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Modelling MIMO Mobile-to-Mobile Channels

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Background and Motivations

- **MIMO-Multiple Input Multiple Output:**
  - Both the Tx and Rx are equipped with multiple antenna elements.
  - Main benefits: spatial multiplexing and spatial diversity.
- **Mobile-to-Mobile (M2M) communications:**
  - Applications: mobile ad hoc networks, relay-based cellular networks, dedicated short range communications (DSRC) for intelligent transport systems (e.g., IEEE 802.11p).
  - Both the Tx and Rx are in motion and equipped with low elevation antennas.
  - MIMO technology is very promising for M2M communications since multiple antenna elements can be easily placed on large vehicle surfaces.

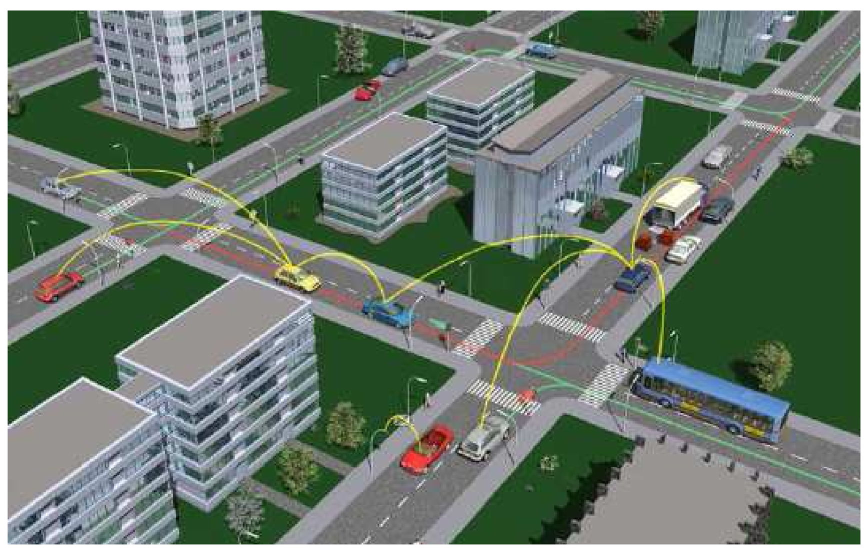

Fig. 1. An example for M2M communications.

- The proper design of a MIMO M2M communication system requires the detailed knowledge about the underlying propagation channel and a corresponding realistic channel model.
- Gaps in existing M2M geometry-based stochastic models (GBSMs)
  - None of the existing M2M models is sufficiently generic to characterise a wide variety of M2M propagation environments, especially for pico-cell scenarios (Tx-Rx distance<300m).
  - None of these M2M channel models has the ability to take the impact of the vehicular traffic density (VTD) into account.

An Adaptive MIMO M2M GBSM

- We propose a new GBSM that employs a combined two-ring model and ellipse model.
- To consider the impact of the VTD, we use the ellipse model to depict the stationary scatterers located on the roadside and the two-ring model to describe the moving scatterers around the Tx and Rx (as in Fig. 2).

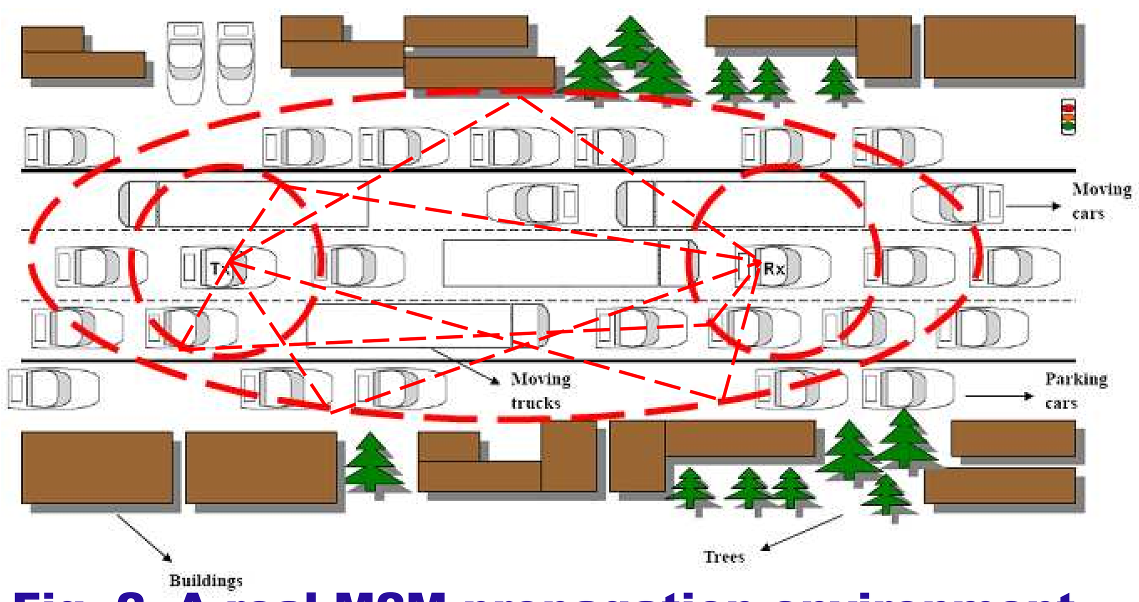

Fig. 2. A real M2M propagation environment.

- For the link $T_p - R_q$ at the carrier frequency f_c, the complex impulse response is a superposition of the LoS, single-, and double-bounced rays:

$$h_{pq}(t) = h_{pq}^{LoS}(t) + h_{pq}^{SB}(t) + h_{pq}^{DB}(t)$$

Important Channel Statistics

- From the proposed model, we derive the space-time-frequency correlation function, space-Doppler-frequency power spectrum density (PSD), level crossing rate (LCR), and average fade duration (AFD).
- Figs. 3 and 4 show the excellent agreement between the theoretical results and measured data, confirming the utility of the proposed model.
- From Figs. 3 and 4, we observe that the VTD significantly affects the Doppler PSD, LCR, and AFD for M2M channels in pico-cell scenarios.

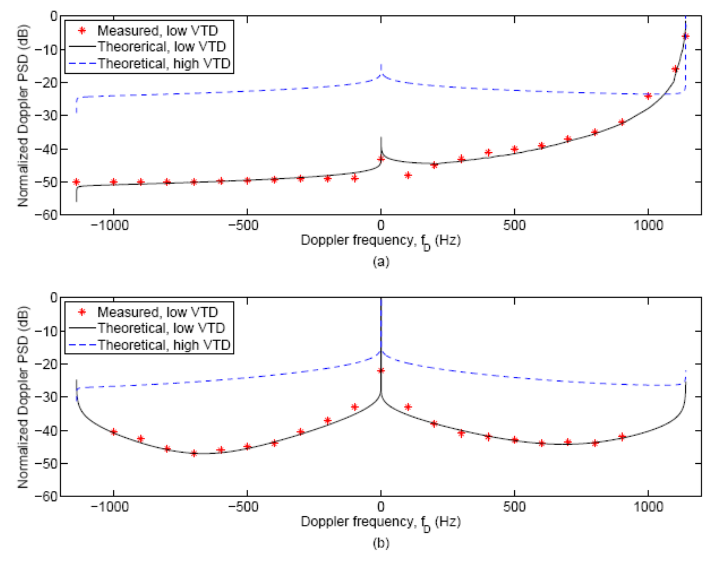

Fig. 3. Normalised Doppler PSDs: (a) opposite directions, (b) same direction.

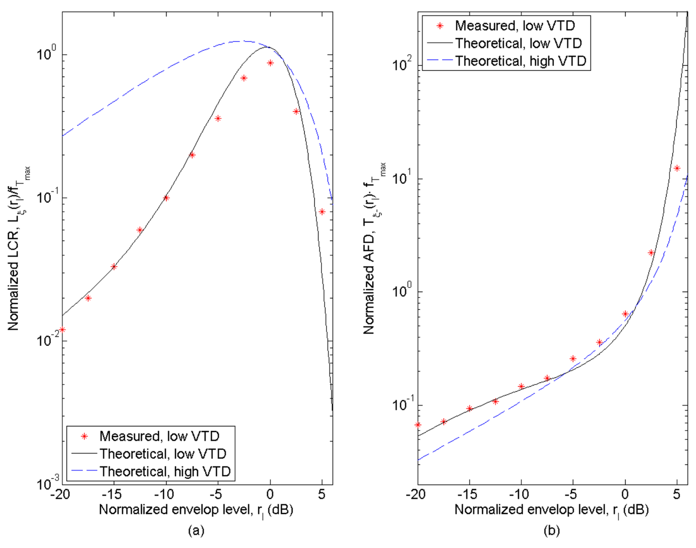

Fig. 4. (a) LCR and (b) AFD (same direction).

Conclusions & Future Work

- We have proposed a new MIMO M2M GBSM to fill up the gaps in existing M2M GBSMs.
- Based on the proposed model, some important channel statistics are, for the first time, studied in pico-cell scenario with consideration of the impact of the VTD.
- Future work:
  - Extend the proposed model into wideband application.
  - Develop a 3-dimensional MIMO M2M channel model.
  - Propose the corresponding M2M simulation models.

Publications

Journals

[1] C.-X. Wang, X. Cheng, and D. I. Laurenson, "Vehicle-to-vehicle channel modeling and measurements: recent advances and future challenges", *IEEE Commun. Mag.*, revised version to be submitted.

[2] X. Cheng, C.-X. Wang, D. I. Laurenson, S. Salous, and A. V. Vasilakos, "An adaptive geometry-based stochastic model for non-isotropic MIMO mobile-to-mobile channels", *IEEE Trans. Wireless* Comm., submitted for publication, 2008.

[3] X. Cheng, C.-X. Wang, D. I. Laurenson, and A. V. Vasilakos, "Envelope level crossing rate and average fade duration of non-isotropic mobile-to-mobile Ricean fading channels", *IEEE Trans. Wireless* Comm., to be submitted.

Conferences

[1] X. Cheng, C.-X. Wang, D. I. Laurenson, and A. V. Vasilakos, "Second order statistics of non-isotropic mobile-to-mobile Ricean fading channels", *IEEE ICC'09*, Dresden, Germany, 14-18 Jun. 2009, accepted for publication.

[2] X. Cheng, C.-X. Wang, and D. I. Laurenson, "Multiple-ring based modeling and simulation of wideband space-time-frequency MIMO channels", *IEEE ICC'09*, Dresden, Germany, 14-18 Jun. 2009, accepted for publication.

[3] X. Cheng, C.-X. Wang, D. I. Laurenson, H.-H. Chen, and A. V. Vasilakos, "A generic geometrical-based MIMO mobile-to-mobile channel model", *IEEE IWCMC'08*, Chania Crete Island, Greece, 6-8 Aug. 2008, pp. 1000-1005.

[4] X. Cheng, C.-X. Wang, D. I. Laurenson, H.-H. Chen, and A. V. Vasilakos, "Space-time-frequency characterization of non-isotropic MIMO mobile-to-mobile multicarrier Ricean fading channels", *IEEE IWCMC'08*, Chania Crete Island, Greece, 6-8 Aug. 2008, pp. 994-999.

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