DWG1 report, second year

1. Highlights from the Graz meeting

During the Graz meeting, DWG1 had 16 TDs, of which 6 were authored jointly by multiple institution members including the IRACON action. No joint session was held with other working groups. The following major technical trends observed:

- New radio channel sounding campaigns in various scenarios, including 1) small indoor and outdoor-to-indoor scenarios, 2) train-to-train, 3) distributed massive MIMO channels and 4) long-range over-the-coast measurements. The carrier frequency covers from 2 to 140 GHz.
- New material and radar measurement campaigns at 7-10, 125 and 300 GHz for physical and electric characterization of objects.
- New methods for simulating radiowave propagation, i.e., 1) reduction of computational complexity in ray-tracing and volume integral equations and 2) inclusion of vibration model into very-short-range millimeter-wave radio link design.
- New radio channel simulation studies, including indoor massive MIMO channels, outdoor millimeter-wave cellular scenarios and below-1GHz channels in Amazon forest, Brazil and mountainous areas.
- New insights from radio channel measurements and simulations, including, 1) dominant paths in train-to-train channels, 2) elevation-dependence of building entry loss, 3) rich multipath of omni-directional 140 GHz channels, 4) noticeable influence of diffuse scattering in outdoor at 28 and 38 GHz especially for deep non-line-of-sight cases, 5) robustness of simple beamforming schemes at millimeter-waves.

The discussion session was used for planning IRACON workshop in EuCAP2018 in London, UK. An idea is to invite representatives from different working group for presenting their results for the first two years. The session can be concluded by a panel that summarizes the remaining important tasks and challenges toward the end of the action.
Another important topic during the session was IRACON channel models. It was agreed that several task forces are formed in the coming months to address important challenges of channel models, e.g., clustering at mm-wave, localization, diffuse scattering and energy reverberation and parameterization of the COST2100 channel model, by a small number of people. WG1 chairs will send an inquiry to the WG1 emailing list to collect interested experts for each task force group.

Highlights for the newsletter

DWG1 had 16 TDs, of which 6 were authored jointly by multiple institution members including the IRACON action. The TD covered various aspects of radio channels, i.e., 1) new radio channel sounding campaigns over wide range of frequencies including material and radar measurement campaigns between 2 and 300 GHz, 2) new radiowave propagation simulation methods including low computational-complexity implementation, 3) new radio channel simulations for various scenarios including Amazon forest, Brazil and 4) new insights from radio channel measurements and simulations, including elevation-dependence of building entry loss, rich multipath of omni-directional 140 GHz channels and noticeable influence of diffuse scattering at Ka-band in deep non-line-of-sight scenarios. The discussion session covered planning of an IRACON workshop in EuCAP2018 in London, UK, and IRACON channel models. It was agreed that several task forces will be formed to address important challenges of channel models.

Appendix: summary of sessions

Day 2, session on indoor and train channel channels, 11:00-12:30 in room HS-i7

- TD(17)05030, comparison between 28 and 140 GHz channel characteristics
  - ✓ Street-level backhaul measurements in a shopping mall. The two channels show same paths from scatterers in the environment, and the large-scale parameters are similar. Omni-directional 140 GHz channels are as multipath rich as 28 GHz.
  - ✓ Collaborative work between Aalto and Nokia.
- TD(17)05010, volume integral equation for indoor propagation modeling
  - ✓ Volume electric field integral equation (VEFIE) applied to solving Maxwell's equation in an indoor scenario, which works at 2D and 3D for received power, pathloss, power delay and angular power profiles. For 2D implementation, a correction factor is required.
- TD(17)05007, elevation-dependence modeling of building entry loss
  - ✓ Measurements at different elevation angles for traditional brick-wall-made office buildings at 2.2, 5.8 and 58.5 GHz. Higher elevation leads to greater entry losses in general, but the loss trend depends on window penetration characteristics too.
- TD(17)05005, spatial characteristics of train-to-train channels
  - ✓ Kalman-filter-based super-resolution algorithm is applied to omni-directional channel impulse responses to detect dominant propagation paths over time.
  - ✓ Doppler-based geometrical representation of the detected propagation paths will be performed.

Day 2, session on scattering, 13:30-15:00 in room HS-i7

- TD(17)05017, wagon-to-wagon millimeter-wave channels
  - ✓ Wireless link replacing train couplers for the front and rear wagons. Channel model is a two-ray model including LOS and ground reflection. Mechanical vibration is measured and modeled through a circuit model of the coupler, and is used to simulated Doppler. The vibration model is integrated with the two-ray model to simulate Doppler effects.
  - ✓ Doppler is small enough to assume that the channels can be considered time-invariant for the duration of 100-packets.
  - ✓ Collaboration between DLR, University of Ulm, and RWTH Aachen University.
- TD(17)05034, Diffuse scattering model at 60 GHz
  - ✓ Kirchoff scattering model is used to simulate scattering from brick walls. Incident angles close to the normal direction to the wall provide good agreement between simulation and measurements.
- TD(17)05040, Characterization of construction materials
  - ✓ Extracting electromagnetic parameters of construction materials using Fabry-Perot resonances.
  - ✓ Interference patterns of measured reflection coefficients are used to estimate

the thickness of the slab material and permittivity, while conductivity is estimated from transmission measurements.
  - ✓ Estimated permittivity is consistent with values from ITU-R tables.
  - ✓ Collaborative works between University of Bologna and Togji University.
- TD(17)05050, Ray-tracing in Ka band for pathloss study
  - ✓ Simulations for two outdoor scenarios, including diffuse scattering and vegetation effects.
  - ✓ Classification of near- and far-building, for which different scattering models are used. Surface profiles of far-buildings can be simplified, leading to less computational time.
  - ✓ Generally good agreement between simulations and measurements at 28 and 38 GHz. Diffuse scattering is important in deep NLOS scenarios.
  - ✓ Collaboration between University of Bologna and Huawei.
- TD(17)05002, Millimeter-wave and terahertz monostatic radar
  - ✓ Radar measurements at 100 GHz and 300 GHz bands to know shapes and relative permittivity of target objects. Focused images produced by Kirchhoff Migration. Images of a paper box and a table tennis ball are successfully created.
  - ✓ Collaboration between UPCT, University of Lille 1 and UPC.

Day 3, session on radio propagation models, 9:00-10:30 in room HS-i7

- TD(17)05026, UHF propagation model in Amazon forest, Brazil
  - ✓ Use of vertically-cut model of propagation environment. Simulated are digital home and mobile TV coverage in Amazon area (521MHz), covering vegetation losses and multipaths from city, rivers and forests. Home provides higher received signal strength than mobile reception because of height gain.
  - ✓ Collaboration between Federal University of Pará, Brazil and IST-Lisboa.
- TD(17)05042, Environment-driven ray-launching method
  - ✓ Ray-launching only toward obstacles and Rx points; ray tube shapes are dependent on obstacle. Walls are discretized into tiles for which a visibility matrix is calculated. The matrix can be calculated by parallel-processing GPU.
  - ✓ Sequentially arranged computation of the visibility matrix and ray bouncing in NVIDIA-compatible GPU allows significant speed-up, e.g., 7000 times faster in San Francisco.
  - ✓ Collaboration between University of Bologna and Polaris Wireless in USA.
- TD(17)05044, Scattering and diffraction study based on point cloud
  - ✓ Use of a digital terrain model for simulating pathloss and channel impulse responses at 69 MHz and 272 MHz in a mountainous area. Diffraction, reflection, scattering and line-of-sight is considered. The scattering model was chosen so that the simulation agrees with measurements. Better comparison with measurements could be obtained.
- TD(17)05012, Channel characterization in maritime environments
  - ✓ Digital radio links operating at 1.457 GHz with 10 MHz of bandwidth are implemented in software-defined-radios. The links send video images from mobile unit to a base station surveillance center. The link was tested in a coastal area with 14km link distance.

Day 3, session on spatial channel models, 11:00-12:30 in room HS-i7

- TD(17)05035, Characterization of distributed massive MIMO channels
  - ✓ Ray-tracing and measurement-based analysis of spatial correlation in distributed massive MIMO systems. Comparison of correlation shows that ray-tracing needs to be improved for better agreement with simulations by, e.g., including diffuse scattering.
  - ✓ Measurements show that the correlation is reduced significantly for distributed receive antennas compared to co-located one.
- TD(17)05039, Multi-user indoor beamforming at millimeter-waves
  - ✓ Measurement-based evaluation of simple multi-user beamforming schemes, i.e., 1) directing beams to LOS directions, 2) maximizing the designed received signals and 3) maximizing the signal-to-interference ratios. The scheme 1) has the widest variation of the realized SINR while 3) has the smallest.
  - ✓ Ray-tracing is capable of simulating desired strong signals, while interference is not always.