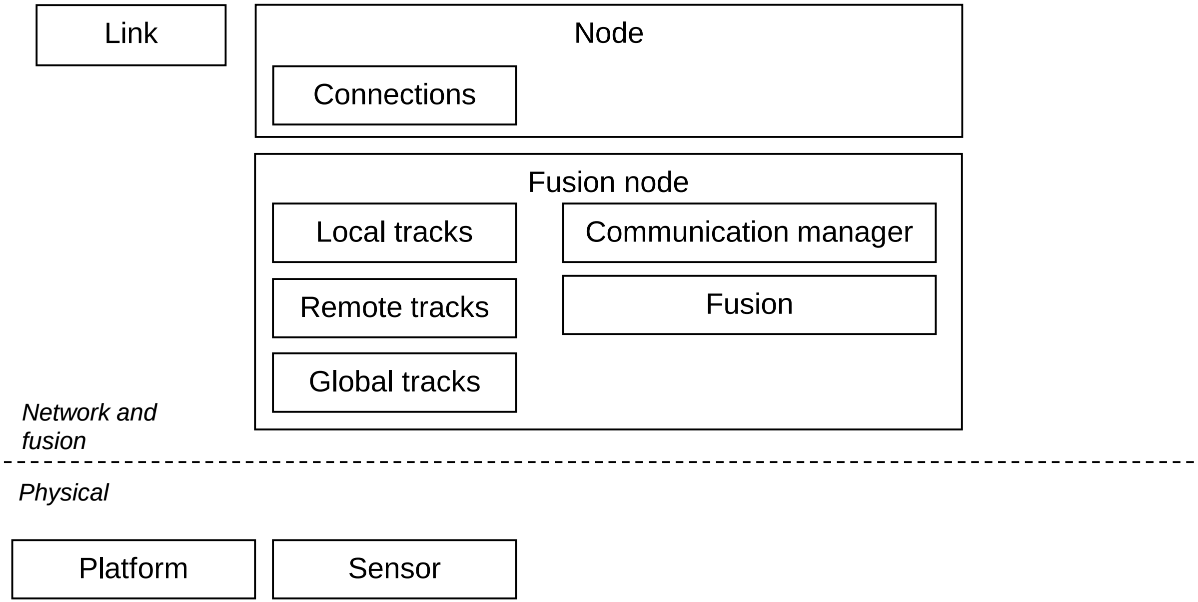
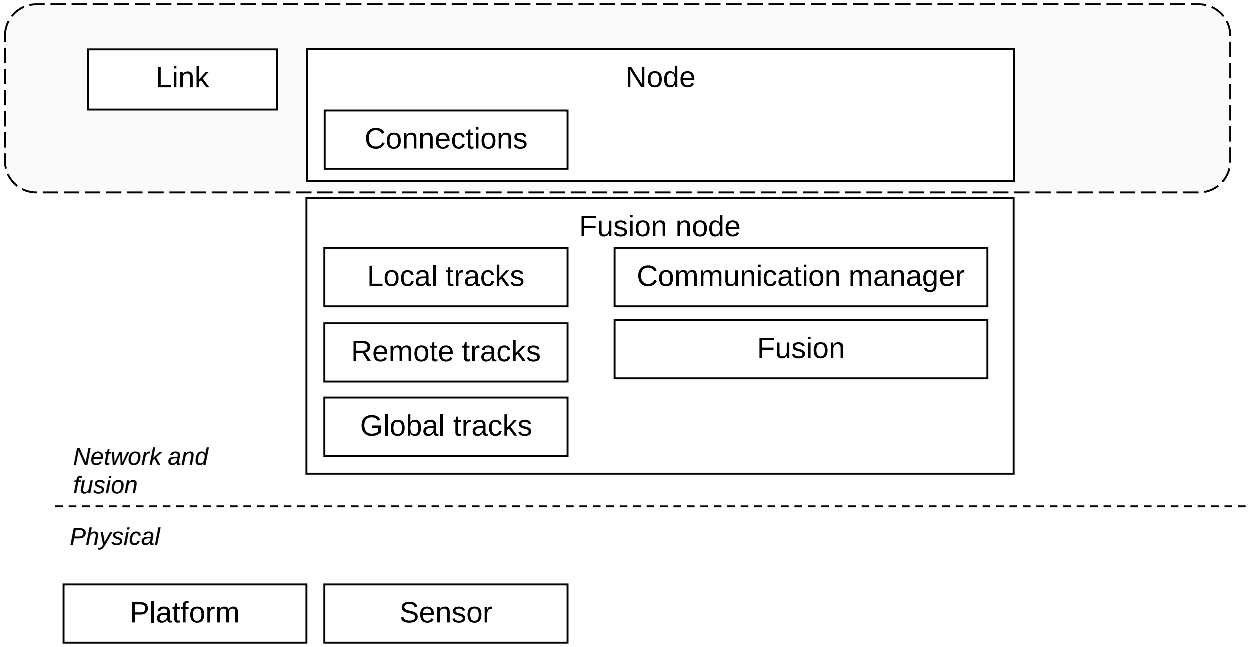
The framework

- Implementation and evaluation
- Tailored for target tracking
- Two parts:
  - Architecture
  - Simulation

The framework - Architecture

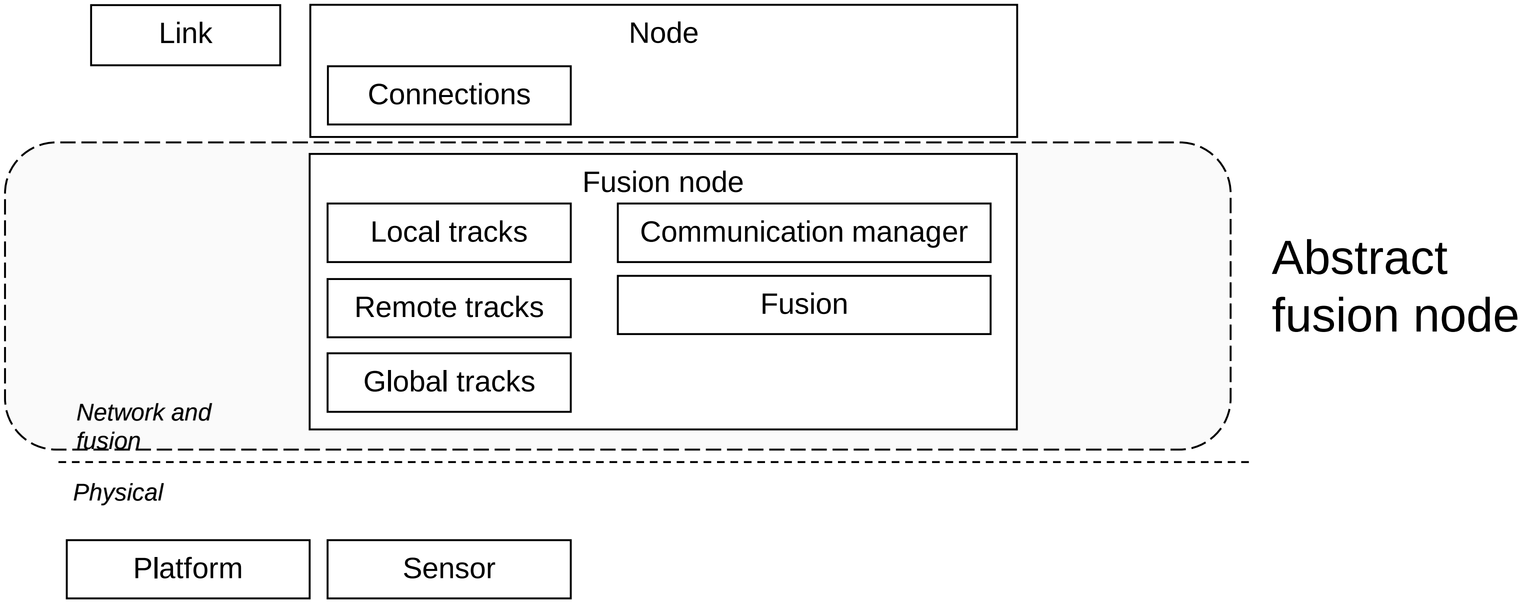


The framework - Architecture

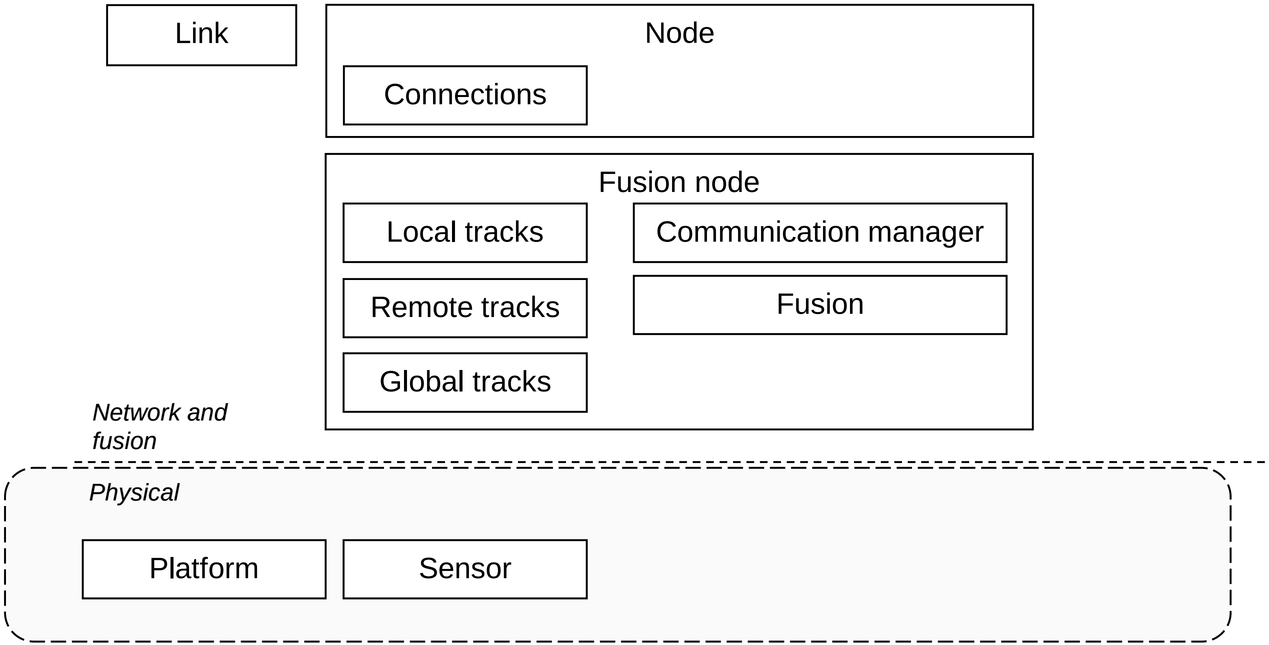


Abstract base objects

The framework - Architecture

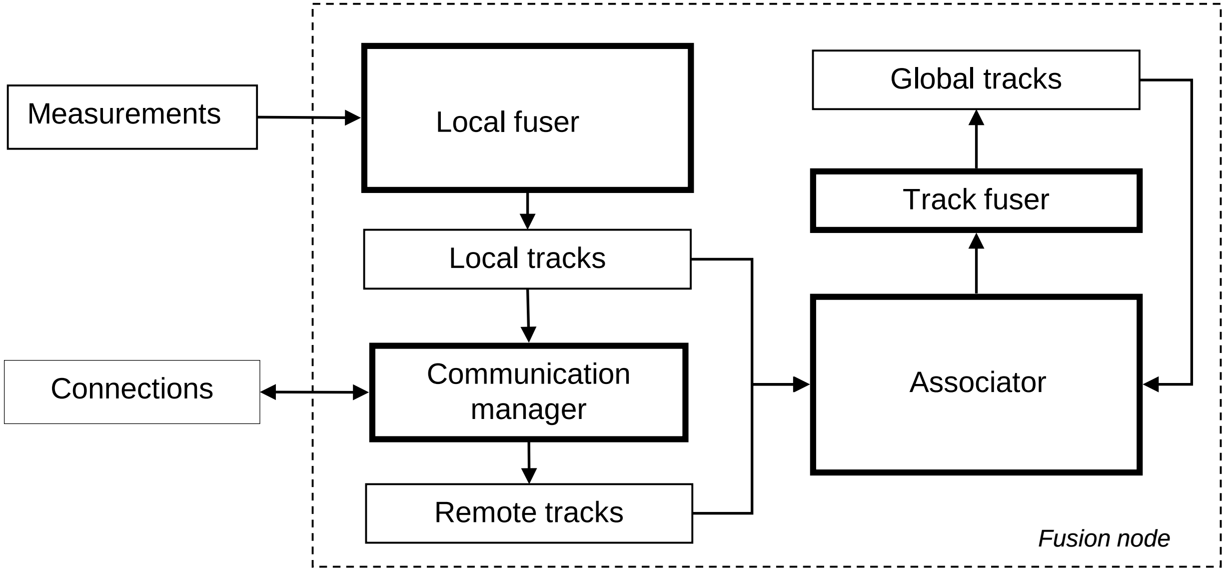


The framework - Architecture



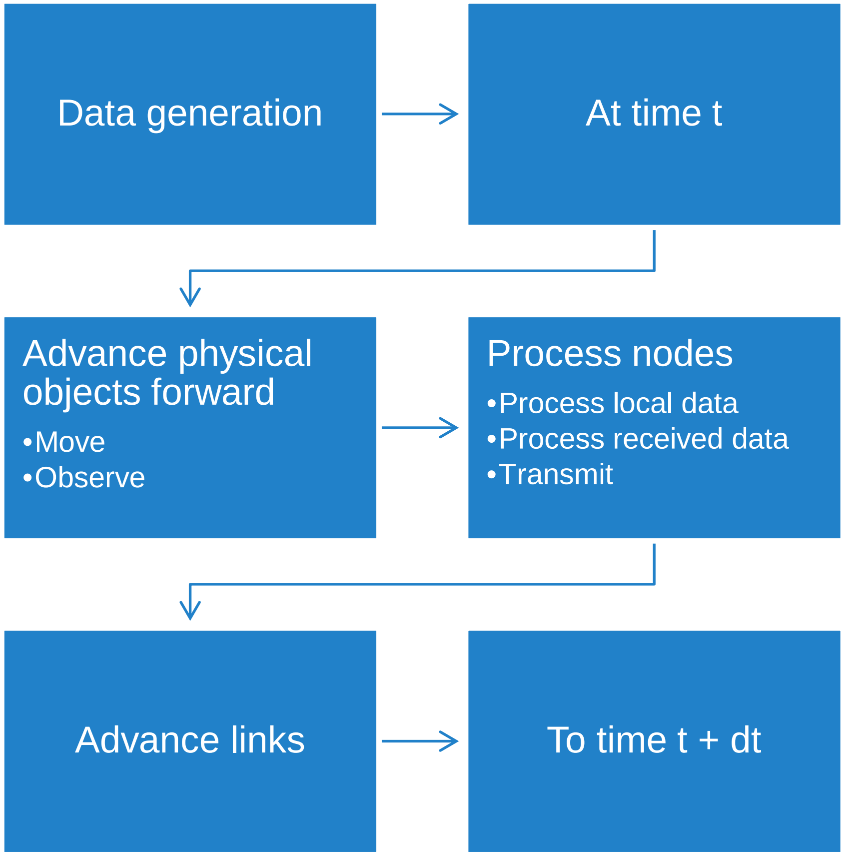
Abstract physical objects

Architecture – Fusion node



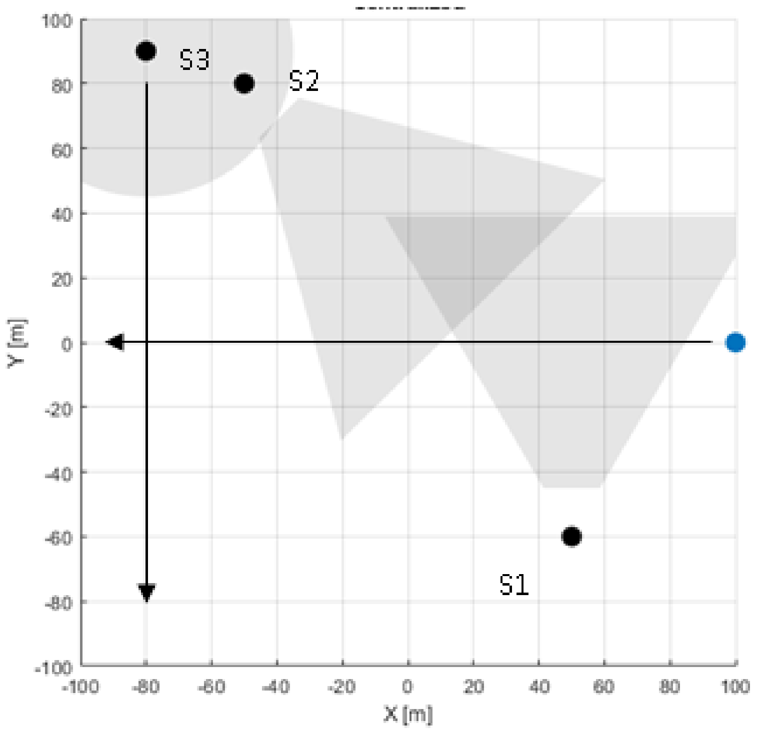
The framework - Simulation

- Physical objects
  - Trajectories
  - Measurements
- Simulation loop
- Tools for evaluation:
  - Monte carlo
  - Performance metrics



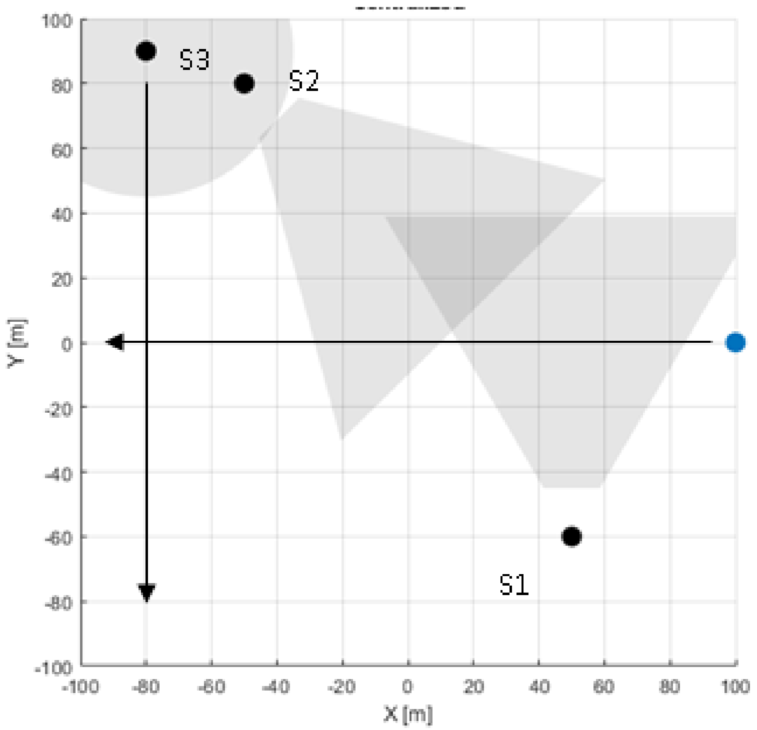
Case study

- Impact of communication reduction wrt to track fusion algorithm
- Area surveillance scenario
- A moving target
- Sensors
  - Visual cameras
  - Two stationary, one mobile
- Network
  - Each sensor acting as fusion node
  - Ideal point-to-point links



Case study - Setup

- Time step 1s
- Target: Constant velocity in 3-D
- Fusion nodes:
  - Measurements: Az-El angles to target (pD 0.7)
  - MHT
- Communication reduction
  - Transmit latest information
  - Full rate (C0), every 2s (C2), every 5s (C5)



Case study – Track fusion algorithms

- Channel cache
  - Information form
  - Inspired by channel filter
  - Single connected tree topology
  - Received information is stored in a local *channel cache*
  - Can handle out-of-sequence situations

- Inverse covariance intersection (ICI)
  - Based on covariance interseciton (CI)
  - Tailored for common information, e.g. target model
  - Less conservative but in many cases still consistent

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Case study - Evaluation

- Scenario 95 s
- Monte carlo, 100 iterations per configuration
- Use GOSPA as performance metric
  - Penalizes localization error as well as missed/false tracks
- Centralized tracking with MHT as baseline

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Case study - Evaluation

		Channel cache			ICI		
	Local	**C0**	**C2**	**C5**	**C0**	**C2**	**C5**
Node 1	9.30	3.69	3.76	4.68	3.80	4.11	4.80
Node 2	10.81	3.69	3.82	4.86	3.80	4.16	5.08
Node 3	10.90	3.69	3.84	4.77	3.78	3.82	4.78
Baseline	3.84						

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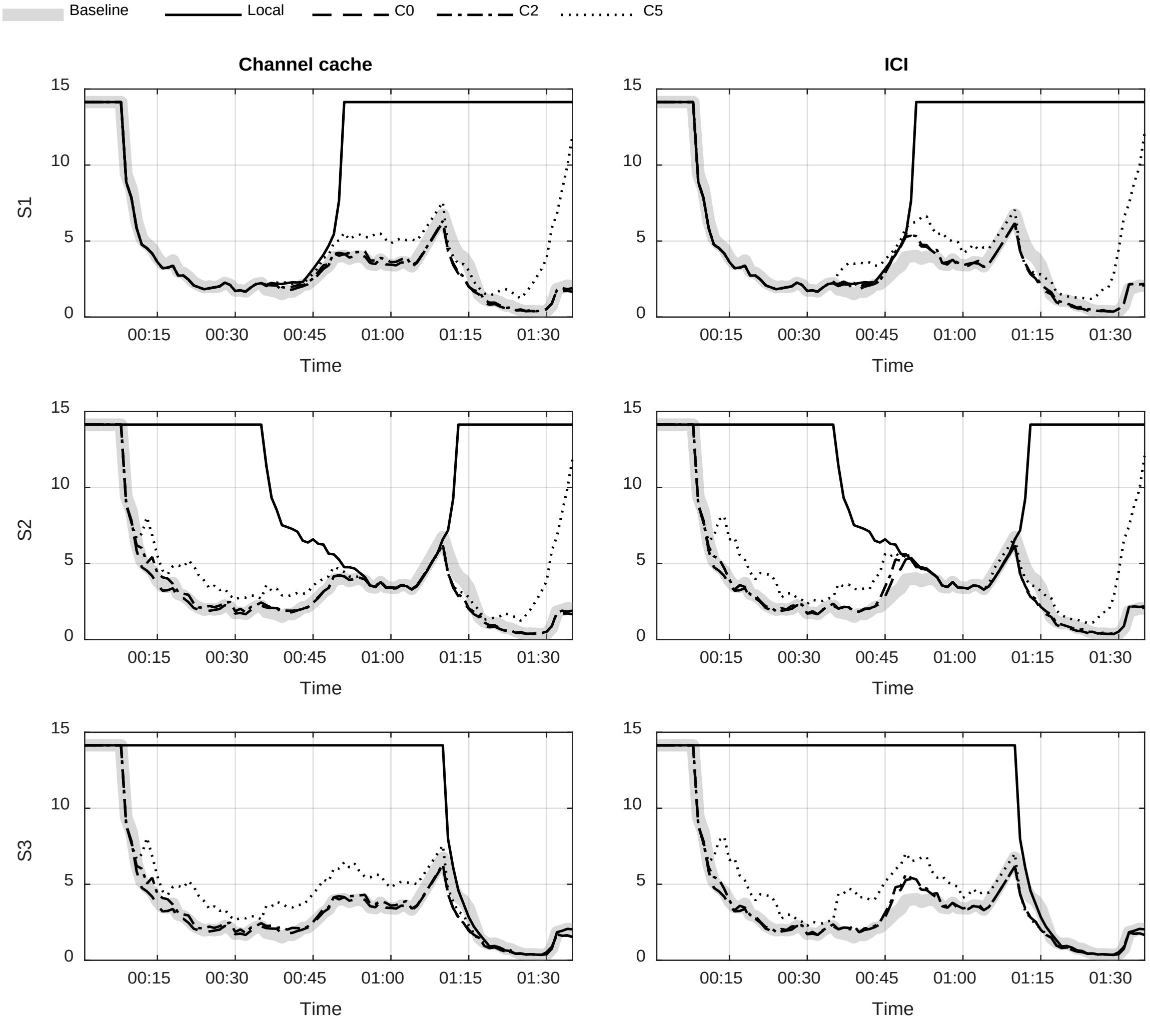
Baseline
Local
C0
C2
C5
Channel cache
ICI
S1
S2
S3
15
10
5
0
00:15
00:30
00:45
01:00
01:15
01:30
Time

Conclusions

- Benefits of decentralized fusion architecture for situational awereness
- A software simulation framework for decentralized networks
  - Track fusion
  - Communication
- Facilitate implementation and evaluation
  - Abstract object architecture
  - Tools for simulation
- Applied in a example case study

Thank you for your attention!

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