Project: IEEE P802.15 Working Group for Wireless Personal Area Network (WPAN)

Submission Title: [Removing the effect of the antenna beam pattern from the angular-temporal measurements]

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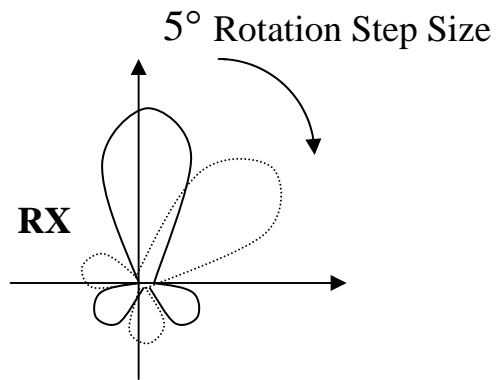**Re:** [Response to the TG3c channel model subgroup call for channel models]

Abstract: [Removing the antenna effect from the NICT measurement data]

Purpose: [Contribution to 802.15 TG3c at the Jan. 2007 meeting in London, UK]

Measurement Process
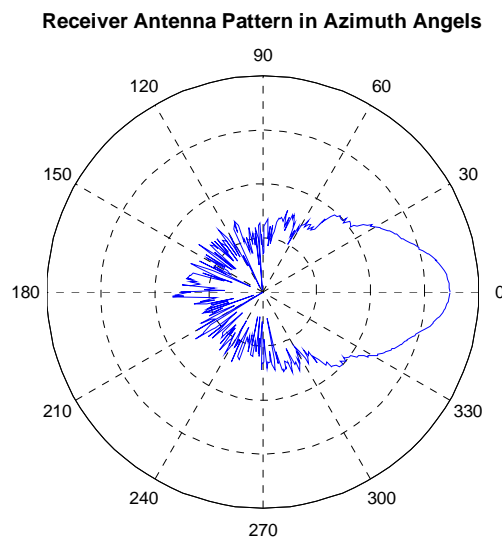

5° Rotation Step Size

RX

The measured data at the receiver is affected by the:

- Transmitted pulse and limited bandwidth of the receiver (windowing, pulse shaping, etc)
- Receiver antenna beam patterns
- Rotation of the receiver antenna

Angular & Temporal Response
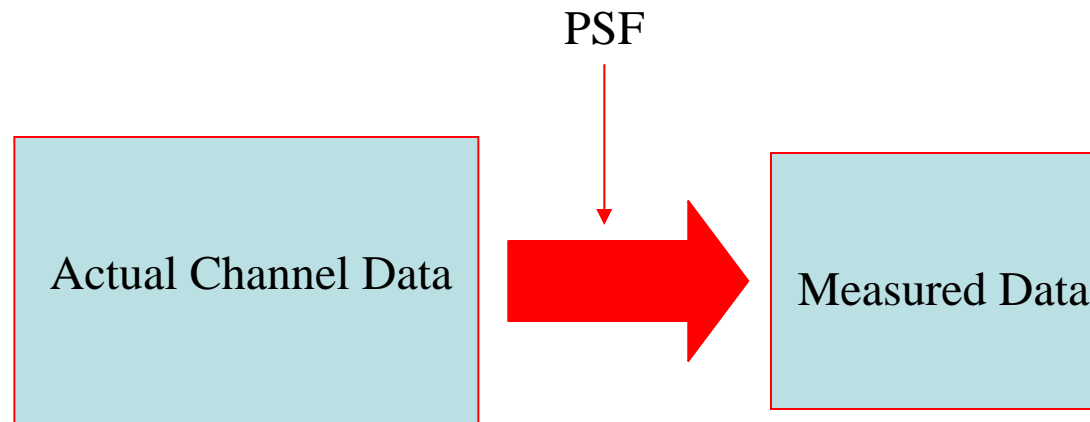
Angular Response in LOS direction
(Normalized)

Temporal Impulse Response in LOS direction
(Normalized)

Receiver Antenna Pattern in Azimuth Angels
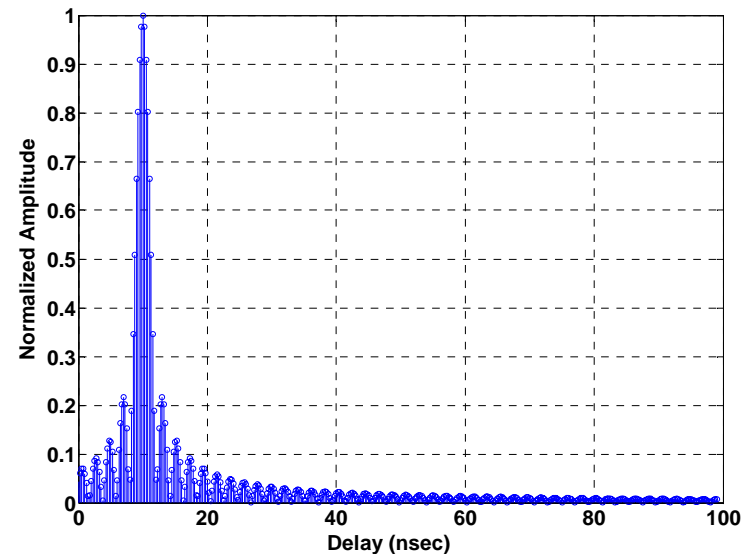
Example antenna pattern used at NICT measurement（62.5GHz center frequency and & 15°beamwidth）

Modeling the Measurement Process

PSF

Actual Channel Data
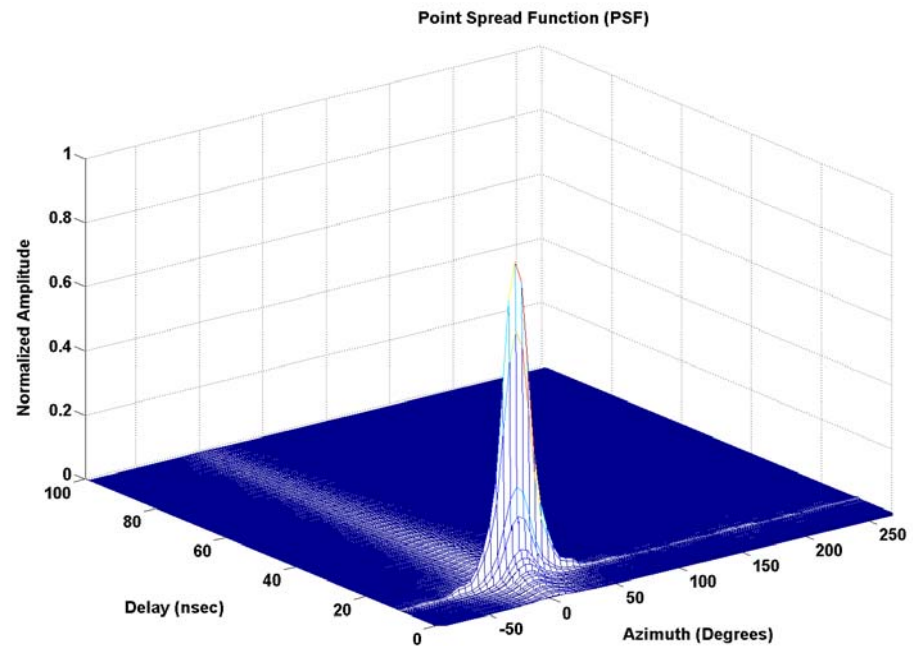
Measured Data

- The measurement process can be modeled as a collection of point sources blurred by Point Spread Function (PSF) and corrupted by additive noise.
- This reduces the problem of identifying exact times and angles of arrival to a two-dimensional (2-D) deconvolution.

Point Spreading Function

The PSF or impulse response of the system was generated by setting up the data acquisition system in a line-of-sight (LOS) environment with a high SNR and no reflections in the vicinity of the direct path.
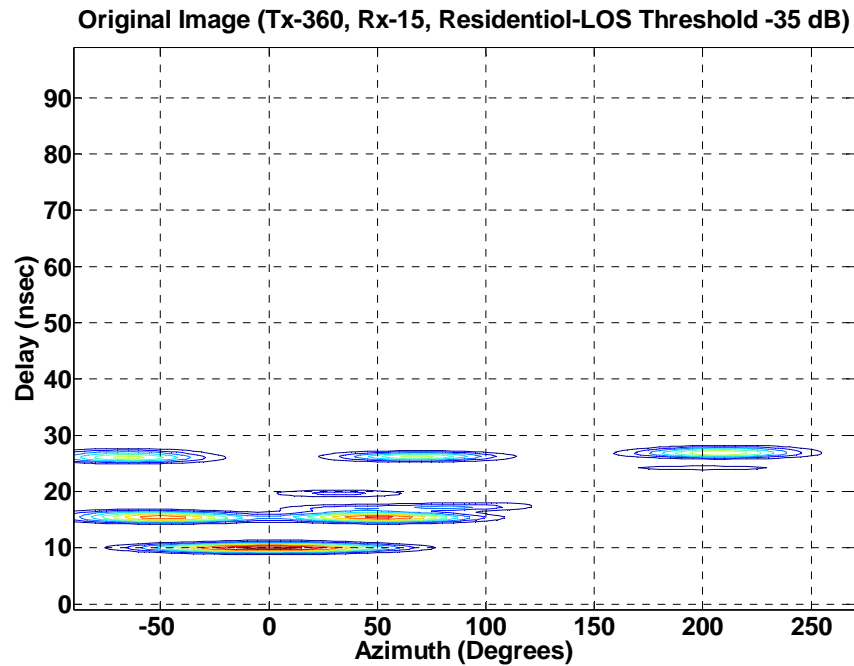

Point Spread Function (PSF)
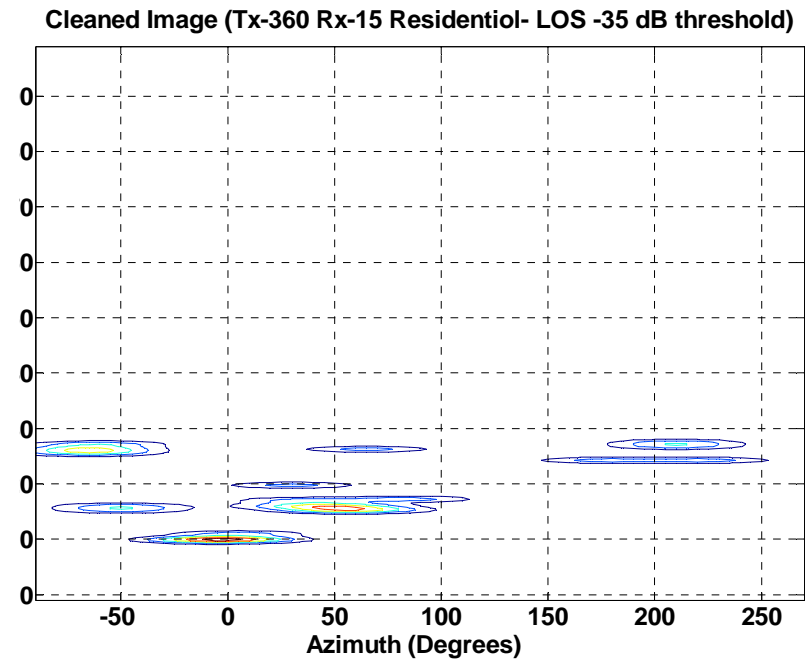
Possible Methodologies

- **Blind deconvolution**
  - This technique deconvolves the measured data with an initial PSF using the maximum likelihood algorithm

- **Lucy-Richardson deconvolution**
  - It is based on maximizing the likelihood of the resulting cleaned arrivals under the assumption of Poisson noise statistics in the original data

- **CLEAN algorithm**
  - CLEAN algorithm is essentially a recursive subtraction of the shifted PSF from the original data
  - Need to fine tune and locally normalize the noise floor for constant false alarm detection
  - A good approach when the PSF is known with reasonable accuracy

Example of the CLEAN-ed Data

Original

Cleaned

Original Image (Tx-360, Rx-15, Residentiol-LOS Threshold -35 dB)

Cleaned Image (Tx-360 Rx-15 Residentiol- LOS -35 dB threshold)

Example of the CLEAN-ed Data (2)

Original

Cleaned

Original Image (Tx-360, Rx-15, Office-NLOS)

CLEAN-ed Image (Tx-360, Rx-15, Office-NLOS)
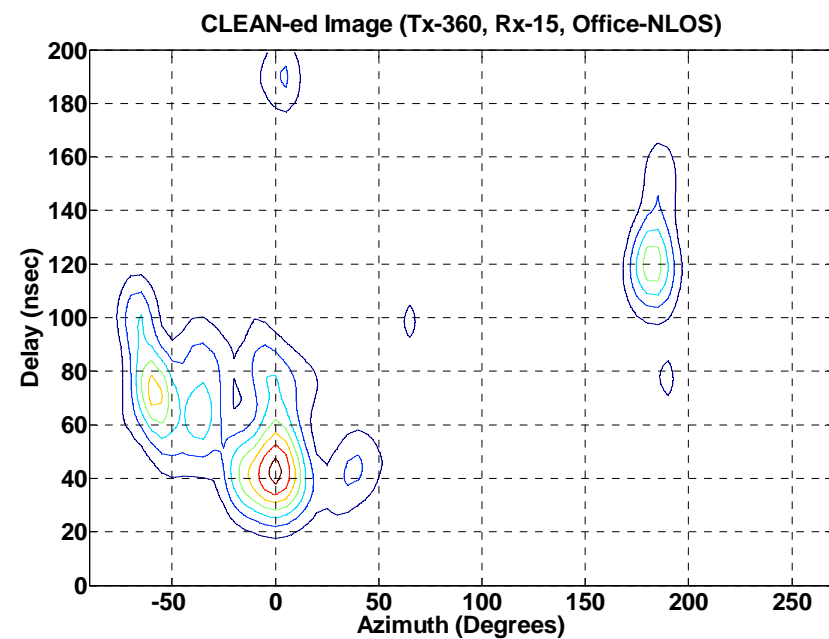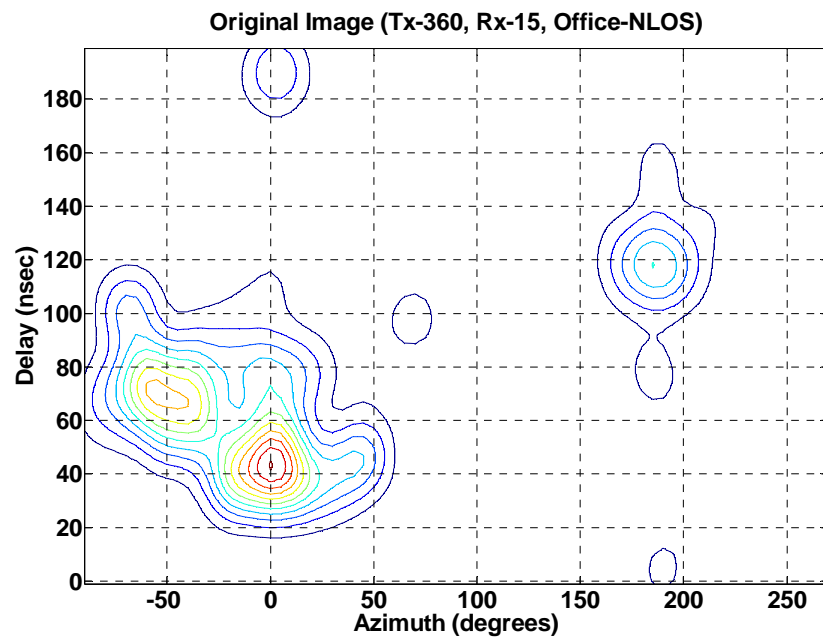
Conclusions

- Effect of the receiver antenna gain pattern can be removed by using a deconvolution algorithm such as CLEAN

- By cleaning the measured data, we can have a better estimate in:
  - Detecting the actual arrivals
  - Removing the false arrivals

- Cleaning the measured 2D data reduces the size of the observed clusters (lower cluster angular and delay spread)

- Cleaning the measured 2D data could in general increase or decrease the number of the observed clusters

References

❑ Hirokazu Sawada, Yozo Shoji, Hiroyo Ogawa, "Angle of Arrival Measurement in Home and Office Environments", National Institute of Information and Communications Technology (NICT), Japan, doc# IEEE 802.15-06-0012-01-003c

❑ J.A. Högbom, "Aperture Synthesis with Non-Regular Distribution of Interferometer Baselines", Astronomy and Astrophysics, 15:417, 1974

❑ K. Sayrafian, B. Neekzad, J. Perez, John S. Baras, "Ray-Tracing Simulation of the NICT Channel Measurements", IEEE Standard 802.15.3c mm-Wave channel modeling subgroup doc. # IEEE 802.15-06-0326-00-003c July 2006