KDD 2012 BEIJING
THE 18TH ACM SIGKDD CONFERENCE ON KNOWLEDGE DISCOVERY AND DATA MINING
Beijing, China August 12-16, 2012

Interacting Viruses in Networks: Can Both Survive?

Alex Beutel
Carnegie Mellon University
abeutel@cs.cmu.edu

B. Aditya Prakash
Carnegie Mellon University
badityap@cs.cmu.edu

Roni Rosenfeld
Carnegie Mellon University
roni@cs.cmu.edu

Christos Faloutsos
Carnegie Mellon University
christos@cs.cmu.edu

How do we model competition between products?

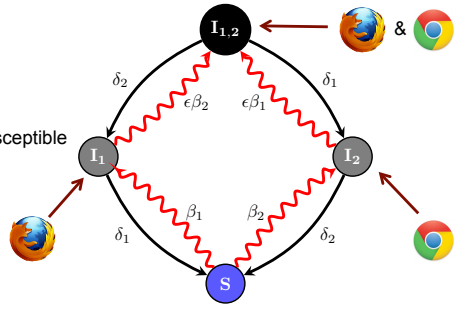
hulu vs. BLOCKBUSTER

Not perfect competition

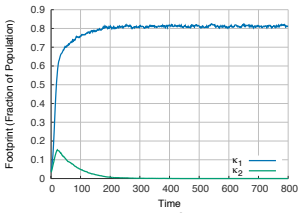
Person can use both Chrome and Firefox

A Simple Model: $SI_{1|2}S$

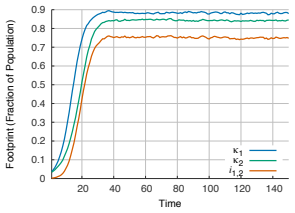
- Modified SIS (flu-like) model
- Susceptible – Infected$_{1 \text{ or } 2}$ – Susceptible
- Interaction Factor ε
  - Full mutual immunity ε = 0
  - Competition ε < 1
  - Cooperation ε > 1



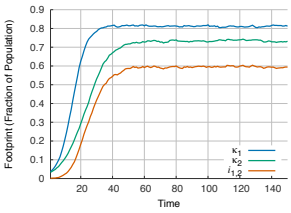
Previous work focused on simpler cases



ε = 0
Viruses are mutually exclusive
Winner takes all

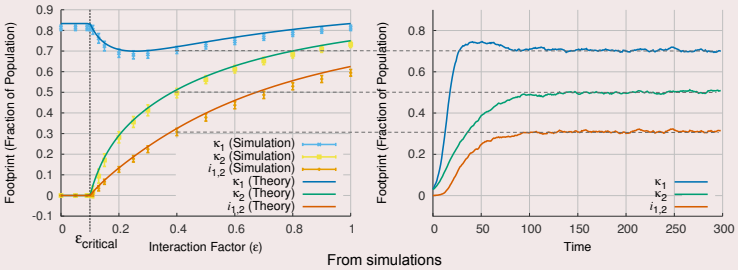


ε = 1
Viruses are independent
Co-exist independently



ε = 2
Viruses cooperate

Our Result: A phase transition exists where viruses can co-exists!



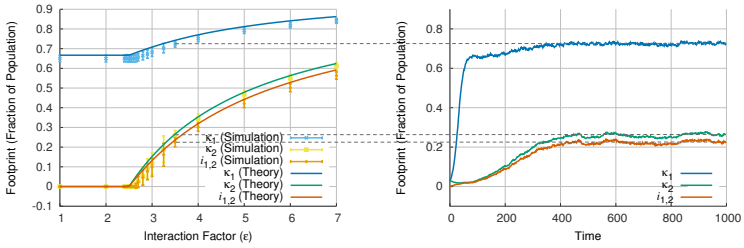
From simulations

Given our $SI_{1|2}S$ model and a fully connected graph, there exists an $\varepsilon_{critical}$ such that for $\varepsilon \geq \varepsilon_{critical}$, there is a fixed point where both viruses survive.

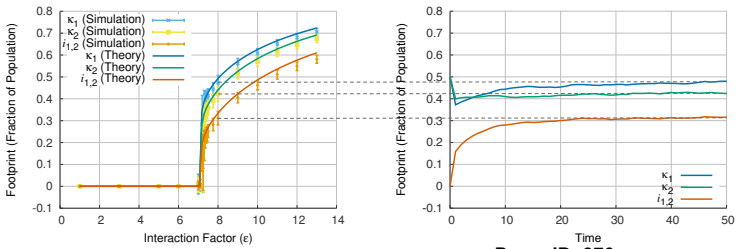
$$\epsilon_{\text{critical}} = \begin{cases} \frac{\sigma_1 - \sigma_2}{\sigma_2(\sigma_1 - 1)} & \text{if } \sigma_1 + \sigma_2 \geq 2 \\ \frac{2(1+\sqrt{1-\sigma_1\sigma_2})}{\sigma_1\sigma_2} & \text{if } \sigma_1 + \sigma_2 < 2 \end{cases}$$

Cooperating Viruses: ε > 1

Piggyback Setting: Strong virus helps weak virus survive ($\sigma_2 < 1 \leq \sigma_1$)

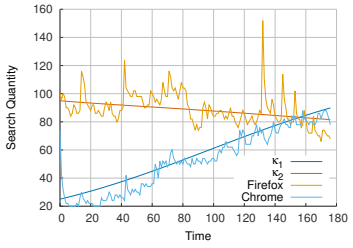


Teamwork Setting: Neither virus can survive on its own ($\sigma_2 \leq \sigma_1 < 1$)

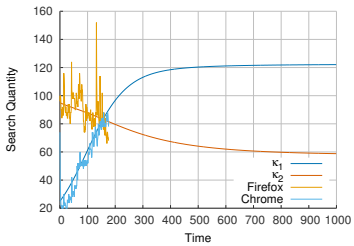


Real World Example:

(data from Google Insights)



Prediction from our model:



Paper ID: 376