Research Project Title: Performance of Power Line Communication System

Project Description: Power Line Communication (PLC) allows data transmission over conductors and does not require extra infrastructure. Therefore, it is considered as a retrofit technology [1]. Power lines not only serve as media for carrying power but are also capable of carrying data for the purpose of communication. Recent developments in telecommunication technologies make PLC one of the most suitable candidates for serving as an independent communication network. Concepts such as smart home, smart grid and system control and automation have drawn considerable attention from researchers across the globe and it has been shown that PLC is one of the most promising solutions for implementing such concepts. Channel and noise models together characterize a PLC system. Channel models can be categorized as (1) statistical and (2) site specific data based. Statistical channel models are generalized but may not be accurate for a particular case. On the other hand, site specific data based channel models can be accurate for a particular case but cannot be generalized. As a result, we prefer statistical channel models over site specific data based channel models because of wide applicability of the former. Statistical channel models for PLC systems show that the PLC channel undergoes fading. The fading gain of the channel can be statistically modelled by a log-normal distribution [3]–[5]. Measurements of the coherence bandwidth for PLC networks have been presented in [6], [7]. The measurements show that PLC networks with good branching (uniform conductors) and matched loads have large coherence bandwidth. Thus, the bandwidth of the transmitted signal can be assumed to be less than the coherence bandwidth and hence, the fading is considered to be flat. The assumption is valid for both narrowband and broadband transmission for large coherence bandwidth. Using transmission line theory [1, ch. 2], a distance dependent signal attenuation channel model is proposed in [2]. By introducing the notion of distance in the statistical channel model, we can improve the accuracy of results in the performance analysis. Hence, we club the two models. Additive noise in the PLC channel is a mixture of impulsive and background noise [1], unlike the additive white Gaussian noise (AWGN) in wireless channels. This additive noise can be well modelled by a Bernoulli-Gaussian process as discussed and used in [8], [9]. In this project, we show that by using multiple independent and non-interfering channels to send an information bearing signal and by employing different diversity combing schemes at the receiver, we can enhance the bit error rate (BER) and

outage performance of a PLC channel corrupted by impulsive noise. Numerical results are presented to demonstrate the improvement in PLC system reliability with increasing number of PLC channels. Further, signal attenuation in long-distance data transmission limits the performance of a PLC system; however, the performance can be improved by introducing repeaters (relays) between the source and the destination nodes [2]. Apart from the distance dependent signal attenuation, variation in signal amplitude (fading) with time and impulsive noise also affect the data transmission in a PLC system. Thus, performance of a PLC system equipped with repeaters will be studied further studied in this project with realistic channel and noise models.

Work Plan:

1. Literature Survey:

The existing approaches towards performance of PLC system are studied with the following agendas:

- Channel and Noise modelling
- Performance metrics
- Issues related to performance degradation in PLS systems
- Assumptions in performance analysis

2. System Model:

The system model consists of PLC link between transmitter and receiver. Transmitter sends the information to the receiver over different number of channels. Further, diversity combing schemes (SC, MRC, GSC) are used at the receiver for improvement of performance of the system.

3. Mathematical Analysis:

Having developed the relevant concepts of PLC system, mathematical derivation of suitable performance measure for performance comes into consideration. We will derive the closed-form analytical expression for the exact and the asymptotic outage probability and error probability. Some useful insights about performance of the PLC system are obtained from the analysis.

3. Simulation/Experiment:

All the analytical results derived are being verified by simulations using MATLAB. This is the verification of our derived results.

4. Study and Comparison:

Computer simulations and analytical results will be compared with existing schemes. The advantages and disadvantages of our results will also be discussed with existing results.

5. Publications:

The useful findings from the analysis will be published in reputed conferences/journals.

Time Schedule:

0-6 months:

1. Literature survey
2. Up gradation of computing facilities
3. Understanding the analytical/simulation results of existing schemes
4. Different types of performance metrics in PLC system
5. Issues related to performance degradation in PLC system
6. System model
7. Problem formulation

6-12 months:

1. Mathematical analysis
2. Verification of analytical results through simulations/experiments
3. Comparison with existing results
4. Results and discussion
5. Writing the observations
6. Publication of results in conferences/journals

12-18 months:

1. Extension of results in dual/multi-hop networks
2. Asymptotic analysis in dual/multi-hop networks
3. Comparison with existing results
4. Study of cognitive radio based PLC system

18-24 months:

1. Publication related to dual/multi-hop networks
2. Problem formulation for cognitive radio based PLC system

3. Solving the problem for cognitive radio based PLC system
4. Publication related to cognitive radio based PLC system
5. Future directions in this project
6. Documentation

References:

[1] H. C. Ferreira, L. Lampe, J. Newbury, and T. G. Swart, *Power Line Communications: Theory and Applications for Narrowband and Broadband Communications over Power Lines*. Singapore: Wiley, 2010.

[2] L. Lampe and A. J. Han Vinck, "On cooperative coding for narrow band PLC networks," *Int. J. Electron. Commun.*, vol. 65, no. 8, pp. 681–687, Aug. 2011.

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[5] S. Galli, "A novel approach to the statistical modeling of wireline channels," *IEEE Trans. Commun.*, vol. 59, no. 5, pp. 1332–1345, May 2011.

[6] M. Tlich, A. Zeddam, F. Moulin, and F. Gauthier, "Indoor power-line communications channel characterization up to 100 MHz—Part II: Time frequency analysis," *IEEE Trans. Power Del.*, vol. 23, no. 3, pp. 1402–1409, Jul. 2008.

[7] M. Antoniali, A. M. Tonello, M. Lenardon, and A. Qualizza, "Measurements and analysis of PLC channels in a cruise ship," in *Proc. 2011 IEEE Int. Symp. Power Line Commun. Appl.*, Udine, Italy, 2011, pp. 102–107

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[9] A. Dubey, R. K. Mallik, and R. Schober, "Performance of a PLC system in impulsive noise with selection combining," in *Proc. IEEE Global Commun. Conf.*, Anaheim, CA, USA, 2012, pp. 3508–3512.

Project Completion Time:

- Short term (upto one semester)
- Mid-term (upto one year)
- **Long term (more than one year)√**

Student Skills Required, Pre-requisites (if any):

MATLAB Programming, Good understanding of courses related to Digital Communications, Wireless Communications, and Information Theory etc.

Number of Students Required (UG/PG) for the project:

- Three UG Students
- Two PG Students

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Any Other Details: No