



Competition over popularity in social networks

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Eitan Altman
March 2012




The involved actors:

- **Individuals** who wish to disseminate content through a social network. **Goal: visibility, popularity**
- **Social network provider (SNP)** interested in maximizing the amount of downloads
- Has **tools** to accelerate the dissemination of popular content.
Example: Recommendation graph

Example: YOUTUBE

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The video player shows a black and white image of Astor Piazzolla playing the bandoneon. The video title is 'Milonga para tres - Astor Piazzolla'. The player controls show a progress bar at 00:14 / 10:42. Below the player, there are buttons for 'Like', 'Add to ▾', and 'Share'. The video has 34,269 views. It was uploaded by ntemlibre100 on Aug 20, 2010. The description says 'No description available.' and the artist is listed as Astor Piazzolla. There is a 'Show more' link below the video information.

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Example: YOUTUBE

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The video player shows a black and white image of Astor Piazzolla playing the bandoneon. A red banner at the bottom of the video frame reads 'EFS ÉTABLISSEMENT FRANÇAIS DU SANG' and 'www.dondelsang.com'. The video progress bar shows 00:14 / 10:42.

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Recom graph

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A list containing other ad events:
Charing and embedding



Significant discovery events

	Date	Event	Views
A	02/22/12	First view from a mobile device	107,108
B	02/22/12	First embedded on – facebook.com	75,452
C	02/22/12	First referral from YouTube search – obama singing	31,008
D	02/22/12	First embedded on – whitehouse.gov	23,221
E	02/22/12	First referral from – facebook.com	19,180
F	02/22/12	First embedded on – plus.google.com	11,465
G	02/22/12	First referral from YouTube search – barack obama singing	7,892
H	02/22/12	First referral from YouTube search – obama sings	8,601
I	02/22/12	First embedded on – failblog.org	5,824

Model



- N content creators (seeds)– players
- M potential destinations
- A destination m is interested in the first content that it will be aware of.
- Information on content n arrives at a destination after a time exponentially distributed with parameter $\lambda(n)$.
- The goal of a seed: maximize the number of destinations $X_i(T)$ at time T (T large) that have its content (dissemination



- Player n can accelerate its information process by a constant **a** at a cost $c(\mathbf{a})$
- Uniformization: let
- $J^i(v, x, a)$ = total utility for player i if at time 0 the system is at state x , player j takes action a_j and the utility to go for player i from the next transition onwards is $v(y)$ if the state after the next transition is y .



$$P_{\mathbf{x} \mathbf{a} \mathbf{z}} = \begin{cases} (M - |\mathbf{x}|) \frac{a_i \lambda_i}{\lambda} & \text{for } \mathbf{z} = \mathbf{x} + e_i, \mathbf{x} \in X \setminus \mathcal{M} \\ 1 - (M - |\mathbf{x}|) \frac{\sum_i a_i \lambda_i}{\lambda} & \text{for } \mathbf{z} = \mathbf{x}, \mathbf{x} \in X \end{cases}$$

Define

$$\delta_j(v, \mathbf{x}) = v(\mathbf{x} + e_j) - v(\mathbf{x}).$$

Define for each player i , $\mathbf{x} \in X \setminus \mathcal{M}$, $\mathbf{a} \in \mathbf{A}$ and $v \in R^X$:

$$J^i(v, \mathbf{x}, \mathbf{a}) = -c_i(a_i) + \frac{(M - |\mathbf{x}|)}{\lambda} \sum_{j=1}^N a_j \lambda_j (\zeta_i(x_i) 1\{j = i\} + \delta_j(v, \mathbf{x}))$$

$$0 = \max_{\mathbf{u} \in \Delta(\mathbf{A}_i)} J^i(v_i, \mathbf{x}, \mathbf{u})$$

□ We solve the DP



- ▣ **For linear dissemination utility, we can reduce the state space to the number of destinations that have some content. 1-dimensional!**
- ▣ **Solution: formulate explicit M matrix games, the equilibrium at matrix m is the equilibrium of the original game at state m**



The case of no information

Let $\bar{x}_i(t) := E[X_i(t)]$ and $\bar{x}(t) := \sum_{i=1}^N \bar{x}_i(t)$. Then

$$\dot{\bar{x}}_i(t) = \lambda_i w_i^i (M - \bar{x}(t))$$

This is a differential game with a compact state space.



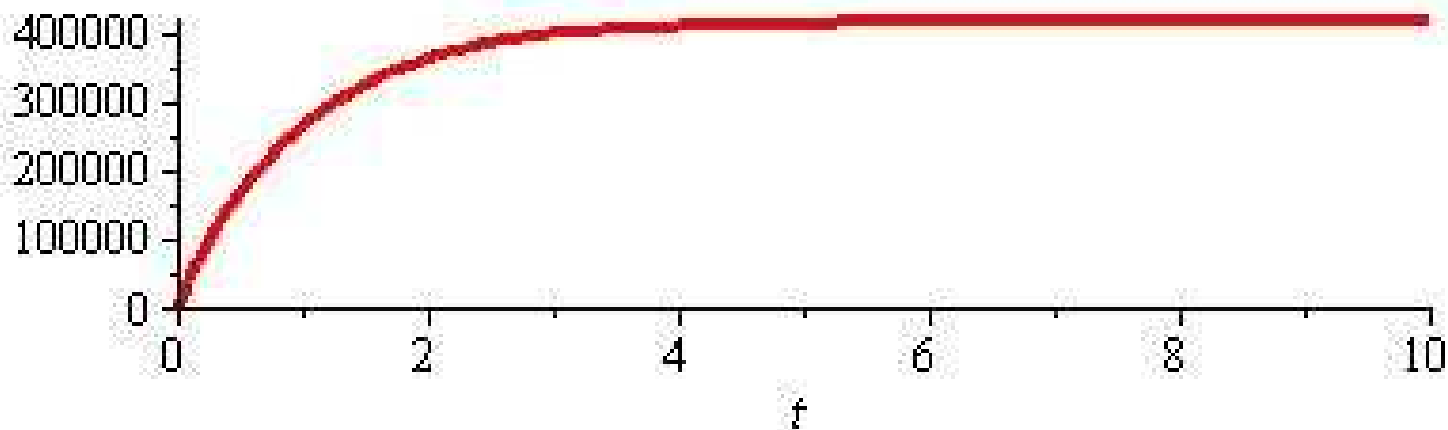
Results

Again state space collapse to dimension 1

- ▮ Equilibrium at state m obtained as equilibrium of m -th matrix game. Now m is a real number
- ▮ For linear acceleration cost – same threshold policies

Results

- Static case (policies constant in time): explicit expressions for the state evolution and the utility.
- The state is proportional to

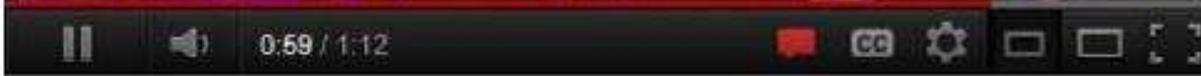


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Good fit!



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