

## Apply It.

# The math behind... Information Epidemics



### Technical terms used:

Optimal Control, modeling, Maki Thompson Rumor Model, Pontryagin's Minimizing Principle, boundary value problem, SIR/SIS model

### Uses and applications:

In elections, campaign managers want to ensure that by Election Day their candidate and platform are well known to the public. Thus, the goal of any campaigner is to try to reach as many people as possible, while effectively using their resources (i.e., staying on budget). To do this, the campaigner wants to optimally control the spread of information leading up to the election to ensure that the maximum number of people are aware of the candidate. This same type of modeling can be used to optimize the spread of information in social awareness campaigns, movie promotions, and product advertising.

### How it works:

A piece of information, such as awareness about a campaign or a product, spreads through a population much like pathogens in the human body. This phenomenon is called an information epidemic. Understanding information epidemics allows campaigners to better allocate resources to maximize awareness of an issue. Mathematically, a solution can be found by employing an optimal control problem where the campaigner wants to minimize the number of people unaware of an issue, subject to constraints on time and resources.

Using a Maki Thompson Rumor Model to describe how information spreads, the population is divided into three categories: ignorants (those who don't have the information), spreaders (those who are spreading the information), and stiflers (those who stop the spreading), where spreaders are generated at some rate due to contact between spreaders and ignorants. Initially, there are no stiflers. The objective is to minimize the number of ignorants (or those who are unaware of the information) by the deadline, given total available resources. The solution to this model is the set of optimal strategies employed by the campaigner at a given time to accelerate information diffusion.

By constructing a series of equations to model the proportion of ignorants in the population, the proportion of spreaders in the population, and the cumulative resources spent, we can construct an optimal control problem. Applying Pontryagin's Minimizing Principle to this problem creates a boundary value problem, which can then be solved using various techniques or algorithms to give the optimal strategies.

### Interesting facts:

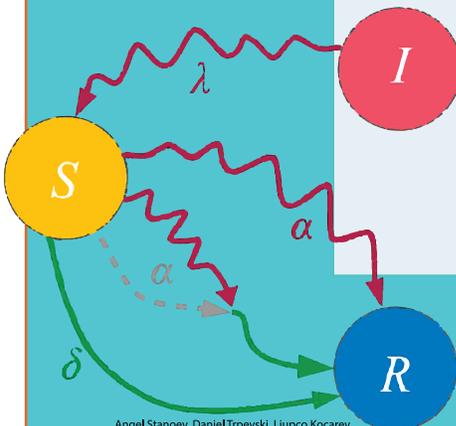
Mathematicians often apply SIR/SIS models, which are used to model the transmission of communicable diseases through individuals, to information epidemics. However, the Maki Thompson Model is a better fit for information spreading because it takes into account the psychological aspects of this phenomenon. For example, the Maki Thompson Model considers the fact that meeting others with the same information can change the spreader's perception of the information, which may turn a spreader into a stifter.

### References:

K. Kandhway and J. Kuri. Optimal control of information epidemics modeled as Maki Thompson rumors. *Communications in Nonlinear Science and Numerical Simulation* 19, 4135-4147 (Dec 2014).

K. Kandhway and J. Kuri. How to run a campaign: Optimal control of SIS and SIR information epidemics. *Applied Mathematics and Computation* 231, 79-92 (March 2014)

Submitted by Emma Young, Bowdoin College, USA, First place, Math Matters, Apply it! contest February 2015



Angel Stanoev, Daniel Trpevski, Ljupco Kocarev