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

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

- Group No : BT_S26
- Name (Roll No) : AU1401090
- Base Article Title:

1. Molecular Communications: Model-Based and Data-Driven Receiver Design and Optimization [1]

2. Molecular Communications: Model-Based Receiver Design and Optimization for Vessel like Environment

1 Limitations of Base Article

Listed below are limitations of the base article [1] or improvements that can be made for more real world behaviour modelling.

- 3D unbounded environment: In real life applications of molecular communications, any messenger particle would be bounded by the environment it is in and how much it can travel in any direction if it wants to communicate with the receiver efficiently. [2]
- ON/OFF Keying modulation: To increase bit rate, other modulation or coding schemes can be considered. [3]
- Perfect channel state information: Model based receiver design proposed in [1] require perfect knowledge of channel. Though the data driven method proposed in [1] resolves this issue somewhat.
- Diffusion without flow: In many real world environments the environment won't necessarily be without flow. Messenger particles would have to contend with flow eg. blood in a human body would be flowing. [4]
- Perfect absorbing spherical receiver: In real world applications, we have to consider that the receiver might be partially or fully covered which would affect the ability to receive the messenger particles. [2]
- Single transmitter/receiver: Increasing transmitter or receiver diversity would greatly increase data rate. [5] [6]
- Linear system of noise: Noise can be often nonlinear in nature in real world scenarios. [7]
- One way communication [8]

2 New Performance Analysis

- **List of symbols and their description**

Symbol	**Description**
r	Receiver radius
d	Distance between Tx and Rx
D	Diffusion Coefficient
T	Slot length
N_{TX}	No of released particles
P_i	Probability of a particle hitting Rx ith time slot
τ	Demodulation threshold
r_v	Radius of vessel

- **System Model:**

Transmitter - Transmitter is assumed to be small enough to be a point. It generates the information particles, which are released into the channel using ON/OFF Keying modulation. At the ith slot, the transmitter releases N_{TX} information particles into the environment when the symbol is $s_i = 1$, otherwise the transmitter does not release any particles. The information particles are assumed to diffuse randomly and independently of each other through the medium (Brownian motion).

Channel model - The environment of the bounded, considered to be vessel-like modelled after veins. Channel is a diffusion channel model without flow, where temperature and viscosity is constant during the whole transmission process. Therefore, diffusion coefficient D remains constant as the particles diffuse freely and no extra energy is needed.

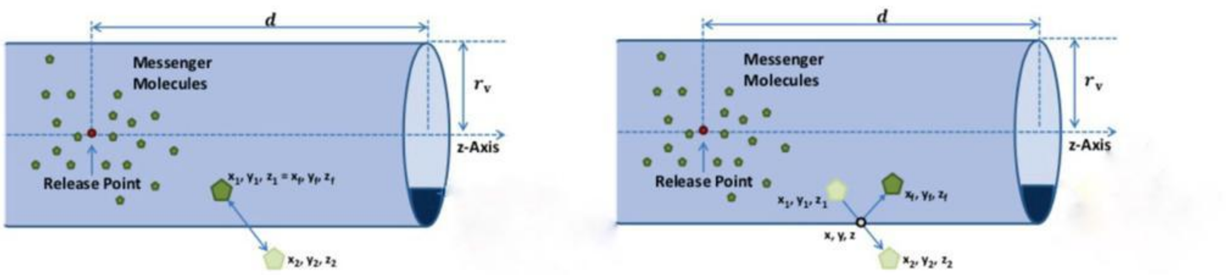
Nature of noise - A large number of information particles are emitted not all of which reach the receiver in the considered time-slot. The information particles that remain in the channel and reach the receiver at a later time-slots causing Inter Symbol Interference (ISI). Background noise λ is also considered during calculations.

- **Derivation of hitting probability of an absorbing receiver for a vessel like an environment:**

We consider a vessel-like bounded environment in which the received molecules are dispersed homogeneously on the cross section of the vessel. The equation for the hitting probability of an absorbing receiver, i.e., the probability to absorb one particle after t seconds that the information particle is released [2]:

$$F_{hit}(t) = N_{TX}\frac{\pi r^2}{\pi r_v^2} erfc(\frac{d-r}{\sqrt{4Dt}}) \tag{1}$$

we know, $erfc(z) = -\frac{2e^{-z^2}}{\sqrt{\pi}}$. Therefore, the hitting rate of each information particle can be expressed



(a) Rollback strategy (b) Elastic reflection strategy

Figure 1: The 3D bounded vessel-like molecular channel model without flow including a point transmitter and a spherical absorbing receiver.

as follows

$$\frac{d}{dt} f_{hit}(t) = N_{TX} \frac{r^2(d-r)}{r_v^2(\sqrt{4\pi D t^3})} e^{-\frac{(d-r)^2}{4Dt}} \tag{2}$$

Now, the probability that one particle hits the receiver during the (i1)th time slot after releasing the particle,

$$P_{i-1} = \int_{(i-1)T}^{iT} f_{hit}(t) dt \tag{3}$$

Then, we obtain

$$P_{i-1} = N_{TX} \frac{r^2}{r_v^2} [erfc(\frac{d-r}{\sqrt{4DiT}}) - erfc(\frac{d-r}{\sqrt{4D(i-1)T}})] \tag{4}$$

Implication

Here, equation[4] is not significantly different from that derived in the base article [1] except for a few constants. As in the base article, equation [4] could be modelled as a Poisson distribution. This would have no impact on the derivation for the optimized demodulation rule. Therefore, it can be said that the demodulation rule does not get affected whether the channel environment is bounded or unbounded.

References

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