Wireless Channel Modeling and Simulation

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Your Questions Answered!
Is it practical to assume same channel in TDD as the multipath may be different in opposite direction?
Further clarification required for use of conjugate in Almouti Scheme!
Columns of Effective Alamouti Channel Matrix

\[
\begin{bmatrix}
h_1 & h_2 \\
h_2^* & -h_1^*
\end{bmatrix}
\]

\[
\begin{bmatrix}
h_1^* \\
h_2^*
\end{bmatrix} \cdot \begin{bmatrix}
h_2 \\
-h_1^*
\end{bmatrix}
\]

\[
= \begin{bmatrix}
h_1^* & h_2 \\
h_2 & -h_1^*
\end{bmatrix}
\]

\[
= h_1^* h_2 - h_1^* h_2
\]

\[
= 0
\]
What are practical ways of knowing channel $h$? If we do not know the channel, whatever we do is useless?
We take only one type of noise in theoretical models: AWGN. In practice there are several different noise sources and types. How these facts can be explained?
Which tools are used to model the wireless channel both indoor and outdoor?
Tools for Wireless Channel Modelling

- Modelling is a theoretical exercise and the only tool required is mathematics and deep understanding of the physical problem you intend to model.
- Simulation of a model requires specific tools
- Different tools are used to simulate
  - different layers of communication stack – physical, network etc
  - different types of communication system – cellular, ad hoc etc
  - different purposes of simulation – dynamic, static etc
Tools for Wireless Channel Modelling

- Two important wireless models (and their associated simulation):
  - Link Model
  - System Model
- Two other simulation scenarios for wireless/mobile systems
  - Static simulator
  - Dynamic simulator
- Suitable tools are selected based on their capabilities.
- In many instances, in-house tools are developed to perform the required task
Tools for Wireless Channel Modelling

- ‘Matlab scripts’ are used for pure theoretical models

- ‘Matlab scripts with GUI’ are used for static simulators for bigger systems
  - Example: Static radio network planning tools for WCDMA – NPSW written by Achem Wacker et al.

- ‘Matlab with Simulink’ is used for a relatively practical model’s simulation

- ‘Matlab and C programming’ for dynamic simulator or simulator where time/speed is prime
Special Interest Groups on wireless channel modelling?
Special Interest Group

- This depends on your specific area of interest and the level/type of simulation you intend to develop.

- For ‘theoretical models’ or ‘models of specific communication techniques’ Mathwork’s Matlab File Exchange website is a good starting point.

- Matlab ‘demos’ or ‘example code’ is also a good starting point in many cases (must have communication toolbox).

- As an example: Turbo/LDPC coding in particular and channel coding in general has many websites sharing Matlab/Octave code.
Inputs and Outputs as parameters for wireless channel model?
Inputs and Outputs of wireless channel models

- Again this will depend on the type of model/simulation but in general the answer is as follows:

- Possible Inputs:
  - Environment i.e. Indoor Outdoor etc and associated parameters like
    - delay spread,
    - maximum doppler spread,
    - communication bandwidth,
    - carrier frequency,
    - path loss exponent,
    - shadow fading standard deviation,
    - number of users,
    - physical dimensions of the communication system,
    - antennas with their type, gains, directivity and polarity etc.
Inputs and Outputs of wireless channel models

- Possible Outputs:
  - Error rate for all or a specific communication link
  - Power requirements for communication
  - Number of accommodated links that can communicate simultaneously
  - Capacity (User or Data)
  - Coverage (Extent over which acceptable service quality is extended)

- Whatever is the output, while comparing several systems extra care must be taken to ensure fairness.
Where and how the information about the channel modelling is used in wireless communication?
Uses of Channel Modelling

To name a few …

- To test new ideas or modifications
- Understanding the next generation of communication systems and extending/improving their design before it is standardised
- Network planning
- Testing possible modifications to the design of a working network equipment, to avoid “trial and error” to some extent
Requirements to implement/test/verify the model?
Requirements for Testing/Verification

- Again depends on specific scenarios
- For theoretical model
  - only a Matlab equipped computer is required for implementation of the model and its simulation
  - For calibration or comparison, well-cited and high quality Journal publications are used as a benchmark.
- For more practical systems,
  - calibration or data fitting is performed using the field measurement data and for this either we need well equipped indoor labs or the necessary equipment to collect data for the outdoors.
Are there any standardizing bodies for wireless channel modelling?
Standardising Bodies for Models

- Usually models are built by theoreticians and they do not like bounds imposed by standards!

- However, the standards do specify specific models to provide benchmark implementations and comparisons of various systems

- A good starting point is to have a look at any 3GPP or ETSI standard document (downloadable from internet)

- They specify the scenario or the model to be assumed with very minute details.
Well known wireless channel models used by well known companies?
Models used by Companies

- All theoretical models with intuitive appeal are well respected by the industry as well.
- They may not seem practical but are very useful in practice to gain insights e.g. power law path loss model.
- For simulations: many mobile operators and equipment vendors build up their in-house simulators (usually with limited access and for the internal use only).
- Usually these simulators are a nice mix of the literature in the public domain and the in-house practical expertise or knowledge.
Thank You

Questions and Discussions