**Author - Shubham Jain**

In this Document we will discuss 3 Network configuration which are simulation of the Cournot game for power control.

**Case 1: Unstable Condition**

In this Network configuration (Fig 1.1) 10 transmitter and 10 receivers are positioned in a Region of 10kmx10km.

The distance between the transmitters and receivers affects the channel gains gij, gij​. Larger distances result in smaller gains due to signal attenuation, which can increase interference between transmitters and affect SINR.

A graph of a graph

Description automatically generated with medium confidence

Fig 1.1

As we can observe in below fig 1.2 power is increasing exponentially at maximum iteration.

A graph with numbers and a line

Description automatically generated

Fig 1.2

In the below Fig 1.3 we can se that Final SINR value for most of the players is less than their initial SINR

A graph of different colored bars

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Fig 1.3

In below Fig 1.4 Total transmission power over iterations is exponentially shooting up which implies this configuration leads to **Failure of Convergence**. The iterative power updates will not converge to a stable set of transmission powers.

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Fig 1.4

In the below Fig 1.5 H matrix is calculated based on the Function H\_ij = gamma \* (g\_ij / g\_ii)

After calculating H matrix than its Perron-Froebenius eigenvalue is calculated which comes out to be **3.3012198728628723** which is greater than 1.

The system is not able to stabilize at an equilibrium where all users transmit at power levels that allow successful communication without excessive interference.

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Fig 1.5

Conclusion : In this Network Configuration Fig 1.1 leads to High interference, inefficient power control, and possibly dropped communications, which would require either more sophisticated power control algorithms or better network planning to reduce interference.

**Case 2: Stable condition with more power**

In this Network configuration (Fig 2.1) 10 transmitter and 10 receiver are positioned in a Region of 10kmx10km.A graph of a function

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Fig 2.1

As we can observe in below Fig 2.2 power is decreasing for each player after few iterations and getting stable but some player are transmitting more power than others.

A graph with colored lines

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Fig 2.2

In the below Fig 2.3 we can observe that Final SINR value for all players converges at same value

A graph of different colored bars

Description automatically generated with medium confidence

Fig 2.3

In below Fig 2.4 Total transmission power over iterations has reached a stable point with in few iterations which leads to **Convergence**.

A graph with a blue line

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Fig 2.4

In the below Fig 2.5 H matrix is calculated based on the Function H\_ij = gamma \* (g\_ij / g\_ii)

After calculating H matrix than its Perron-Froebenius eigenvalue is calculated which comes out to be **0.2969828172635345** which is less than 1.

A screenshot of a computer program

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Fig 2.5

Conclusion : A **Nash equilibrium** is reached, but the cost is that users must transmit at higher power levels.

**Case 3: Stable condition**

In this Network configuration (Fig 3.1) 10 transmitter and 10 receiver are positioned in a Region of 10kmx10km.A graph of a graph

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Fig 3.1

As we can observe in below Fig 3.2 power is decreasing for each player after only few iterations and getting stable to very low power values.

A graph with different colored lines

Description automatically generated

Fig 3.2

In the below Fig 3.3 we can observe that Final SINR value for all players converges to the same value which leads to stability.

A graph of different colored bars

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Fig 3.3

In below Fig 3.4 Total transmission power over iterations has reached a stable point with in few iterations to the lowest value of powers which leads to power efficiency.

A graph with a blue line

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Fig 3.4

In the below Fig 3.5 H matrix is calculated based on the Function H\_ij = gamma \* (g\_ij / g\_ii)

After calculating H matrix than its Perron-Froebenius eigenvalue is calculated which comes out to be **0.23807094671566298 ,** which is less than 1.

A screenshot of a computer program

Description automatically generated

Fig 3.5

Conclusion: A **Nash equilibrium** is reached , The system reaches **convergence**. Power control works efficiently, ensuring acceptable SINRs for all users with no significant power spikes or oscillations. Total transmission power remains controlled, and interference is minimized.