Estimation of Channel Utilization at the Beacon Edge

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Problem statement

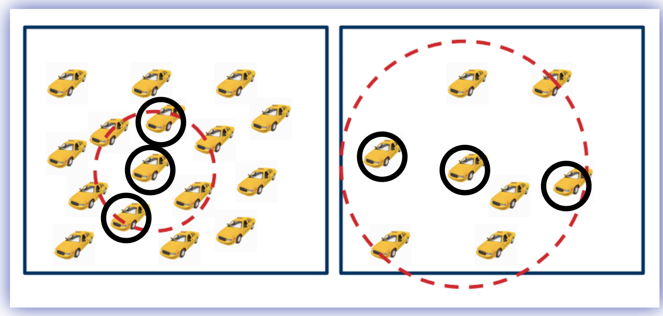
Estimating channel utilization at beacon edge is important, so that power control feedback can be based on comparing this utilization rate to a target level.

The beacon edge channel utilization estimate presented in the "Resource Sharing Principles for Vehicular Communications" paper* is revised with the following aspects:

- taking an estimate of link asymmetry into account
- interpolating on link attenuation metric instead of distance metric

*: Kovacs, A.: "Resource Sharing Principles for Vehicular Communications", *IEEE Communications Society AutoNet conference*, December 2008.

Definition of algorithm input nodes



To perform the estimation, three nodes are selected from location table:

1. Ego node (*EN*): this own measured data

2. Node with highest link attenuation(*HLA*): among all beacon sources, this is the one with highest link attenuation level, meaning highest Tx_{beacon} - Rx_{beacon} difference. In case of multiple nodes with same attenuation measurement, the node with furthest geometric distance is selected among these.

3. Furthest opposite node from *HLA* node (*FO*): the third selected node must be a far away node in the opposite direction as *HLA* node. In this case geometric assessment must be used; the node is selected from location table whose distance to *HLA* node is largest.

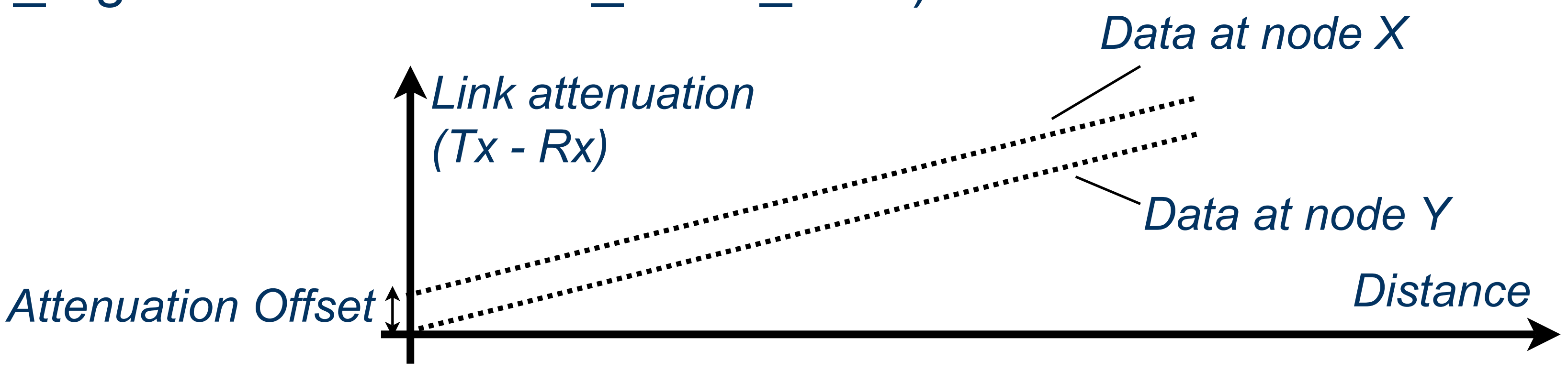
Generated input measurement

The following input data is required to be included in beacon data:

1. Channel utilization (*CU*): the measured carrier sensing rate

2. Transmission power (*Tx*): the power level at which beaconing is transmitted.

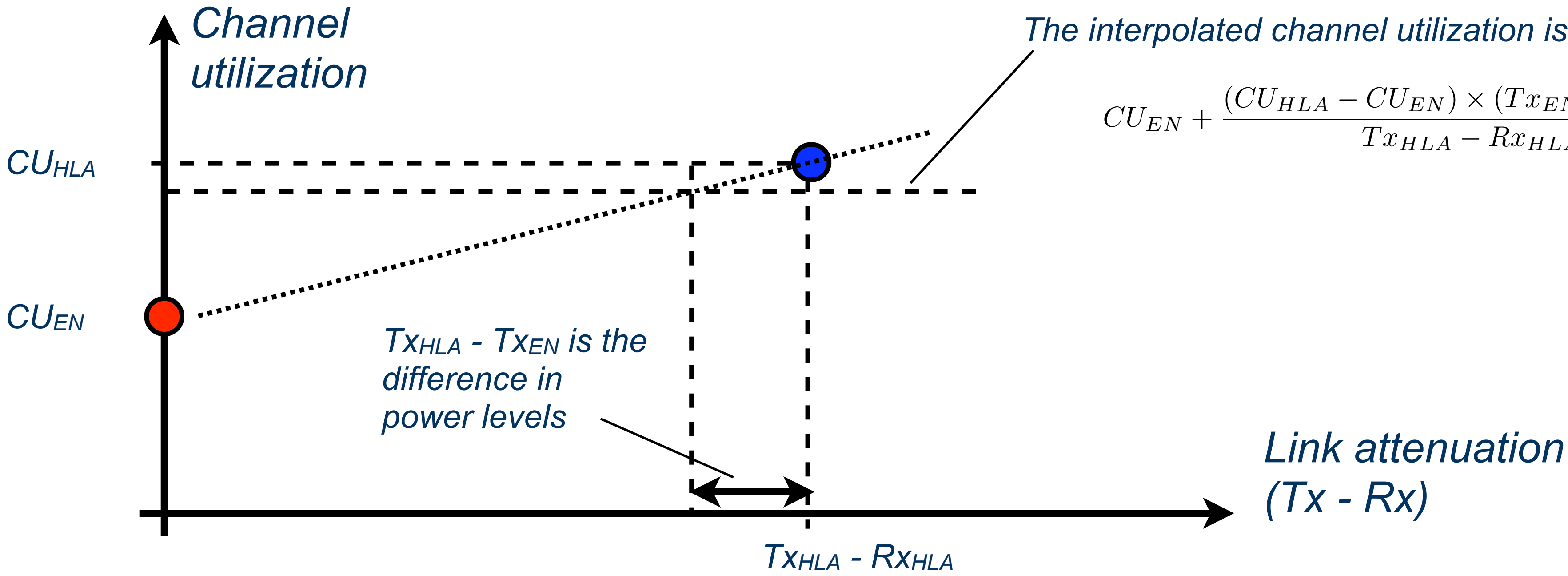
3. Estimated attenuation offset (*AO*): the link attenuation level (Tx_{beacon} - Rx_{beacon}) of received beacons versus distance is a line crossing the origin - in absence of nearby attenuators. Nearby obstacles are causing attenuation offset; this value is used for broadcast asymmetry estimation. The average steepness of attenuation versus distance is about the same for all nodes in a given area. Attenuation offset can be calculated from received beacon data through linear regression (see: http://en.wikipedia.org/wiki/Linear_regression#Univariate_linear_case).



When these data are used on following slides, the subscript indicates the related node (e.g.: AO_{HLA}).

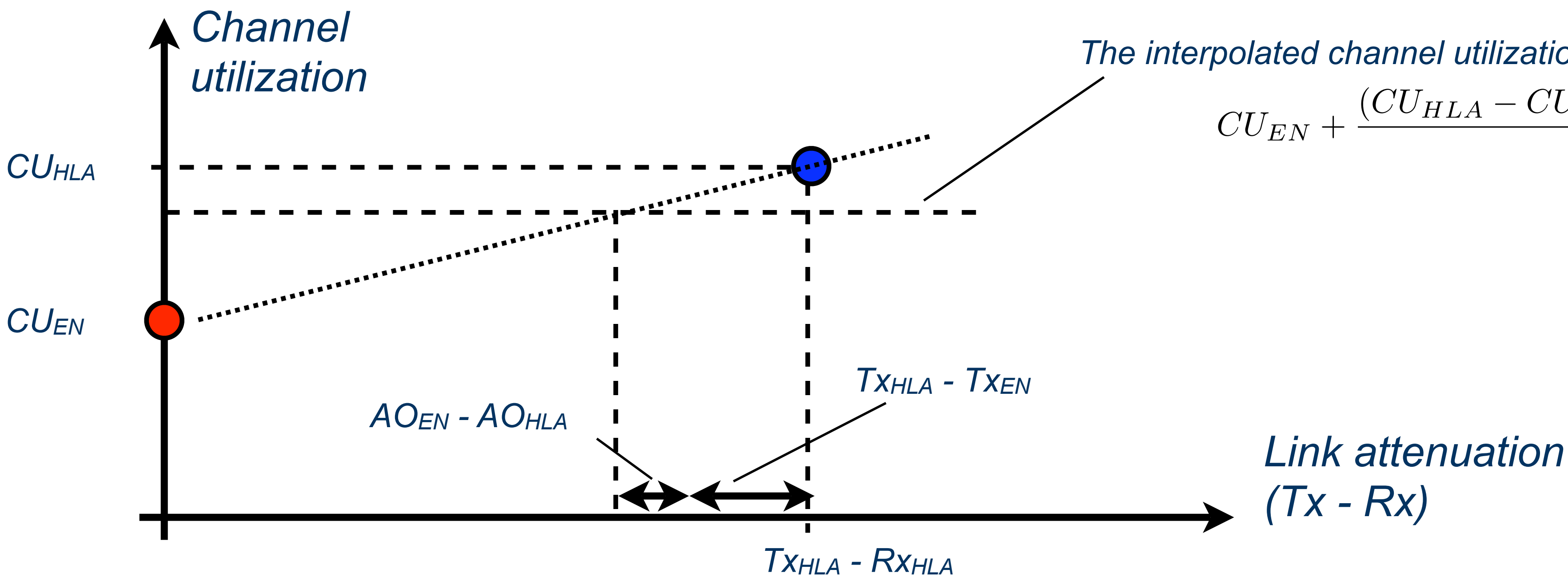
Estimation of channel utilization in one direction

Taking just the difference in transmission levels into account, the estimation of channel utilization is following:



$$CU_{EN} + \frac{(CU_{HLA} - CU_{EN}) \times (Tx_{EN} - Rx_{HLA})}{Tx_{HLA} - Rx_{HLA}}$$

Taking also possible asymmetry of the channel into account, the estimation of channel utilization is following:



$$CU_{EN} + \frac{(CU_{HLA} - CU_{EN}) \times (Tx_{EN} - Rx_{HLA} + AO_{HLA} - AO_{EN})}{Tx_{HLA} - Rx_{HLA}}$$

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Estimation of channel utilization in both directions

Accounting for both HLA and FO nodes, the final formula channel utilization rate at beaconing edge is the average of the interpolation at these two nodes:

$$CU_{EN} + \frac{(CU_{HLA} - CU_{EN}) \times (Tx_{EN} - Rx_{HLA} + AO_{HLA} - AO_{EN})}{2 \times (Tx_{HLA} - Rx_{HLA})} + \frac{(CU_{FO} - CU_{EN}) \times (Tx_{EN} - Rx_{FO} + AO_{FO} - AO_{EN})}{2 \times (Tx_{FO} - Rx_{FO})}$$

Power control feedback can be based on comparing target channel utilization rate with against value derived from above formula.