An Estimation's Method at Most Attainable of Length Path in Fixed Broadband Wireless Access: Engineering-Maintenance of the Calculation

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Abstract - **Methods of the engineering evaluation at most attainable lengths of the part in fixed radio systems with detailed conclusion of the equation of distance is offered. It's discussed technological spare on expected Noise Margin (NM) on base 5-th balls scale criterion Mean Opinion Score (MOS) Quality-of-Service (QoS) of digital telecommunications under subjective perception Quality-of-Experience (QoE).**

Keyword – **Access Network Transport (ANT), Equations Part & Span in Broadband Wireless Access (BWA).**

I. INTRODUCTION

Modern fixed radio systems, delivering three united multi-services Voce/Data/Video (Triple-Play service) with using BWA-technologies Worldwide Interoperability for Microwave Access (WiMAX) [8, 9] or High-performance radio MAN (HiperMAN) [8, 10], and/or Wireless Fidelity (Wi-Fi) [9, 12] or High-performance radio LAN (HiperLAN) [8, 10], in recently enough broadly and multifunctional are used on transport segment of the ANT [7, Scenario 5c] both on Metropolitan Area Network (MAN) region/town, and on Local Area Network (LAN) departmental/subscription distributing area radio networks.

The methods of the engineering evaluation at most attainable distance BWA is offered in paper with detailed conclusion of the generalized equations lengths of span and path.

II. STATEMENT

Radio equipments Base Station (BS) in mode Multiple Input Multiple Output (MIMO) and Customer Premises Equipment (CPE) can work boundary Line-of-Sight (LOS), Obstructed LOS (OLOS) or Near LOS (NrLOS) and even Non LOS (NLOS) [1, 2]. Consequently, length of the path BWA will is limited on the one hand limit to direct visibility LOS d_{LOS}, but with other distance d_{xLOS} ('x' – 'any' O, Nr, N) on possible path loss radio signal [3, 5] in absence of direct visibility

$$d_{BW} = \underset{x}{\boldsymbol{min}}\{d_{LOS};\ d_{xLOS}\} \qquad (1)$$

according to below brought situational scheme with inflicted on Fig. 1 level diagram.

Then length of span r_{BW}, as the shortest distance between BS and CPE station on surfaces of the land, forms

$$r_{BW} = \sqrt{d_{BW}^2 - (h_{BS} - h_{CPE})^2}\ . \qquad (2)$$

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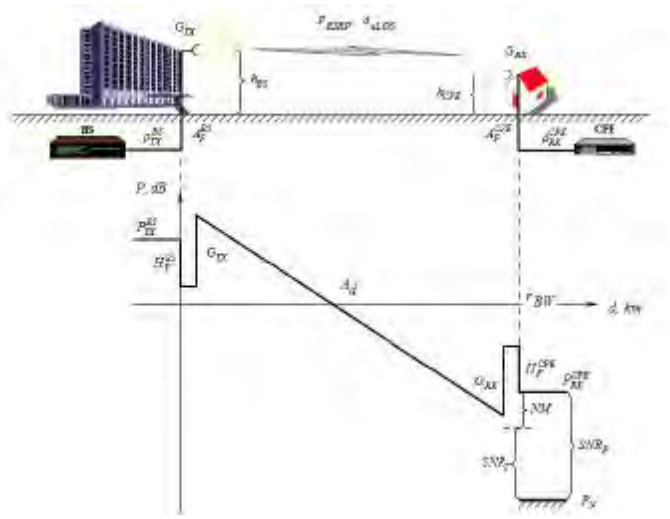

Fig. 1 Situational scheme of path BWA

Known that distance LOS in kilometer d_{LOS}, [km] is defined drawn near a correlation of the type

$$d_{LOS} = \sqrt{2R_{Earth}}\left(\sqrt{h_{BS}} + \sqrt{h_{CPE}}\right) \approx 3.57 \times \left(\sqrt{h_{BS[m]}} + \sqrt{h_{CPE[m]}}\right),\ [km]. \qquad (3)$$

Here $R_{Earth} \approx 6\,371$ km – average radius of the Earth [2]; $h_{BS[m]}$ и $h_{CPE[m]}$ – heights of the installing the antennas, provided in meters[m], base BS and CPE station accordingly.

III. EQUATION OF THE LENGTH BWA

What follows from level's diagram on Fig. 1 expected noise-immunity (***practically*** realized Signal-to-Noise Ratio) SNR_P, [dB] is noise-proof of the taken signal from total hindrances P_N, [dBm] on the one hand, equal [1]

$$SNR_P = P_{RX}^{CPE} - P_N = P_{EIRP} - A_d + (G_{RX} - H_F^{CPE}) - P_N = \\ = \left|S_{AFT}^{CPE} = G_{RX} - H_F^{CPE}\right| = P_{EIRP} - A_d + S_{AFT}^{CPE} - P_N,\ [dB], \qquad (4)$$

but with other – SNR_P must be always above possible noise-immunity (***theoretical*** norms SNR) $SNR_T(BERT)$ for achievement QoS of the work whole radio system on error probability (BER – Bit Error Rate) [6]

$$SNR_P = SNR_T(BERT) + NM(\lambda,\ BERT),\ [dB] \qquad (5)$$

under given validity of the digital signal (BERT – Bit Error Rate Testing) on subscription area of the network radio access [9–12]

$$BERT = 10^{-6}, \qquad (6)$$

on value subjective technological margin $NM(\lambda,\ BERT)$, [dB] by normally noise-immunity [4].

To such technological spare [5]

$$NM(\lambda, BERT) = NM_{MOS} + NL(\lambda) - NA(BERT) \quad (7)$$

follows to refer Noise Margin in mode LOS NM_{LOS} on noise-proof $SNR_T(BERT)$; additional Noise Loss $NL(\lambda)$ xLOS, different from direct visibility, under given wavelength λ radiated electromagnetic energy; technological (energy) Noise Advantage $NA(BERT)$ on possible noise-immunity radio signal under given threshold to probability BERT .

Maximum possible level Effective Isotropic Radiated Power (EIRP) of the radiation P_{EIRP} is found in study and at present doesn't exceed following recommendations and standardizations value [7–12]:

- $\rho_{EIRP}^{CEPT} = 1\,W$ ($P_{EIRP}^{CEPT} = 30\,dBm / 0\,dBW$) for HiperMAN-technology in "licensed" span CEPT ERC/DEC/(99)23;
- $\rho_{EIRP}^{FCC} = 4\,W$ ($P_{EIRF}^{FCC} = 36\,dBm / 6\,dBW$) for WiMAX-technology in "licensed" span FCC CFR Title 47, part 15;
- $\rho_{EIRP}^{CEPT} = 200mW (P_{EIRP}^{CEPT} = 23dBm/-7\,dBW)$ for HiperLAN-technology in "unlicensed" span $(5\,250.0 \ldots 5\,350.0)$ MHz ;
- $\rho_{EIRP}^{FCC} = 100\,mW$ ($P_{EIRF}^{FCC} = 20\,dBm/-10\,dBW$) for Wi-Fi-technology in "unlicensed" span $(2\,400.0 \ldots 2\,483.5)$ MHz .

Consequently, overlaid path loss of radio tract A_d, [dB] is uniquely determined by EIRP, which is main limiting factor under installation of the transition level P_{TX}^{BS} from BS.

$$A_d = P_{IERP} - [SNR_T(BERT) + NM(\lambda, BERT)] + S_{AFT}^{CPE} - P_N . \quad (8)$$

That fading radio tract A_d is determined known loss of the transmission radio signal at passing of the electromagnetic wave in free space [1, 3]

$$A_d = 20\,lg\left(\frac{4\pi \cdot d_{xLOS}}{\lambda}\right), \quad (9)$$

after transformations definitively we shall get ***Equation Path*** (10) fixed BWA

$$d_{xLOS} = \frac{\lambda}{4\pi}\sqrt{\frac{\rho_r}{kT\Delta F}} \times dec\left\{0.05 \cdot \left(P_{EIRP} - \left[SNR_T(BERT) + NM(\lambda, BERT)\right] + S_{AFT}^{CPE} - Q_N\right)\right\}. \quad 10)$$

In Eq. (10) length of part d_{xLOS} are incorporated following importances and values: λ – wavelength radiations; ρ_N – power white Gaussian of nose in band of the frequencies span ΔF [4, 6] radio channel; $Q_N = (3...9)$ dB – noise-factor [3]; $dec\{x\} = 10^x$ – the factor degree with base 10 .

IV. Conclusion

For example in Table 1 are given results of the linear experiments and completely him corresponding to calculation of the length path between BS and CPE station on WiMAX(HiperMAN)/Wi-Fi (HiperLAN) technologies at organizations BWA with use high-performance radio systems Wifless™ ESS Italian manufacture company Essentia ® S.p.A. [13], which consist in media-group GENBAND http://www.genband.com/media-center/press-releases/system-integrator-essentia-spa-and-general-bandwidth-form-distribution-a.

Table 1

TABLE OF THE ESTIMATION AT MOST ATTAINABLE OF LENGTH PATH FIXED BROADBAND WIRELESS ACCESS

BW-technologies	***Span f, MHz***	***Distance r_{BW}, km***
WiMAX	licensed $(5\,590.0 \ldots 5\,630.0)$	~ **12.6**
HiperMAN	licensed $(5\,590.0 \ldots 5\,630.0)$	~ **6.3**
Wi-Fi	unlicensed $(2\,400.0 \ldots 2\,483.5)$	~ **4.6**
HiperLAN	unlicensed $(5\,250.0 \ldots 5\,350.0)$	~ **2.9**

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