School of Engineering and Applied Science (SEAS), Ahmedabad University

B.Tech(ICT) Semester V: Wireless Communication (CSE 311)
Innovation Report

- **Group No :** *BT_S24*
- **Group Members{Name(RollNo)}:** *Shaili Gandhi(012), Manav Vagrecha(022), Devam Shah(044)*
- **Base Article Title :** @ARTICLE8695004, author=X. Qian and M. Di Renzo and A. Eckford, journal=IEEE Access, title=Molecular Communications: Model-Based and Data-Driven Receiver Design and Optimization, year=2019, volume=7, number=, pages=53555-53565, doi=10.1109/ACCESS.2019.2912600
- **Alternate Name :** Molecular Communications: Model-Based Absorbing Receiver Design including Signal Reception and Optimization.

1 Introduction:

In molecular communication the major issues are Inter-symbol interference(ISI) and the less hitting probability of the Information molecules. So we thought of a more realistic system model that increases the hitting probability, thus in turn decreasing the Bit error rate. The model considers the rate of reaction as an affecting factor which induces imperfect reception process with small receptor present on the surface of the receiver.
A messenger molecule is received only when it binds with a receptor. The other molecule will only get received after the first molecule gets reacted so that it can contribute to the signal only once and not cause ISI.

- **System Model/Network Model :**

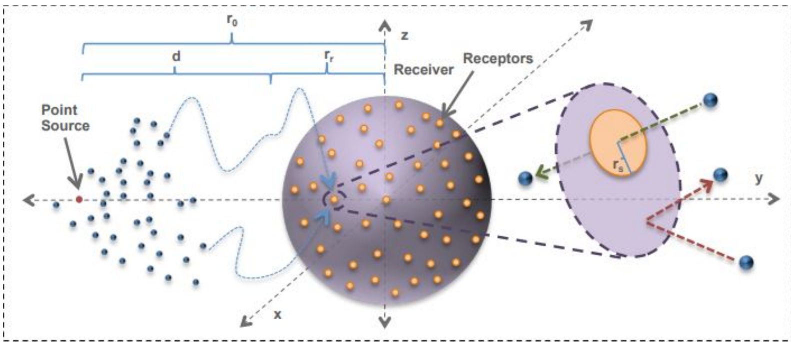

Figure 1: New System Model

- **Channel Model :** 3-D unbounded fluid propagation model, point transmitter, spherical receiver with absorbing receptors.
- **Transmitted Signal :** Information particles, On-Off Modulation keying (OOK)
- **Nature of Noise :** ISI and background noise
- **List of symbols and their description For Example:** (see the table for your reference)

Symbol	Description
r_r	Radius of spherical Receiver
r_s	Radius of receptors
r_0	Initial distance between point source and receiver
n	Number of conductive patches
D	Laplacian Operator
F_{hit}	Fraction of molecules absorbed by receptors
ω	Rate of reaction

2 Assumptions:

- The fluid medium is assumed to be unconfined and extending to infinity in all directions.
- The diffusion of the information particles through the medium is independent and random, so extra energy is not required.
- During the whole transmission, the temperature and viscosity are assumed to remain constant.
- Released time of Information particles from the transmitter is considered to be negligible.

3 New Performance Analysis

- Detailed derivation of innovation

  For the system model considered, the hitting rate of each information particle can be expressed as follows :

$$f_{\text{hit}}(t) = \frac{r_r w}{r_0}\left(\frac{1}{\sqrt{\pi D t}}\exp\left[-\frac{\alpha^2}{4Dt}\right] - \beta \exp\left[\beta\alpha + \beta^2 Dt\right]\operatorname{erfc}\left[\frac{\alpha}{\sqrt{4Dt}} + \beta\sqrt{Dt}\right]\right) \tag{1}$$

where, $\alpha = r_0 - r_r, \quad w = \frac{n r_s D}{\pi r_r^2}, \quad \beta = \frac{n r_s + \pi r_r}{\pi r_r^2}$

$$P_{hit}(t) = \int_0^t f_{hit}(t)dt, \qquad P_{i-1} = \int_{(i-1)T}^{iT} f_{hit}(t)dt$$

$$P_{\text{hit}}(t) = \frac{r_r\beta - 1}{r_0\beta}\left(1 + \text{erf}\left[\frac{\alpha}{\sqrt{4Dt}}\right] - \exp\left[\alpha\beta + Dt\beta^2\right] \text{erfc}\left[\frac{\alpha + 2Dt\beta}{\sqrt{4Dt}}\right]\right) \tag{2}$$

$$P_{i-1} = P_{\text{hit}}(iT) - P_{\text{hit}}((i-1)T)$$

$$\begin{aligned}\therefore P_{\text{i}-1} = &\left[\frac{r_r\beta - 1}{r_0\beta}\left(1 + \text{erf}\left[\frac{\alpha}{\sqrt{4DiT}}\right] - \exp\left[\alpha\beta + DiT\beta^2\right] \text{erfc}\left[\frac{\alpha + 2DiT\beta}{\sqrt{4DiT}}\right]\right)\right] \\ - &\left[\frac{r_r\beta - 1}{r_0\beta}\left(1 + \text{erf}\left[\frac{\alpha}{\sqrt{4D(i-1)T}}\right] - \exp\left[\alpha\beta + D(i-1)T\beta^2\right] \text{erfc}\left[\frac{\alpha + 2D(i-1)T\beta}{\sqrt{4D(i-1)T}}\right]\right)\right]\end{aligned} \tag{3}$$

$$\text{where,} \quad \alpha = r_0 - r_r, \quad w = \frac{nr_sD}{\pi r_r^2}, \quad \beta = \frac{nr_s + \pi r_r}{\pi r_r^2}$$

Note : *Other Formulas will remain same as in base article. We just have to substitute (3) as value*

4 New Numerical Results

4.1 Simulation Framework

We haven't carried out any simulations. We have only generated the analytical plots and thus we have no simulation framework to include

4.2 Description of Figures

- Innovation Figure-1

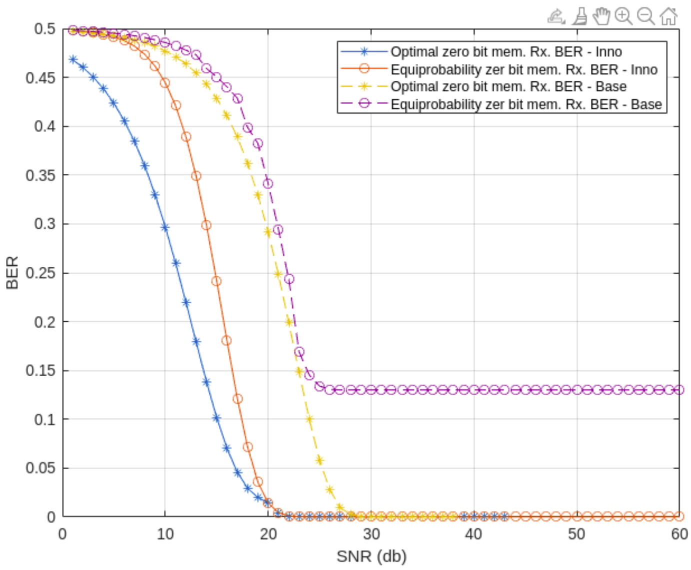

Figure 2: BER vs SNR plot : The Nature of BER of Zero-Bit Memory Receiver depending on Signal to Noise Ratio (SNR in dB)

- Inferences:
    * At lower *SNR* values, the *BER* values are almost similar.
    * By changing the system model, we can see from the graph that the *BER* is decreased as we increase the *SNR* value.
    * Our innovation system model makes the system power efficient.

- Innovation Figure-2

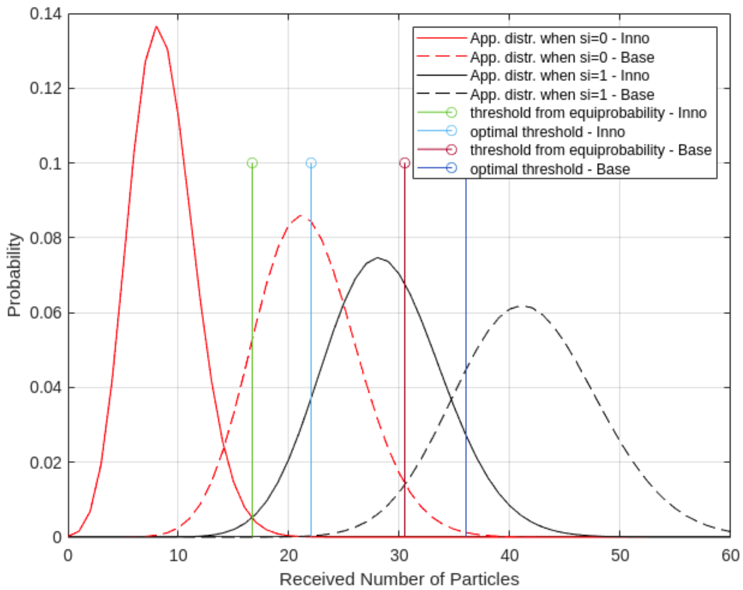

Figure 3: Distribution of Probability of Symbol based on Number of Received particles

- Inferences:
    * The hitting probability increased after changing the the system model of the receiver for both the cases as seen from the peek which symbolizes more precise estimation of symbol
    * More the hitting probability, which increases number of absorbed particles and thus decreasing the chances of error.

5 References :

[1] @ARTICLE6967753, author=A. Akkaya and H. B. Yilmaz and C. Chae and T. Tugcu, journal=IEEE Communications Letters, title=Effect of Receptor Density and Size on Signal Reception in Molecular Communication via Diffusion With an Absorbing Receiver, year=2015, volume=19, number=2, pages=155-158, doi=10.1109/LCOMM.2014.2375214

6 Contribution of team members

6.1 Technical contribution of all team members

Tasks	**Shaili Gandhi**	**Manav Vagrecha**	**Devam Shah**
Analysis	✓	✓	✓
Derivation	-	✓	-
Coding	-	✓	-
Inferences	-	✓	✓

6.2 Non-Technical contribution of all team members

Tasks	**Shaili Gandhi**	**Manav Vagrecha**	**Devam Shah**
Reference Article Selection	✓	✓	✓
Video	✓	✓	✓
MIRO	✓	✓	✓
Report	✓	✓	✓