MAPPING THE POSITIONS OF POINT SCATTERERS

Dissemination Day
Barcelona, March 31st 2009

Luca Reggiani
CNIT-Milano (Politecnico di Milano - Italy)

Mats Rydström, Erik G. Ström, Arne Svensson
Chalmers University of Technology, Goteborg (Sweden)

Applications

The goal is to create an algorithm for locating point scatterers and/or relays using a wide-band wireless network.

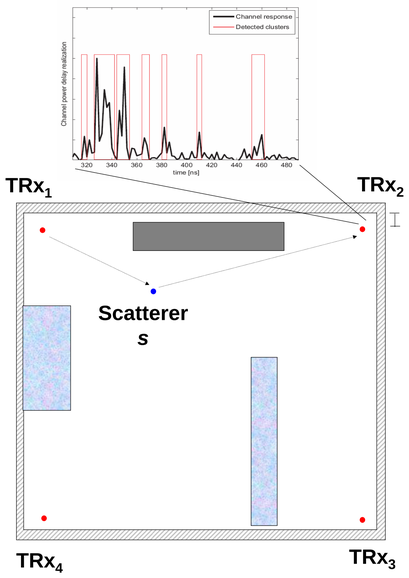
Potential applications numerous:

- advanced and inexpensive intrusion-detection / monitoring systems
- tracking of passive objects in, e.g., industrial environments
- positioning and tracking of persons in critical or emergency conditions
- mechanisms of environment-learning for improving communication in networks with many sensors (channel estimation and mapping)

Scenario

Detection of **new scattering objects** in an environment → Signal component clustering and path length estimation

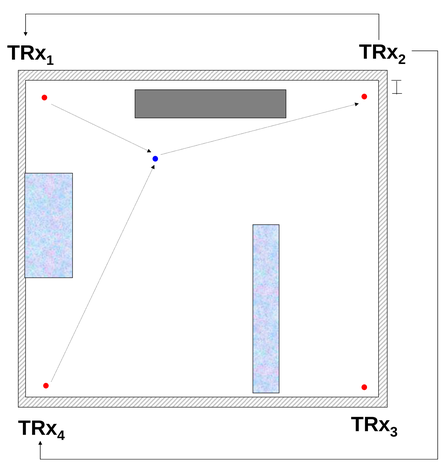
Standard system



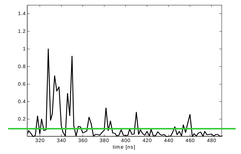
System with response enhancement (beamforming)

PN preamble sequence at TRx_4 is chosen and shifted for enhancing the received energy between TRx_1 and TRx_2.

Feedback channels (e.g. wired)



Clusters estimation



Hard version

Threshold

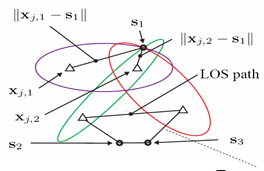
Clusters are formed as groups of consecutive samples classified as signal components.

Soft version

- Each output sample y_n is associated with an **approximate probability** P_n that a signal component is present at the given delay.
- Separate clusters are then formed by investigating signal content probabilities at adjacent correlator samples.
- Each cluster is selected according to its overall estimated probability.

By tuning the parameters in the two versions of the algorithm, we are able to control the number and average time duration of the clusters that are used for path length estimation.

Mapping algorithm



Error sources

A propagation length measured between a pair of transceivers should correspond to

$$d_j(\mathbf{s}) = \|\mathbf{x}_{j,1} - \mathbf{s}\| + \|\mathbf{x}_{j,2} - \mathbf{s}\|$$

First step: solution of an assignment problem, where sub-sets of all available multipath distance estimates from the transceiver pairs are assigned to a number of point scatterers at unknown location.

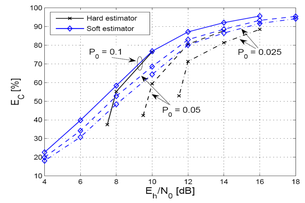
Second step: estimate of the scatterer position (e.g. by means of weighted least-squares or WLS)

$$\hat{\mathbf{s}}_i = \min_{\mathbf{s}\in\mathbb{R}^d} \|\hat{\mathbf{d}}_i - \mathbf{d}(\mathbf{s})\|^2_{\mathbf{W}}$$

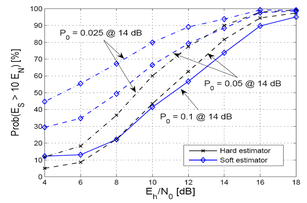
M. Rydstrom, E. G. Strom, A. Svensson, and L. Reggiani, "An algorithm for positioning relays and point scatterers in wireless systems," *IEEE Signal Processing Letters*, vol. 15, pp. 381–384, 2008.

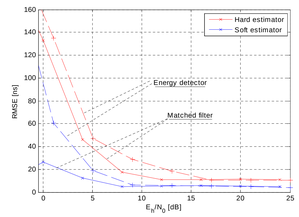
Numerical results

Captured cluster energy with parameters optimized at each E_h/N_0

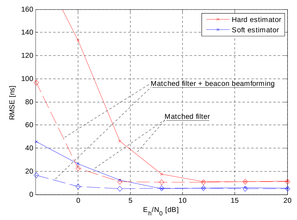


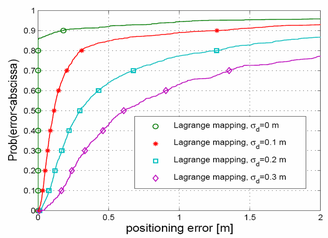
Robustness to non optimal parameters. E_S and E_N are the signal and noise energies in the estimated clusters.





RMSE for different architectures





Impact of RMSE on positioning

J = 5 transceiver pairs
L = 3 scatterers.