**A**

**Project**

**SYNOPSIS**

**on**

**Simple Geometrically Interpolated Enhanced Spatial Modulation with Decode and Forward Relaying for Beyond 5G Communications**

*Submitted by*

**Rakshith Kamath**

**Reg. No: 170907048**

**Section: B**

**Roll No.:11**

*Under the guidance of*

**Dr. Goutham Simha G D**

**(Internal Guide)**

**Department of E&C Engineering**

**Manipal Institute of Technology**



**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**

**MANIPAL INSTITUTE OF TECHNOLOGY**

Manipal Academy of Higher Education

MANIPAL – 576104, KARNATAKA, INDIA

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| **Details of the organization**  **(with postal address):** | **Department of Electronics and Communication Engineering, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal-576104, Karnataka, India** |
| **Name of Guide with contact details and email address:** | **Dr. Goutham Simha G D**  **Assistant Professor**  **Department of E&C Engineering**  **MIT Manipal**  **Karnataka- 576104**  **India**  **Mobile: 9740773415.**  **goutham.simha@manipal.edu** |
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| **Signature of Guide with seal:** |  |

1. **Introduction**

With an increase in data consumption on mobile devices, wireless communication systems need to use innovative transmission schemes to achieve higher spectrum efficiency. To achieve this goal multiple-input multiple-output (MIMO) technology has emerged as a leading solution to fulfilling the said objective. MIMO systems promise a boost in spectral efficiency by simultaneously transmitting data from multiple antennas to an array of receivers. Alamouti discovered a simple diversity transmit technique that was called space-time coding (STC). They achieved diversity gain by transmitting multiple redundant copies of data from the transmitter to enable reliable coding at the decoder. While this had the distinct advantage of not requiring Channel State Information at the Transmitter (CSI-T) it came at the cost of lower spectral efficiency

The main limitation in MIMO systems is that its implementation complexity increases the number of antennas. There are certain cases where constraints in cost and energy availability lead to implementations using reduced number of RF chains in the transmitter than the number of transmit antennas. This is often the case in mobile and fixed user equipment since the number of antennas is dictated by the performance requirement of the downlink signal, but the cost and energy requirement may limit the number of RF chains that might be implemented. When the RF chains are lesser than the number of transmit antennas there are two methods available to exploit the inherent antenna redundancy. The first method is antenna switching to improve the system performance. If the CSI at the transmitter side is known the antennas corresponding to the best channel can be selected for transmission and this is known as *switching diversity.*

The second approach that can be used is called space modulation techniques (SMT) it is considered an innovative approach to tackle the problems faced by previous MIMO systems. In SMTs, a new spatial constellation diagram is added and utilized to enhance the spectral efficiency while conserving energy resources and receiver computational complexity. This is done by using the multipath nature of the channel and assigning information based on the indices of the active antennas that are transmitting.

Cooperative communications create collaboration through distributed transmission/processing by allowing different nodes in a wireless network to share resources. The information for each user is sent out not only by the user but also by other collaborating users. Cooperative communication has been shown as a promising approach to combat wireless impairments by exploiting spatial diversity without the need of multiple antennas at one node. In the case of cooperative AF relaying, a source (S) and destination (D) nodes are communicating, and multiple or single AF relays participate in the communication protocol as illustrated below in **fig1** wherein each node or relay receives the signal sent by the source, amplifies the signal, and then retransmits it to the destination node. The destination then decodes the message being sent from a combination of signals transmitted directly from the source and each of the relays in the system.

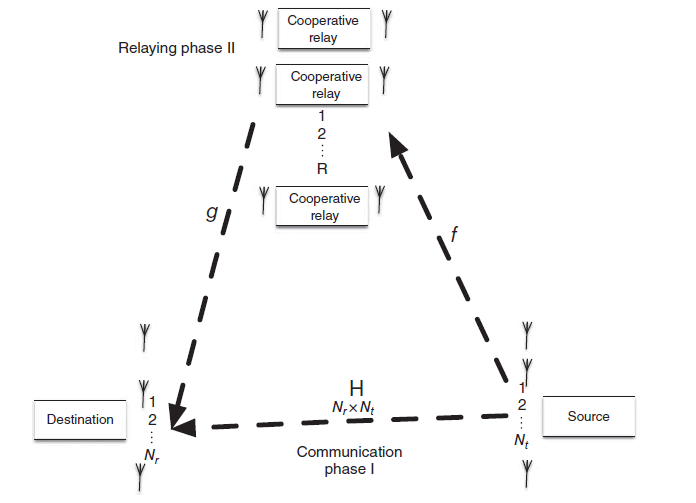


Fig1-Cooperative SMT block diagram

1. **Need for the project**

With the advent of several wireless technologies such as Wireless Sensor Networks, IoT, MANETS emphasis has fallen upon improving the performance of our current wireless network infrastructures. This can be primarily by modifying the physical layer to provide increased data speeds to improve connectivity. This project aims to achieve that by seeking an improvement of spectral efficiency and reduce the required transmission power for a given wireless communication system while maintaining the same cell coverage. Further since bandwidth is a scarce resource it is highly desirable to improve cell throughput by increasing the spectral efficiency rather than increasing bandwidth. A great way to improve the spectral efficiency is to simultaneously serve many user terminals in the cell, over the same bandwidth, by means of spatial multiplexing.

Driven by the several advantages of space modulation techniques (SMTs) and cooperative communication technologies, cooperative SMTs have been extensively investigated in the past few years. Reported results promise significant enhancements in spectral efficiency and network coverage which will enable further improvements in applications built around a wireless platform such as:

* Video Streaming and Live Broadcasting
* Autonomous Vehicles
* IoT in Smart City Infrastructure and Traffic Management
* Industrial Automation
* Augmented and Virtual Reality
* Digital FPV Systems

1. **Objective**

Analyze the performance of a MIMO Wireless Communication system transmitting using an energy efficient Spatial Modulation Technique and enhance the system performance using Decode-and-Forward relay technique.

1. **Methodology**

The project is carried out in into following parts

* Generating system model for Enhanced Spatial Modulation (Type-2)
* Develop simulation scripts to generate signal constellations for ESM type 2 as given in [1]
* Development of Monte Carlo Simulations using a Maximum Likelihood Detector
* Analysis of system performance through Symbol Error Rate vs SNR plots
* System enhancement through decode-and-forward cooperative SMT
* Generate system model to enable decode-and-forward (DF) relaying
* Comparative analysis between system with and without relaying
* Expanding system to incorporate multiple DF relays.
* Performance evaluation of system under channel correlation
* Bring about notion of channel correlation using the Kronecker Model
* Compare performance of system with and without relay for various magnitudes of channel correlation
* Designing of low complexity decoder
* Develop and simulate low complexity sphere decoder
* Performance analysis between high complexity ML decoder and low complexity sphere decoder

1. **Project Schedule**

**Sample schedule for four-month duration**

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| *January 2021* | * Literature Survey * M-ary signal constellation design for simulations using MATLAB. * Implementation of ESM type 2 as given in [1] |
| *February 2021* | * Development of Monte Carlo simulations for ESM type 2 * Comparative analysis of ESM type 2 with baseline Generalized Spatial Modulation (GSM) * Understanding of cooperative SMTs |
| *March 2021* | * Implementation of Cooperative SMT through decode-and-forward (DF) relaying. * Simulation of DF relaying and comparative studies with decode-and-forward (DF) relaying using MATLAB. * Comparative study of system model using Rayleigh, Rician and Nakagami channel fading |
| *April 2021* | * Simulation and comparative study of system model under various fading environments with channel correlation * Design and Implementation of low-complexity Sphere Detector * Compilation of results and paper writing |

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| ***Student Details*** | | | |
| **Student Name** | **Rakshith Kamath** | | |
| Register Number | 170907048 | Section / Roll No | B-11 |
| Email Address | Rakshith7kamath99@gmail.com | Phone No (M) | 9591685722 |
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| *Organization Details* | | | |
| **Organization Name** | **Manipal Institute of Technology** | | |
| Full postal address with pin code | Department of Electronics and Communication Engineering, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal-576104, Karnataka, India | | |
| Website address | https://manipal.edu/mit.html | | |