# PageRank Manipulation: A Study on Bot Farms

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## 1 Introduction

The objective of this project is to explore how the PageRank algorithm works and investigate strategies for manipulating PageRank rankings through strategic link formations. You will analyze the effect of bot farms and strategic linking in a directed graph and assess how they can influence the ranking of a specific target node. We use a damping factor of $\alpha = 0.85$ in all PageRank computations.

## 2 Project Setup

You are given a directed graph (click this link) in the form of a list of directed edges. You will be in control of a set of bot nodes and will use them to manipulate the PageRank of a designated **target node**. The target node for this experiment is labeled as **Node 81**.

## 3 Tasks and Experiments

### 3.1 Task 1: Setting Up a Bot Farm

You will create a bot farm of 10 new nodes under your control. The initial strategy is to:

- Measure the PageRank ranking of the target node before introducing the bot farm.
- Make all bot nodes follow the target node and recompute the PageRank ranking of the target node.
- Apart from all bot nodes following the target node, make the target node follow all the bots in your farm. Recompute the PageRank ranking of the target node.

Should the target node follow the bots?

### 3.2 Task 2: Exploring Intra-Bot Links

Sometimes, it is convenient to mark the structure of the bot farm by adding links among the bots. Now, we will see how modifying the bot farm by adding internal links affects the ranking of our target node:

- Apart from all bots following the target, and vice versa, form a regular graph of degree 1 among the bots (i.e., pairs of bots follow each other).
- Observe how intra-bot linking affects the PageRank of the target node.
- Compare with the case of forming a regular graph of degree 2 among the bots.

Should the bots follow each other if the only objective is to increase the ranking of the target node?

### 3.3 Task 3: Convincing Other Nodes to Follow You

If you can convince other nodes in the network to follow you, this could further increase your PageRank. Perform the following experiments:

- Convince 1 influential node to follow the target node and measure its new ranking.
- Convince 3 influential nodes to follow the target node and measure its new ranking.
- Analyze whether having the target node reciprocate these links has an additional effect.

What are your conclusions from these experiments?

## 4 Expected Outcomes and Analysis

After performing the experiments, you should be able to:

- Identify the most effective strategy for increasing the PageRank of the target node.
- Understand how intra-bot linking can impact the effectiveness of the bot farm.
- Analyze the role of high-PageRank nodes in boosting your target node's ranking.
- Determine whether mutual linking is beneficial or not in different scenarios.

## 5 Deliverables

Your final report should include a well-structured and annotated Python notebook where you describe the strategies used, show how the PageRank ranking of the target node changes with each strategy, and include conclusions and recommendations for the most effective way to manipulate PageRank.