Word of Mouth: Rumor Dissemination in Social Networks

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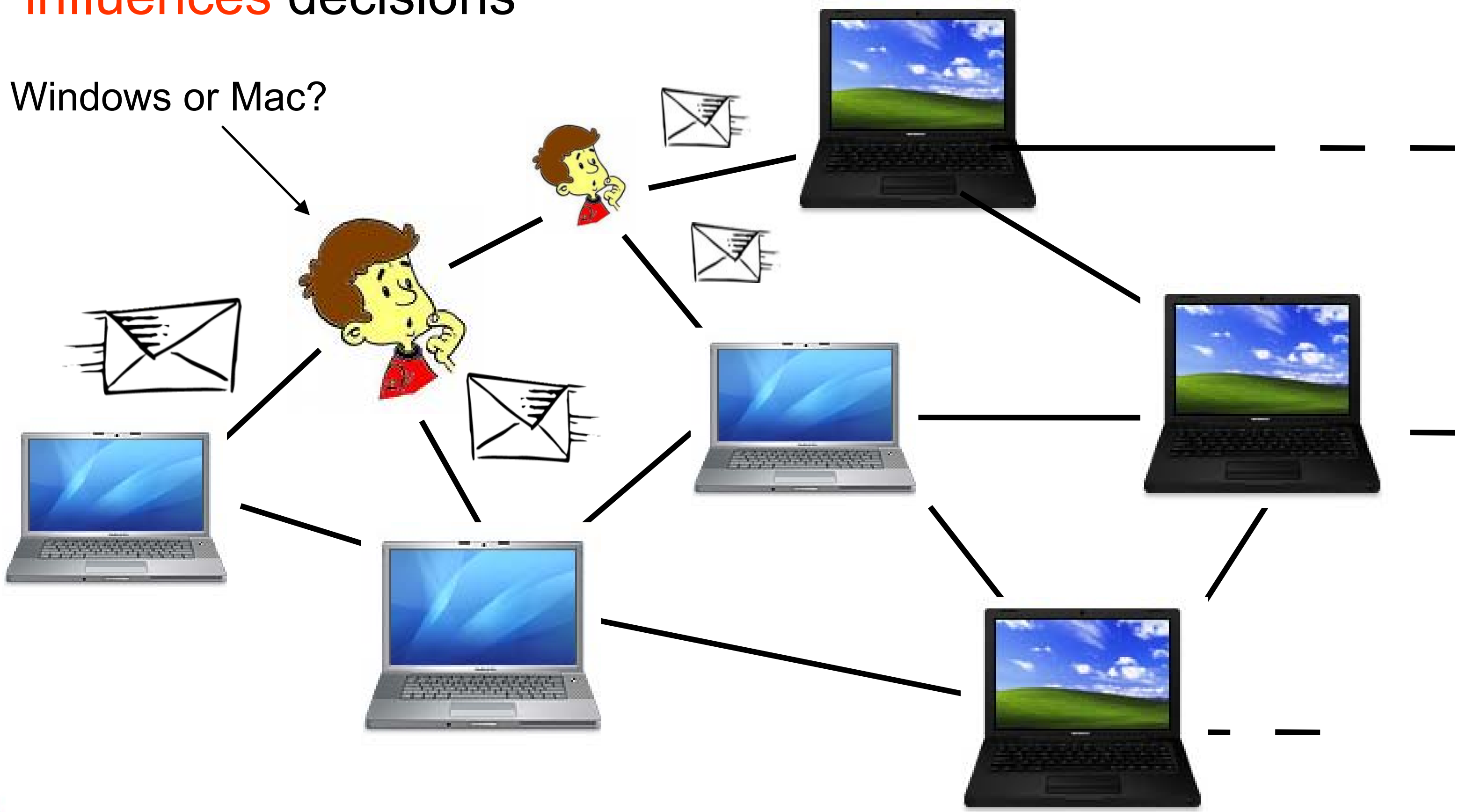
Introduction

social networks everywhere: facebook, co-authors, email ....

=> effects dissemination of information

=> influences decisions



Introduction

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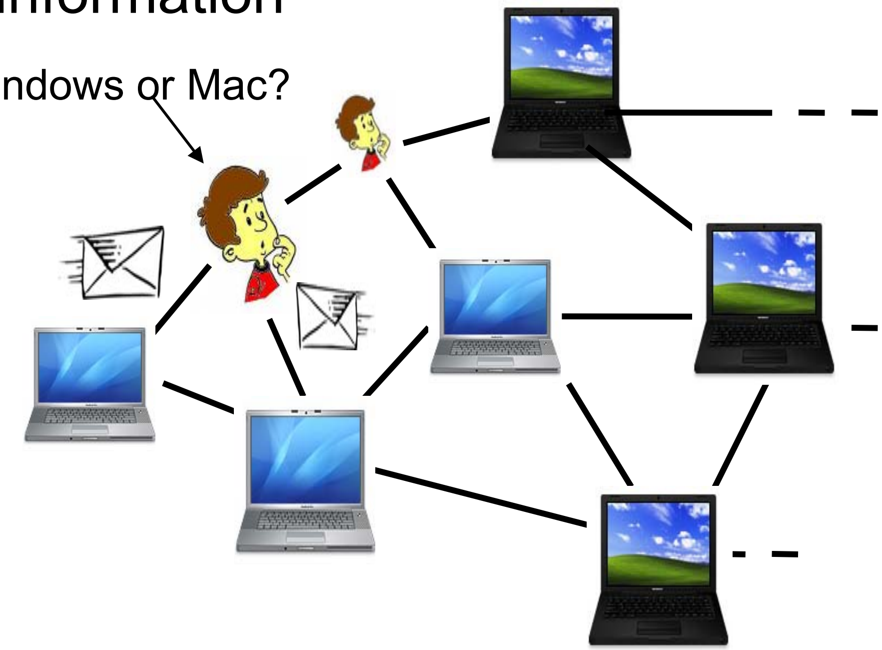
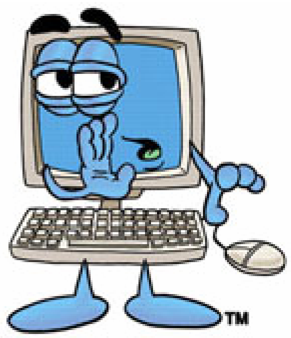


- viral marketing
- competing theses, theories
- virus vs immunisation

GOAL: select optimal initiator set,
to convince as many nodes as possible

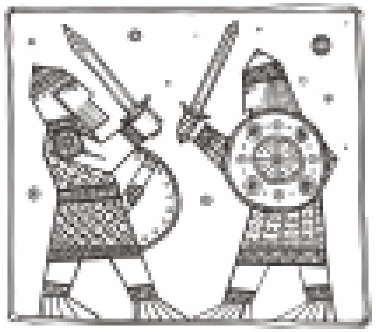
Related Work

1 rumour



- epidemics, physical processes:
  sophisticated propagation models + simulation
- Kempe et al. [KDD03] :
  selecting optimal initiators is NP-hard
  greedy hill climbing algorithm: (1-1/e)-approximation

2 competing rumours



- Bharati et al.[WINE07], Carnes et al.[ICEC07]
  2nd player: selecting optimal initiators is NP-hard
  hill climbing works as well

What about the 1st player?

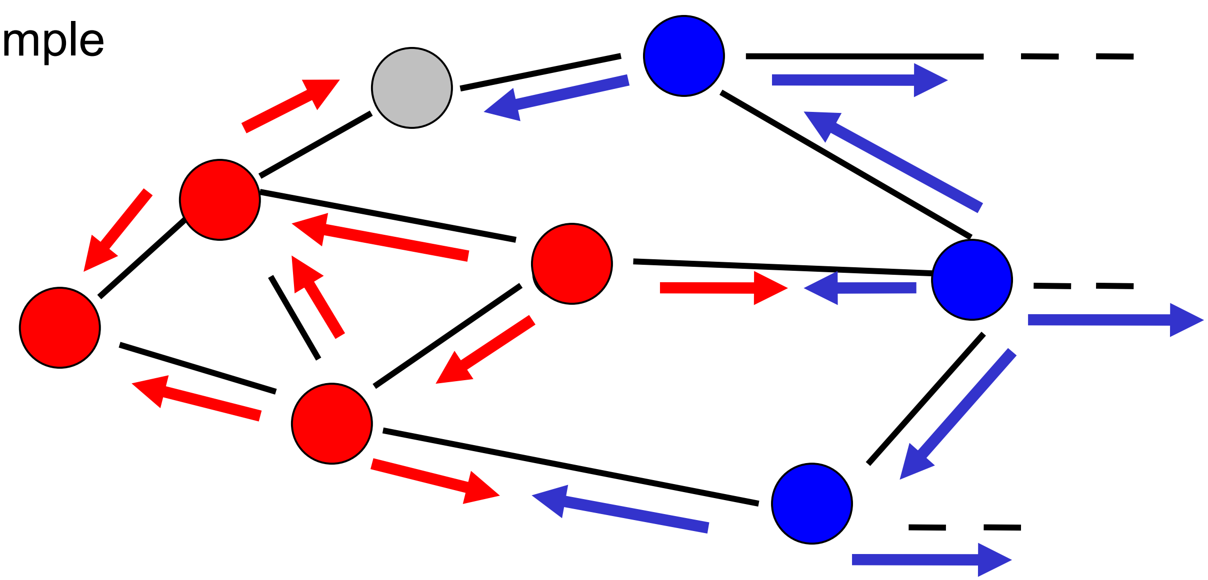
Basic Model

- strategy: select set of nodes to initiate the rumour
- rumour propagation:
  - accept first rumour encountered
  - forward rumour to all adjacent nodes

Payoff:

 # convinced nodes

Example



1st player:

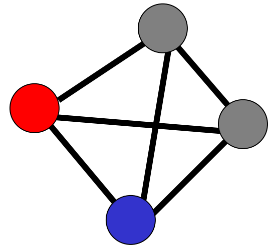
4 nodes

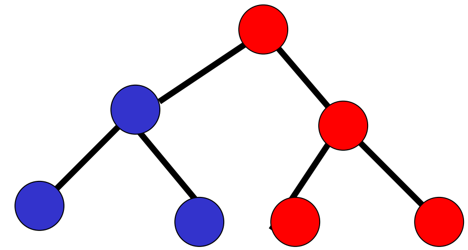
2nd player:

3 nodes

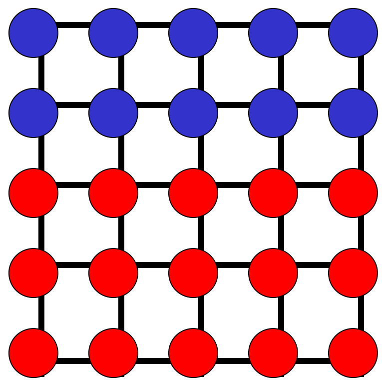
variations: more players, payoff definition, propagation model (cascade, threshold, …), weighted or directed edges, …

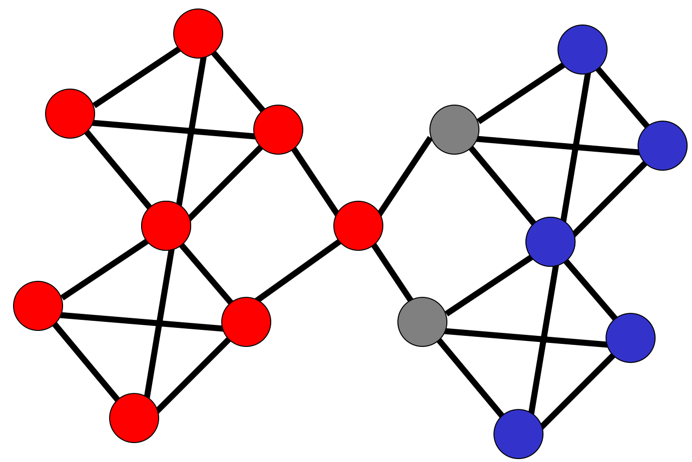
Warm-Up: 1 vs 1





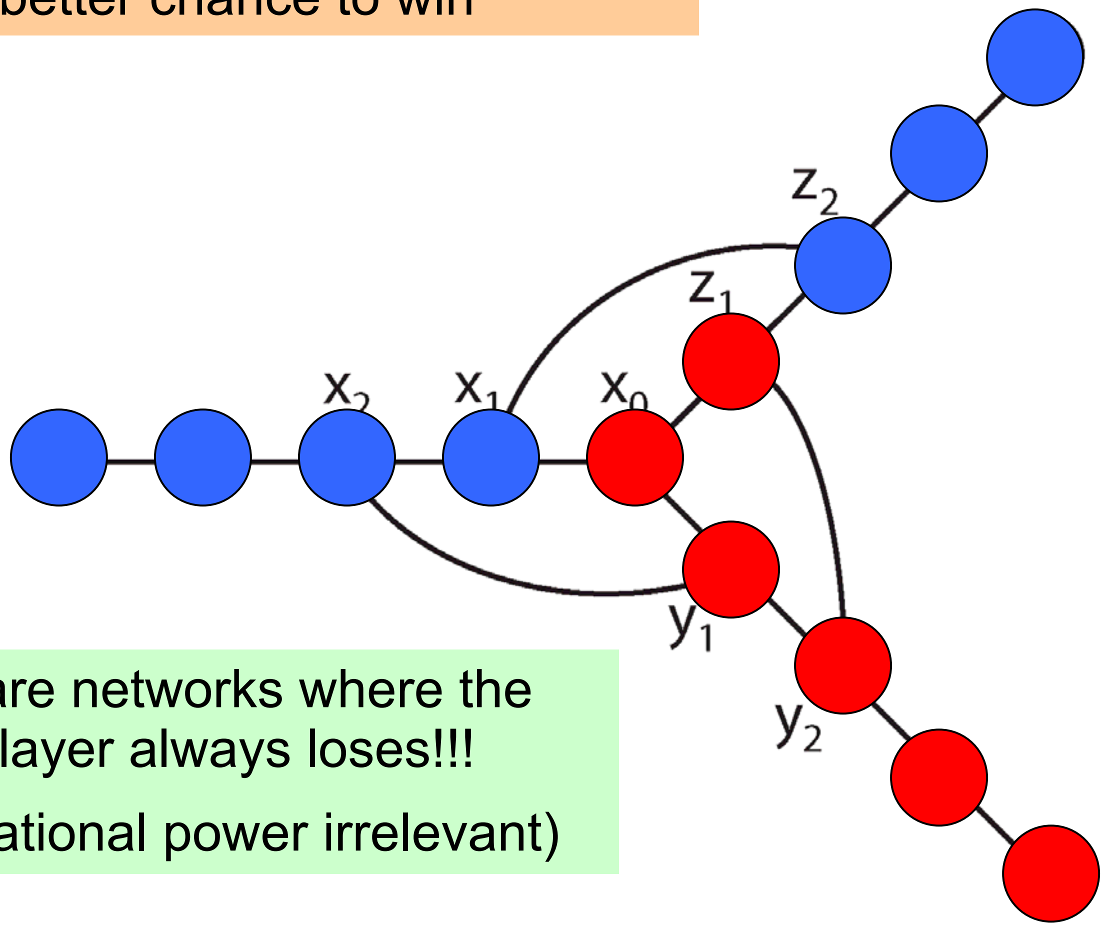
- Complete graph
- Trees
- Grid
- Bottleneck





He who laughs last, laughs best?

Intuition: 1st player has more choice
$\Rightarrow$ better chance to win



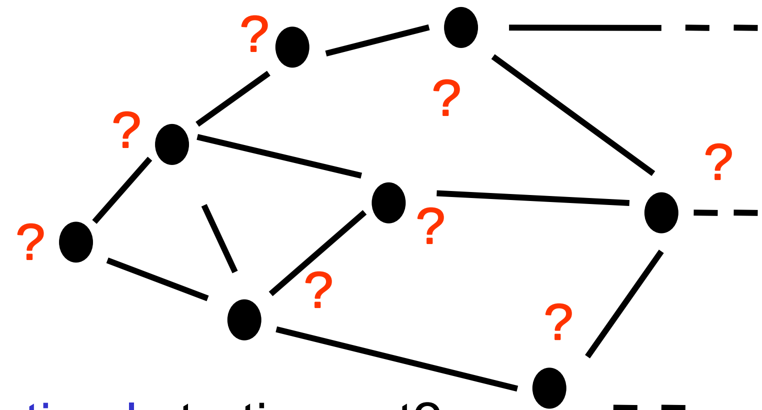
There are networks where the
1st player always loses!!!

(computational power irrelevant)

How hard is it to compute the optimal strategy?

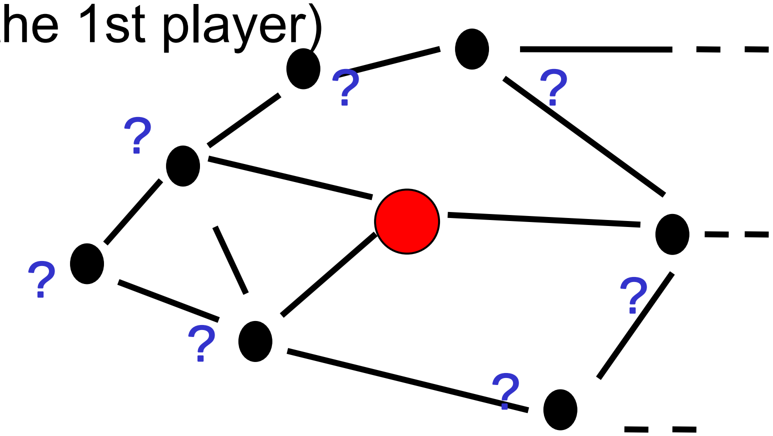
Centroid Problem

1st player: how do I choose the optimal starting set?
(knowing how many nodes the second player can select)



Medianoid Problem

2nd player: how do I choose my optimal starting set?
(knowing the nodes selected by the 1st player)



NP-hardness of Medianoid Problem

Theorem. *The (r|p)-medianoid problem is NP-hard.*

Proof:

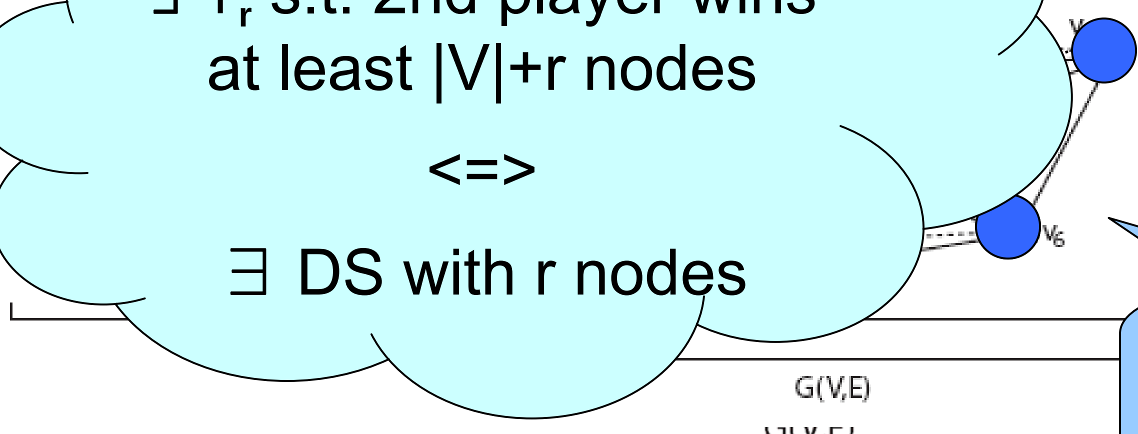
Reduce Dominating Set (DS) problem to (r|1)-medianoid problem.

Idea: show that
∃ Y_r s.t. 2nd player wins
at least |V|+r nodes

<=>

∃ DS with r nodes

1st player chooses x_1
2nd player selects Y_r



payoff 2nd player:
nodes closer to Y_r
than to X_p.

DS

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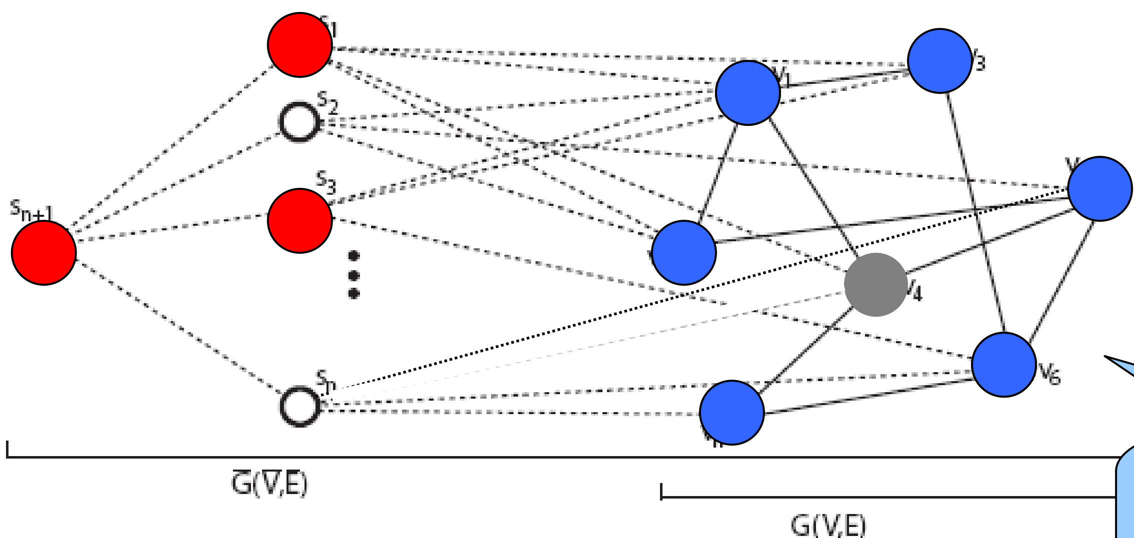


1st player chooses x_1
2nd player selects Y_r

payoff 2nd player:
nodes closer to Y_r than to X_p .

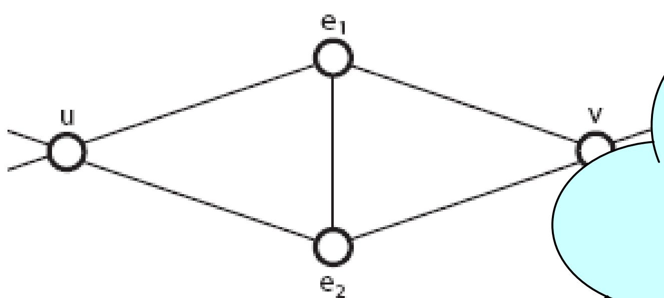
Y_r != DS

NP-hardness of Centroid Problem

Theorem. *The (r|p)-centroid problem is NP-hard.*

Proof:
Reduce Vertex Cover (VC) problem to (1|p)-centroid problem.

Given graph G(V,E), replace each edge with "diamond structure"



1st player chooses X_p
2nd player selects $Y_1(X_p)$

Idea: show that
$\exists$ X_p s.t. less than 2 nodes closer to $Y_1(X_p)$
<=>
$\exists$ VC with p nodes

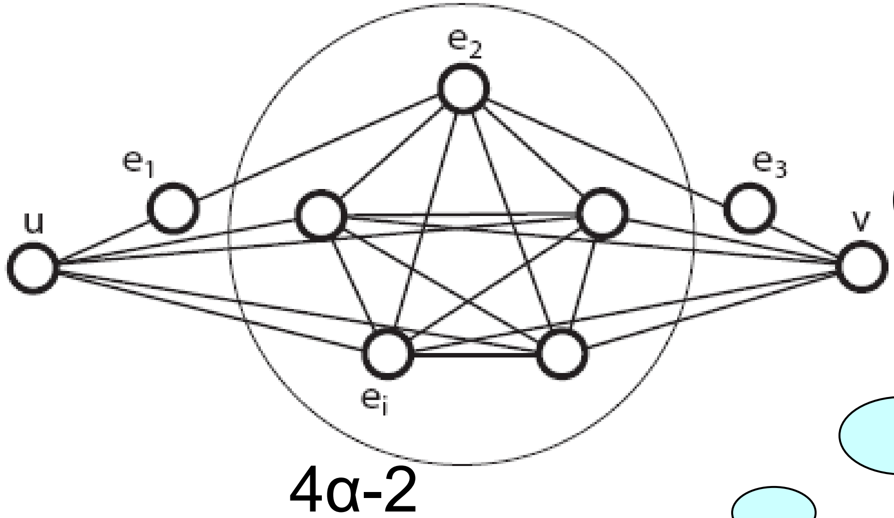
f x_i on every ... d, we are ok
if no x_i on diamond, contradiction

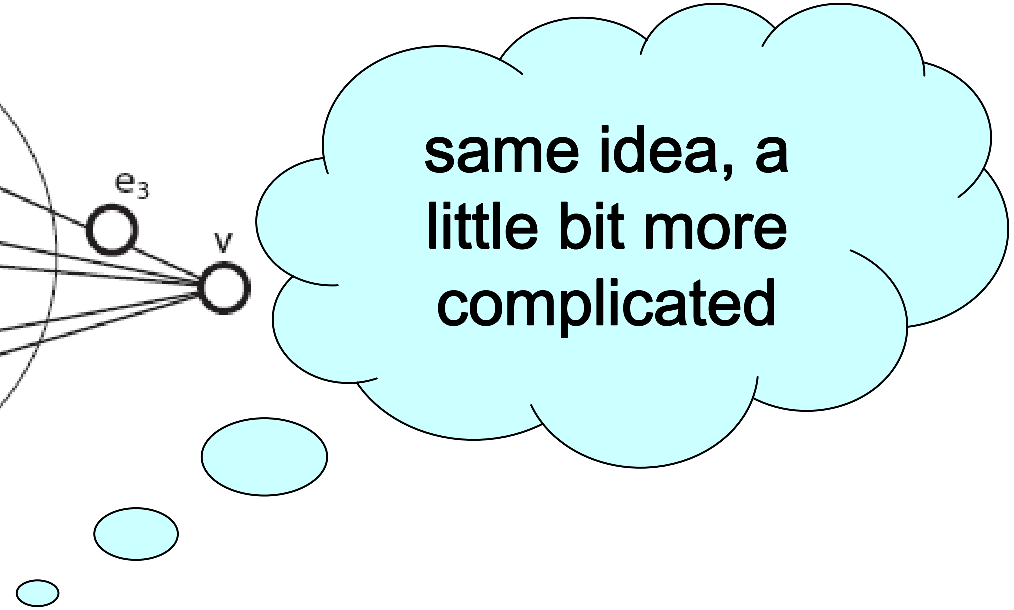
NP-hardness of Approximating the Centroid Problem

Theorem. *Computing an α-approximation of the (r|p)-centroid problem is NP-hard.*

Proof:
Reduce Vertex Cover (VC) problem to (1|p)-centroid problem.

Given graph G(V,E), replace each edge with "clique structure"





More findings…

- relationship Condorcet vertex – centroid
- characterize weaknesses of heuristics for centroid
  - small radius
  - high degrees
  - midpoint of spanning tree
- (not in paper) simulation of strategies in random graphs:
  Kleinberg, Watts, Epstein model

The End!

THANK YOU!

Questions? Comments?