NYU | TANDON SCHOOL OF ENGINEERING

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Title: **Proposal for Improved RMa model and upgraded open source channel simulator**

Source: NYU WIRELESS
To: 3GPP TSG RAN WG1
Cc: 3GPP TSG RAN

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Attachments: NYU Rural Macrocellular (RMa) Model for above 6 GHz and Measurement Slides

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1. Introduction:

NYU WIRELESS (http://nyuwireless.com/) has conducted extensive 73 GHz Rural Macrocellular (RMa) measurements beyond 10 km distances, in concert with a detailed study of the currently published ITU-R and 3GPP RMa Models. In this liaison contribution (which will be given as a keynote speech and published on October 7, 2016, at the ACM MobiCom “All things cellular” workshop in New York City), we show that the current TR 38.900 RMa path loss model is unusable above 9.1 GHz, and has not been proven by measurements. We offer results of the first known detailed propagation study for RMa scenarios at 73 GHz, and provide a much simpler and more accurate path loss model for RMa scenarios, based on the physically-motivated 1 m free space reference distance. We contend that an improved RMa path loss model is needed in TR 38.900 to correct the existing mathematical errors in the current RMa model.

NYU shows in the attached power point presentation that the current 3GPP RMa model published in TR 38.900 - http://www.3gpp.org/DynaReport/38900.htm - is not only very complicated, but is also *mathematically invalid* and not usable above 9.1 GHz, and furthermore was not validated by extensive measurements over meaningful distances at millimeter wave (mmWave) frequencies. The mathematical error in the present TR 38.900 RMa model is caused by the LOS breakpoint (see: TR 38.900, RMa LOS and NLOS models on page 24, and footnote 5 on page 25), and stems from the fact that this RMa path loss model was likely transcribed from the ITU-R M.2135 path loss models developed nearly a decade ago for frequencies below 6 GHz.

The attached power point presentation offers a new, more accurate, much simpler, and physically-based RMa model that can be used to replace (or inserted as an option to) the existing RMa models published in TR 38.900 for LOS and NLOS. The attached slides also offer concrete evidence, from measured data, showing the validity of the proposed RMa models. The results from these slides will be published in the upcoming paper:

> **G.R.MacCartney, S.Sun, and T.S. Rappaport, “Millimeter Wave Wireless Communications: New Results for Rural Connectivity,” 5th Workshop on All Things Cellular Proceedings; in conjunction with ACM MobiCom, Oct.7, 2016, New York City.**

The attached slides develop a much simpler RMa path loss model that is valid across the entire 500 MHz to 100 GHz range and is proven from field measurements at 73 GHz and simulations from 1 to 73 GHz. The key to this model is that it uses a simple free space factor that is dependent upon frequency in the first meter of propagation, similar to the optional models recently approved for UMi, UMa and InH in TR38.900.

The RMa models we have developed for this LS are supported in the attached presentation, and are given by:

LOS: PL(d, f)_dB= 32.4+ 21.6log (d) + 20 log (f); std dev= 4 dB for d > 1 m, f is in GHz and d is in meters.
NLOS: PL(d, f)_dB = 32.4+27.5log(d) + 20 log (f); std dev = 8 dB for d > 1 m, f is in GHz and d is in meters.

The above two expressions are valid, mathematically, over the entire frequency range from 500 MHz to 100 GHz, and benefit from a path loss exponent that is not frequency dependent (n=2.16 in LOS and n=2.75 for NLOS) over all frequencies, as was also shown to be the case in UMa scenarios. The models may be used from 1 meter to 12 km distance. Rain and frequency-dependent absorption are easily added to these models.

We suggest that 3GPP consider adopting the above “close–in free space” models for RMa, at least as an option to its existing RMa model which is not defined above 9.1 GHz, is not validated, and is overly complex.

Our study into the RMa modeling issue was originated by first doing simulations of the ITU-R M.2135 model and matching it with a simpler CI model for RMa, as presented to NTIA in June 15, 2016, pages 25-30, as found here:

http://wireless.engineering.nyu.edu/presentations/NTIA-propagation-presentation-JUNE-15-2016_v1%203.pdf

The measurements described in the attached slides gave us further validation that the proposed close-in free space models are accurate over a very wide range of frequencies, and led us to make a very slight adjustment (from n=2.05 to 2.16 in LOS, and from n=2.78 to n=2.75 for NLOS) in the RMa path loss exponents to match the attached measured RMa data collected this month.

To assist the global wireless research community, NYU will release on August 19, 2016 version 1.3 of its open-source millimeter wave channel simulator, called NYUSIM, using the above new RMa model along with other enhancements that have been requested by users. NYUSIM produces realistic 3-D spatial and temporal channel impulse response for a vast range of frequencies, bandwidths, and antenna beamwidths. NYUSIM now includes atmospheric, polarization, foliage, and temperature/humidity variables as a function of frequency, and will update its RMa model to the above-proposed RMa model, to allow the use of the simulator in a wide range of urban and rural scenarios over the entire frequency range of 500 MHz to 100 GHz.

The NYUSIM simulator includes source and executable code and is free and open to the public for any type of use. The models used to create NYUSIM are given in the July 2016 IEEE Transactions on Microwave Theory and Techniques (T-MTT), available as an open source document here:
http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=7501500
The program may be used free of charge, all you need to do is include the NYU copyright notice in your code, and cite the July 2016 IEEE T-MTT paper and the above-mentioned October 2016 “All things cellular” paper when using the software. To access this new release of NYUSIM on August 19, and to view the user manual, please visit the NYU WIRELESS research page at:
http://wireless.engineering.nyu.edu/5g-millimeter-wave-channel-modeling-software/

Various simulation parameters, and typical default values, are found from the literature and are cited in the NYUSIM user manual and implemented in the code. As one example, the values for foliage loss and polarization mismatch loss are set to default values of 0.4 dB/m foliage loss, and 25 dB cross pol. loss, respectively, as found in:
https://arxiv.org/pdf/1509.00436v1.pdf
All parameter values as well as the entire code base may be easily changed by the user.

NYU WIRELESS is able to provide this resource due to the generous support of our NYU WIRELESS Industrial Affiliate sponsors, and the National Science Foundation.

NYU WIRELESS is a multi-disciplinary academic research center at New York University in Brooklyn that combines NYU’s Tandon School of Engineering program with NYU’s School of Medicine and the Courant Institute of Mathematical Sciences, and offers a depth of expertise with unparalleled capabilities for the creation of new wireless networks, theories, circuits and systems, as well as new computational approaches and health care solutions for the wireless industry. We welcome inquiries from companies wishing to join the NYU WIRELESS Industrial Affiliates program.

2. Actions:

To RAN:

ACTION: **For your consideration**. The intention is to share the results of recent modelling and measurements that will correct errors in the existing 3GPP RMa model as it appears in TR 38.900, and to offer recently published results that may help in system and link-level simulations, as well as highlighting the use of these results in an improved version of an open source simulator discussed in a July 2016 IEEE T-MTT paper and in the upcoming October 2016 “All Things Cellular” paper that presents an archival paper based on the attached slides. NYU WIRELESS is pleased to offer a personal-use preprint of the October 2016 “All things cellular” paper to any interested party. The paper provides a detailed description of the RMa measurement campaign, as well as an in-depth analysis and historical study of the origins of the current RMa model.