Localization Techniques for Underwater Acoustic Sensor Networks

based on: *Localization Techniques for Underwater Acoustic Sensor Networks*, M. Erol-Kantarcii, T. Mouftah.

Łukasz Farian

Department of Informatics
University of Oslo

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What is the UASN?

Underwater Acoustic Sensor Networks:

Group of sensors and vehicles deployed underwater and networked via acoustic links, performing collaborative tasks.

Current offshore applications:

- Environment monitoring,
- oil platform monitoring,
- disaster prevention,
- assisted navigation,
- distributed tactical surveillance,
- ...

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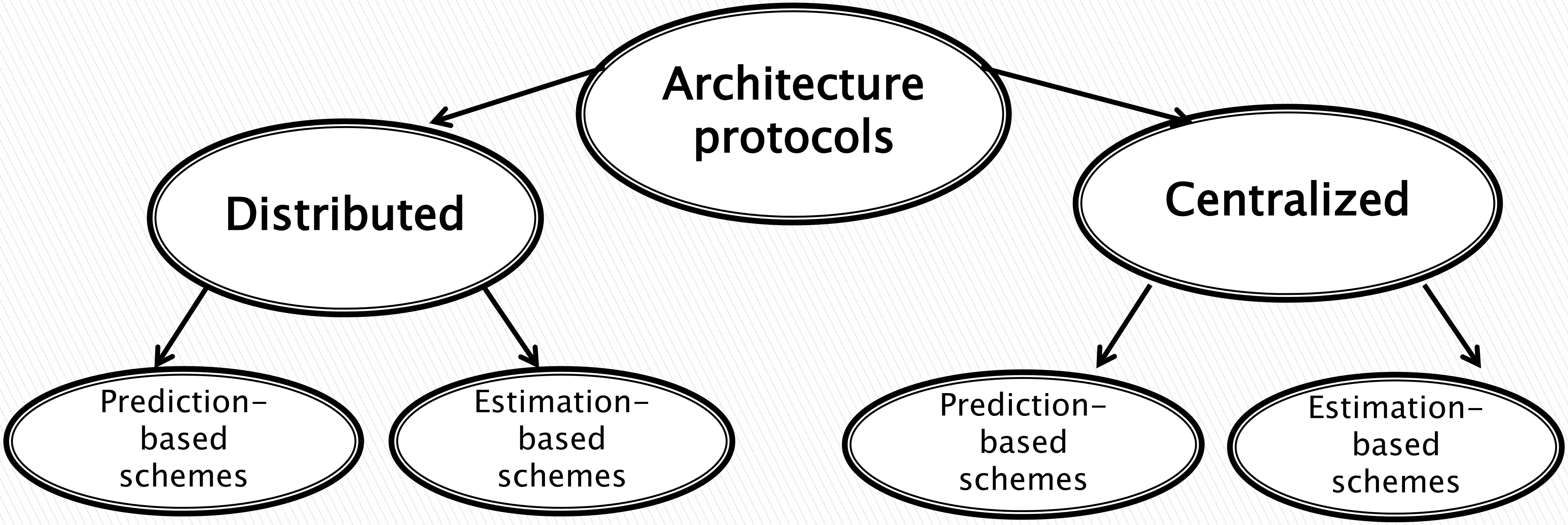
Challenges for UASN (1/2)

- Why acoustic signals?
  - more robust in water than radio or optical signals,
- Water as medium?
  - low data rate:
    - 1500 m/s acoustic signal speed in water,
  - low link quality:
    - multipatch signal propagation,
    - time variability of the medium,

Challenges for UASN (2/2)

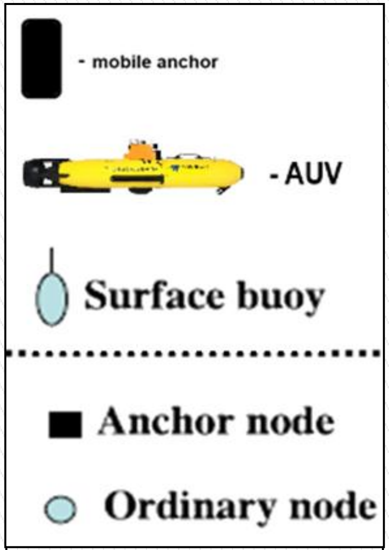
- Underwater Sensor Network:
  - hardly accessible environment ≈ expensive
  - human independent,
  - energy-limited:
  - not all nodes are fixed to position

New solutions proposed:



Necessary definitions:

- Communication:
  - silent,
  - iterative,
  - active,
- „Beacon” signal
- Time stamped signal
- ToA,
- TDoA.



UASN elements

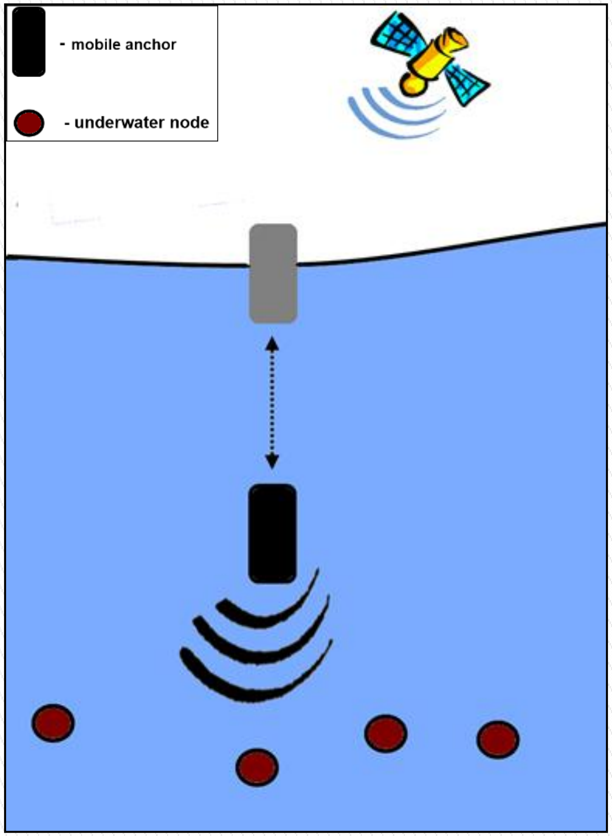
Distributed Localization Techniques:

Dive and Rise Localization
Multi Stage Localization
AUV-Aided Localization
Localization with Directional Beacons
Large Scale Localization
Underwater Positioning Scheme
Large Scale Localization-Scheme
Scalable Localization with Mobility Prediction

The Dive and Rise Localization (DNRL):

- ❑ energy efficient
- ❑ accurate estimate
- ❑ high coverage

- ❑ expensive
- ❑ non-homogenous
- ❑ slow



	Distributed/ Centralized	Estimation/ Prediction	Anchor type	Ranging method	Communication	Synchronization
DNRL [3]	Distributed	Estimation	Non-propelled mobile anchors	ToA (one-way ranging)	Silent	Yes

Distributed Localization Techniques:

- Dive and Rise Localization
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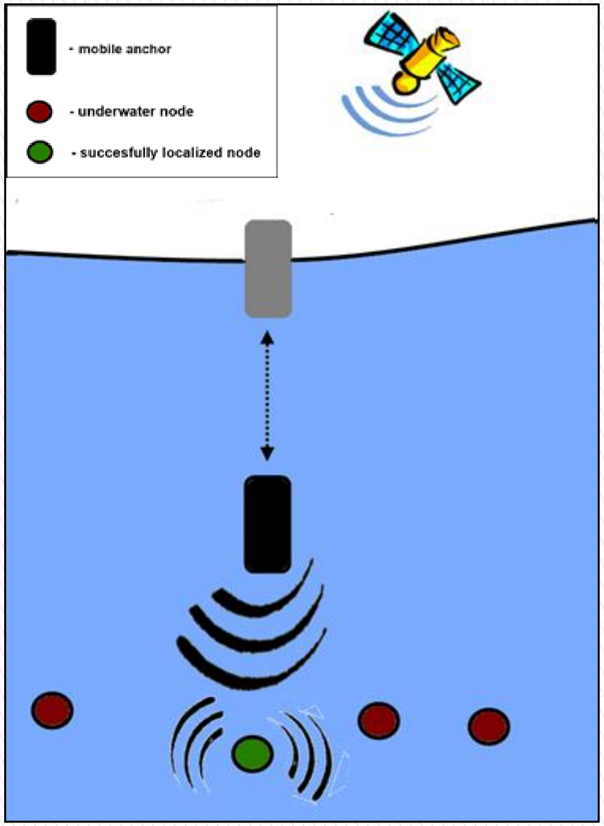
The Multi Stage Localization (MSL):

- ❑ high coverage
- ❑ more homogenous
- ❑ faster

- ❑ error accumulation
- ❑ less energy efficient
- ❑ expensive



	Distributed/ Centralized	Estimation/ Prediction	Anchor type	Ranging method	Communication	Synchronization
MSL [4]	Distributed	Estimation	Non-propelled mobile anchors and reference nodes	ToA (one-way ranging)	Iterative	Yes

Distributed Localization Techniques:

- Dive and Rise Localization
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- **AUV-Aided Localization**
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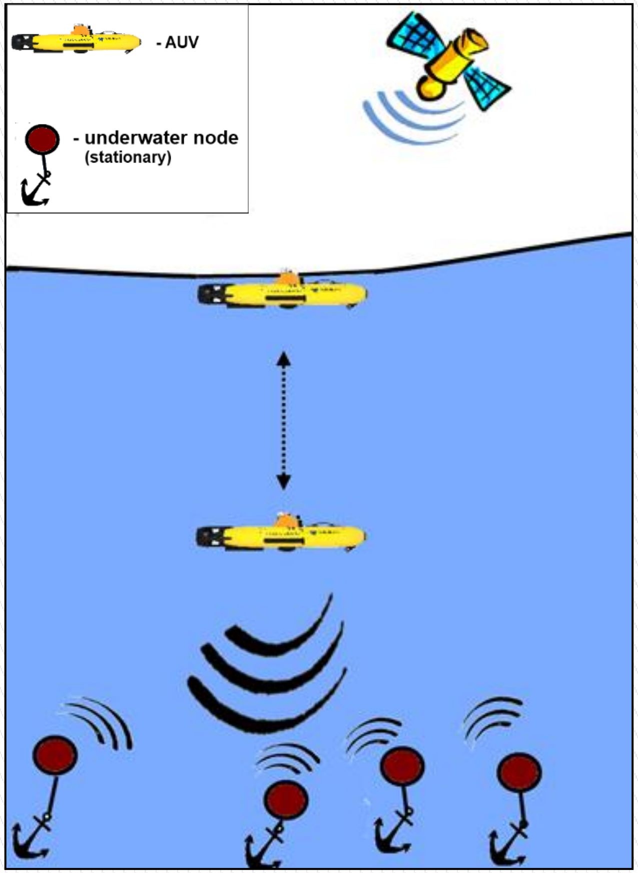
The AUV-Aided Localization (AAL):

- ❑ high coverage

- ❑ error accumulation
- ❑ communication overhead
- ❑ slow
- ❑ low accuracy
- ❑ low energy efficient
- ❑ expensive



	Distributed/ Centralized	Estimation/ Prediction	Anchor type	Ranging method	Communication	Synchronization
AAL [5]	Distributed	Estimation	Propelled mobile anchor (AUV)	ToA (two-way ranging)	Silent	No

Distributed Localization Techniques:

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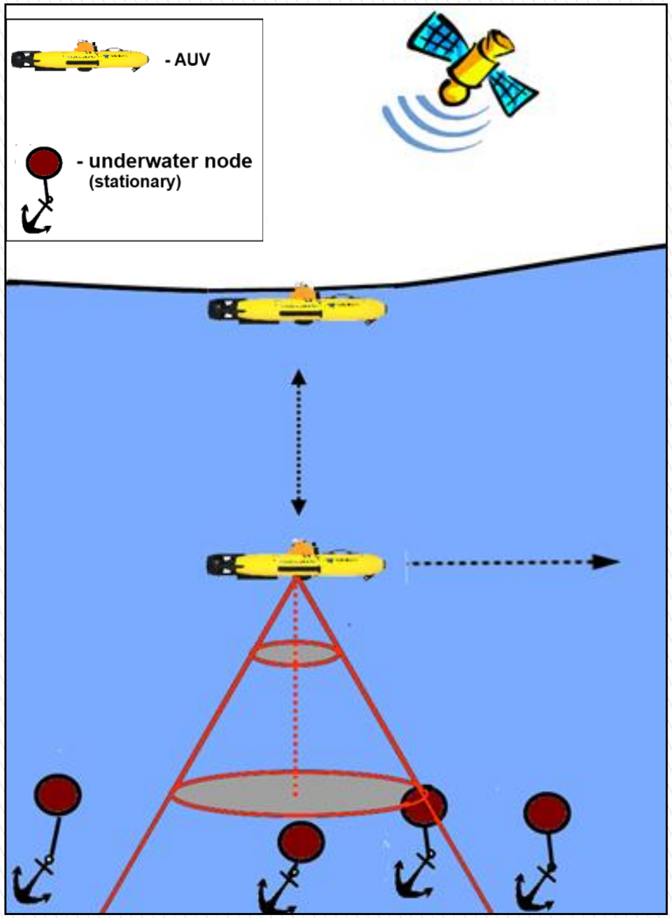
The Localization with Directional Beacons (LDB):

- ❑ no synchornization
- ❑ cost-effective
- ❑ range-free
- ❑ energy efficient

- ❑ low accuracy
- ❑ slow
- ❑ unrealistic solution



	Distributed/ Centralized	Estimation/ Prediction	Anchor type	Ranging method	Communication	Synchronization
LDB [6]	Distributed	Estimation	Propelled mobile anchor (AUV)	Range-free	Silent	No

Distributed Localization Techniques:

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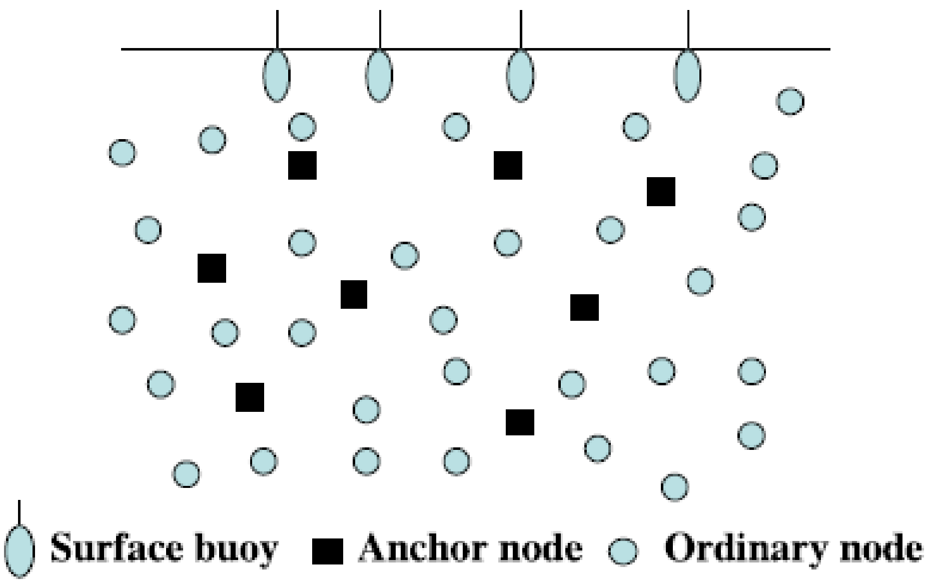
The Large Scale Localization (LSL) (1/2):

- hierarchical localization scheme
- only anchor nodes can communicate with boys
- ordinary nodes can communicate only with anchor nodes
- confidence value estimated

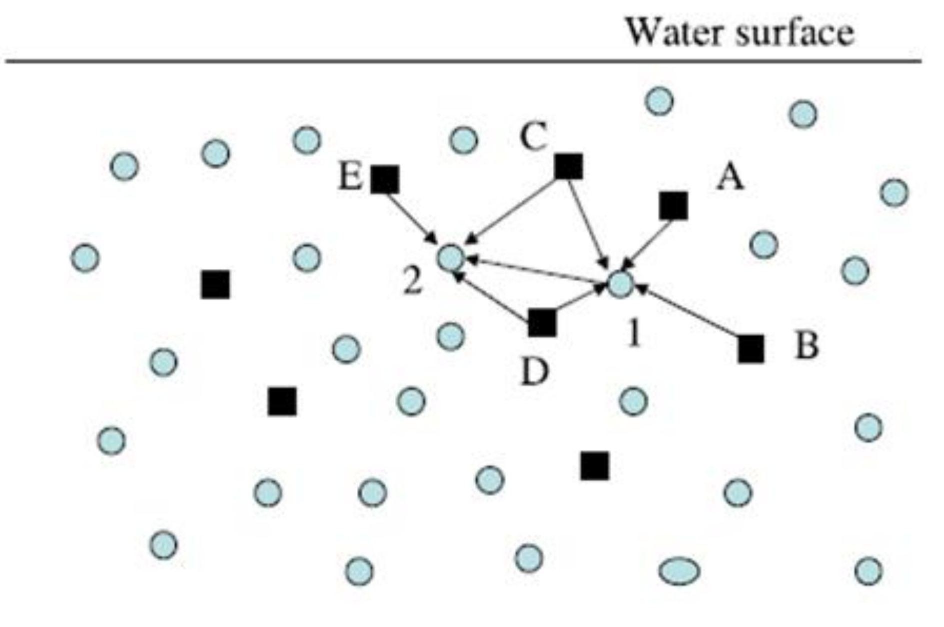


	Distributed/ Centralized	Estimation/ Prediction	Anchor type	Ranging method	Communication	Synchronization
LSL [7]	Distributed	Estimation	Surface buoys, underwater anchors, and reference nodes	ToA (one-way ranging)	Iterative	Yes

The Large Scale Localization (LSL) (2/2):

- ❑ Large scale

- ❑ not energy efficient
- ❑ overhead communication
- ❑ complex solution



Recursive location estimation

	Distributed/ Centralized	Estimation/ Prediction	Anchor type	Ranging method	Communication	Synchronization
LSL [7]	Distributed	Estimation	Surface buoys, underwater anchors, and reference nodes	ToA (one-way ranging)	Iterative	Yes

Distributed Localization Techniques:

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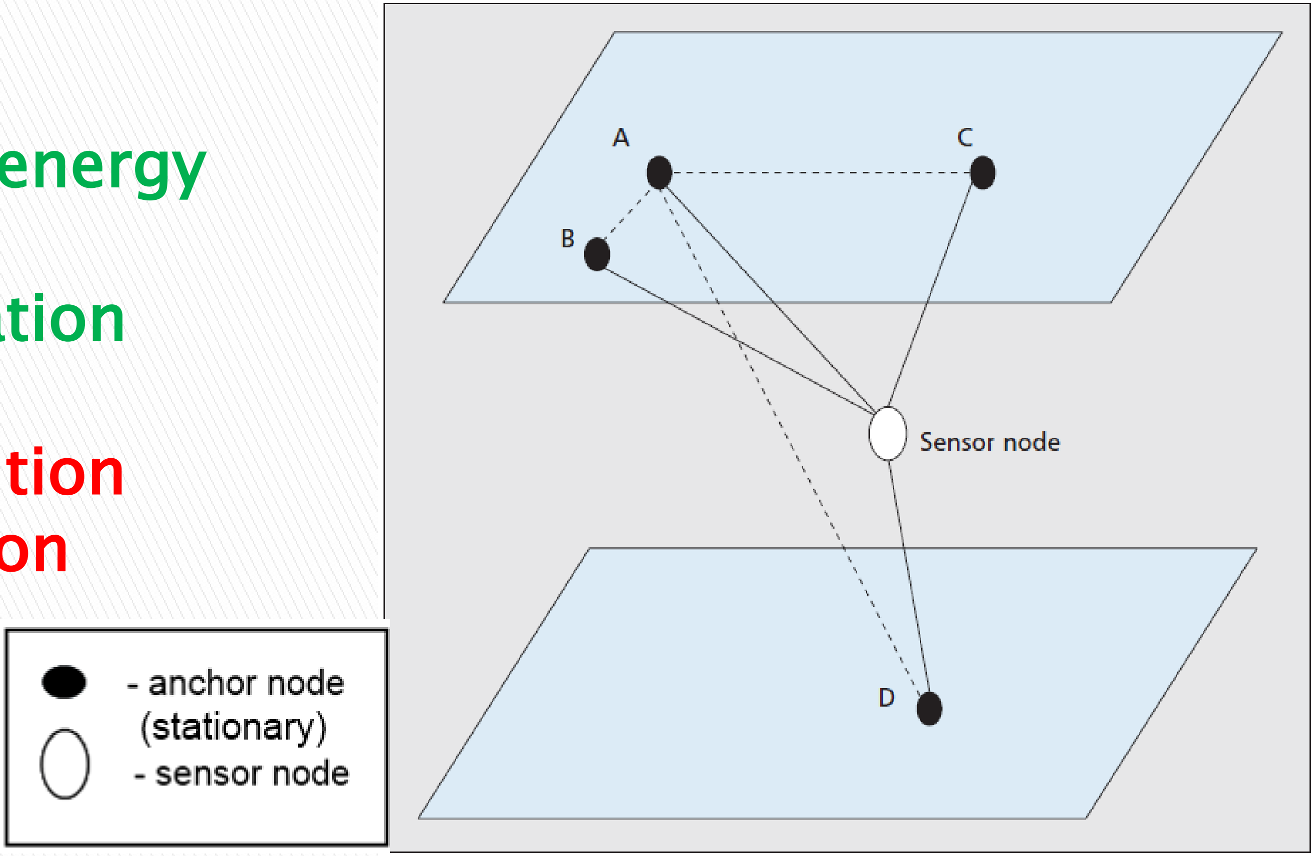
The Underwater Positioning Scheme (UPS):

- relateviley low energy consumption
- no synchronization

- unrealistic solution
- complex solution



The UPS scheme using TDoAs of beacon signals from four anchors.

	Distributed/ Centralized	Estimation/ Prediction	Anchor type	Ranging method	Communication	Synchronization
UPS [9]	Distributed	Estimation	Stationary anchors	TDoA	Silent	No

Distributed Localization Techniques:

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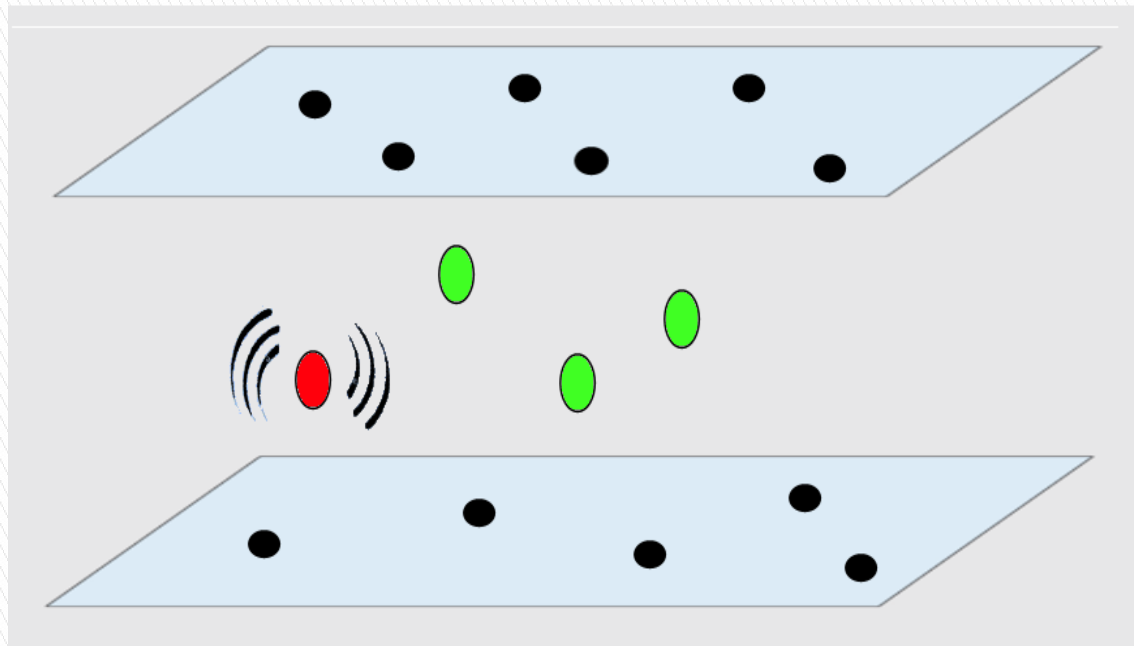
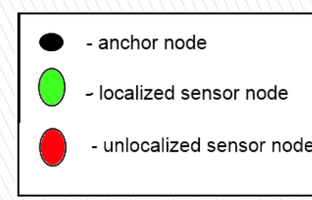
The Large-Scale Localization Scheme (LSLS):

- LSLS = UPS + complementary phase
- large-scale localization
- higher overhead
- higher energy consumption





	Distributed/ Centralized	Estimation/ Prediction	Anchor type	Ranging method	Communication	Synchronization
LSLS [10]	Distributed	Estimation	Stationary anchors and reference nodes	TDoA	Iterative	No

Distributed Localization Techniques:

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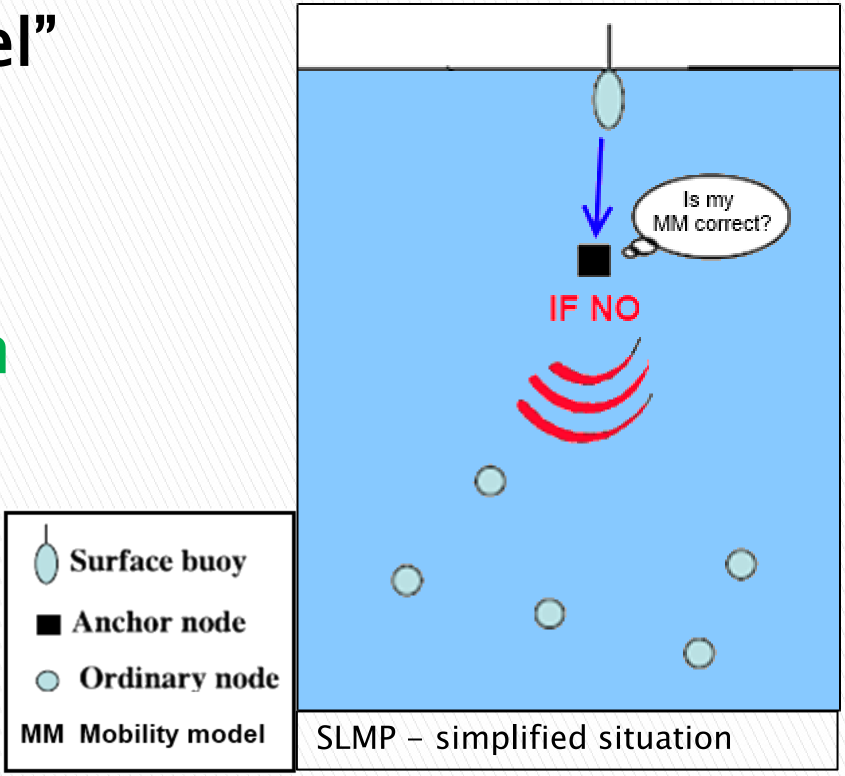
- **Scalable Localization with Mobility Prediction**

The Scalable Localization with Mobility Prediction (SLMP):

- ❑ SLMP = LSL + „mobility model"
- ❑ based on correleted motion
- ❑ low overhead communication
- ❑ unexplored solution



SLMP – simplified situation

	Distributed/ Centralized	Estimation/ Prediction	Anchor type	Ranging method	Communication	Synchronization
SLMP [12]	Distributed	Prediction	Surface buoys, underwater anchors, and reference nodes	ToA (one-way ranging)	Iterative	Yes

Centralized Localization Techniques:

- Proposed **Centralized localization techniques are unsuitable for UASN** becasue they do not suport realtime location information,

- but... there can be found some specific applications scenarios, e.g.: Colaborative Localization (CL) for research of depths of oceans.

Conclusion (1/2):

- localization **vs.** energy-efficiency:

The better localization accuracy -> the worse energy-efficiency
The worse localization accuracy -> the better energy-efficiency

- one-way ranging **vs.** two-way ranging:

Two-way ranging spends more energy, but one-way ranging requires synchornization.

- centralized **vs.** distributed schemes:

centralized schemes are less flexible, but they are computationally light

Conclusion (2/2):

- Prediction-based **vs.** estimation-based schemes:

Prediction-based schemes have better performance and lower overhead and are energy-efficient, but they have not been examined properly yet.

Estimation-based solution is simplier.

There is no winner and there is no looser – solution suitability depends on a specific application.

Paper criticism:

Localization Techniques for Underwater Acoustic Sensor Networks, M. Erol-Kantarcii, T. Mouftah:

- ❑ insufficient basic explanations (even for survey)
- ❑ no simple pictures
- ❑ not evaluated multipatch signal propagation and time variabilty problems (even not mentioned)

- ❑ illustrative table with fundamental properties of the surveyed techniques

Literature

M. Erol-Kantarcii, T. Mouftah, Localization Techniques for Underwater Acoustic Sensor Networks, *Sema Oktug, Istanbul Technical University*

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Online source: http://www.argo.ucsd.edu/

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