Numerical Estimation of Propagation Path Loss for Smart Gas Meters in Built-up Areas Based on Large-Scale FDTD Simulation

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Next-generation smart gas meter systems are being developed to meet the increasing need remote meter reading and safety services that conserve energy. The system is required to operate for 10 years on battery power, and can connect to meters outside the zone of wide-area wireless coverage. Adequate wireless link planning is possible only with an accurate and reliable method for estimating the propagation characteristics in real-world environments. To numerically estimate the propagation characteristics in urban areas, the ray tracing method has been used (e.g. Christian Müller et al., IEEE Conference on Smart Grid Communications, 2011). When installing smart gas meter at a detached house, the position of the meter is limited by the gas pipes and the installation position is low. Therefore, a simulation method that can output precise and comprehensive results in a multi-reflector environment is required for estimating the propagation characteristics of a smart gas meter system. In this paper, the propagation characteristics for multi-hop communication across the outside walls of detached houses in a typical built-up area are analyzed using a large-scale parallel FDTD analysis technique; the fundamental path loss characteristics are estimated statistically.

3-dimensional simulation model of a typical built-up area is developed. The dimensions of the built-up area used in the analysis follow actual dimensions as closely as possible. The area is 237.3 m long, 105 m wide, and 10.0 m high. 920 MHz-band wireless transmitters are placed on the outer wall of each house at heights of around 0.4 m. About 3.5 TB of memory was required to execute the analysis. The calculations were performed by large-scale parallel computing using 48 nodes of a supercomputer. Simulated results of electric field distributions were complicated due to scattering, shadowing and multiple reflections by the houses and multiple propagation paths along the street can be observed. We estimated the fundamental path loss characteristics in the built-up area between Tx- and Rx- smart meters based upon the simulated field distributions. Evaluated path loss values were compared to basic path loss models obtained from formula (1).

$$P_{lossd} = 20\log_{10} f + 10n\log_{10} d - 27.6 \quad (1)$$

where: f = Frequency [MHz], d = Separation distance [m], n = Distance power loss coefficient (n=2.01: Line-of-Sight propagation)

Based on the statistically estimations, we found that averaged value of propagation loss exhibited by smart gas meter multi-hop communication in the built-up area might be approximately 60 dB larger than free-space propagation and these results were well predict measured results.
We also intend to conduct other estimations that consider effects of other objects in actual environments such as humans, trees and so on.