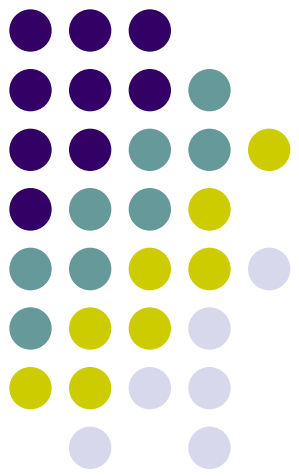


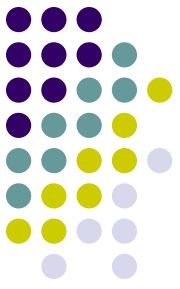
THE FLIP SIDE OF METCALFE'S LAW: THE MULTIPLE and GROWING COSTS OF NETWORK EXCLUSION

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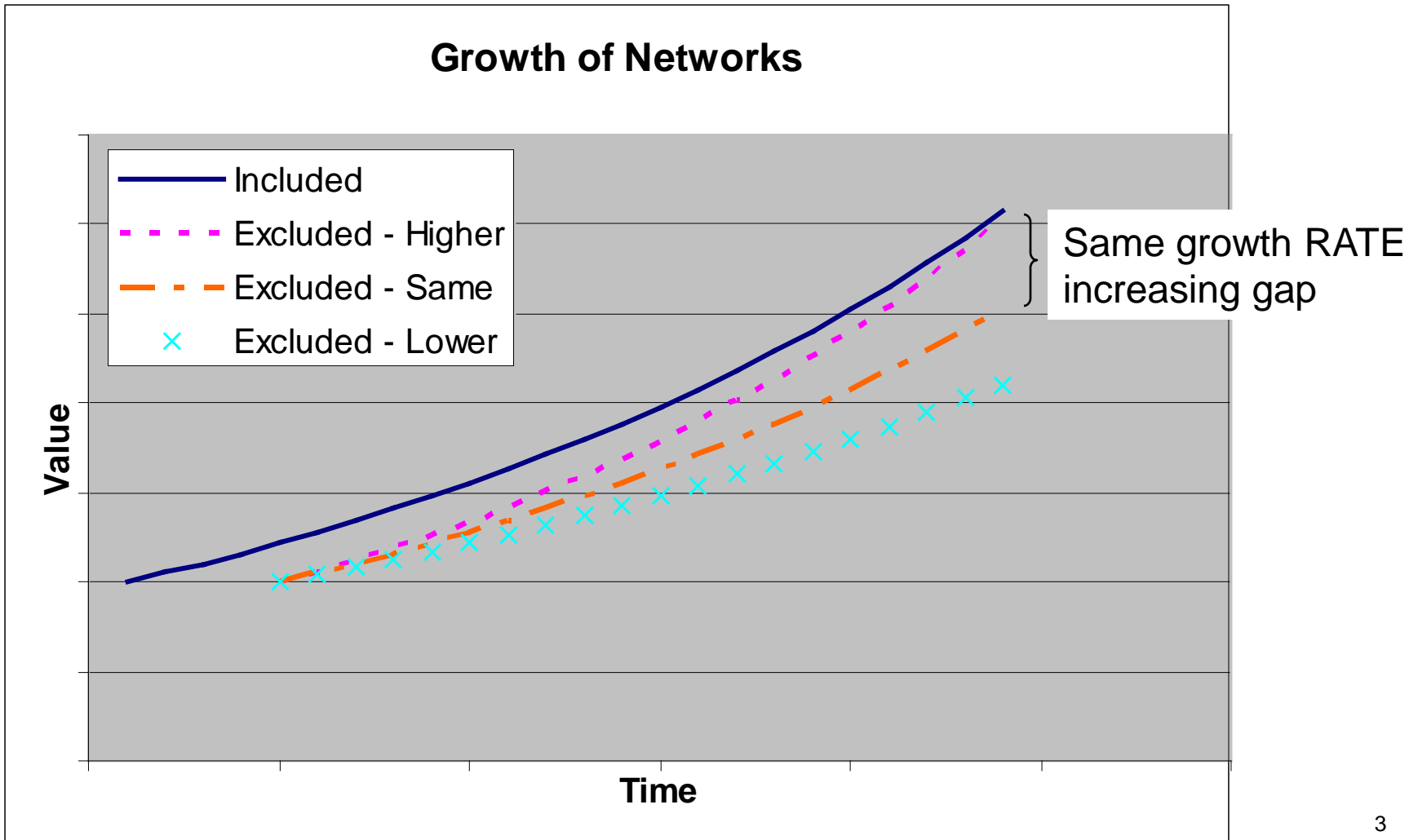
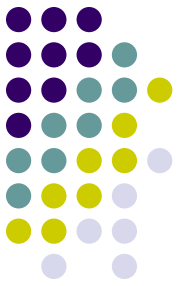
Overview of Presentation



How should we usefully think about network exclusion?

- Overview of literature and current frameworks
 - Find a narrow examination of the digital divide
 - Most network values are based on network inclusion
- Limitations of inclusion-frameworks
- Alternative framing of disparity based on exclusion
 - Comparing inclusion vs. exclusion framings
- Grey areas – multiple networks and non-binary states
- Costs to society (not just individuals) of exclusion
- Conclusions and further discussion

Included vs. Excluded – do they Catch up (varying growth rates)?

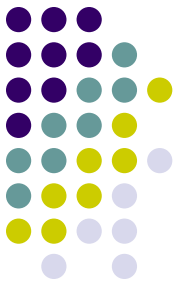


Where's the Exclusion?: “6 Degrees of Separation”



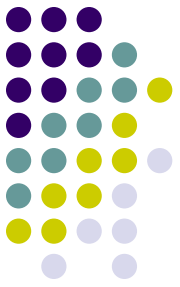
- Oft-cited example of Small Worlds
- Based on Stanley Milgram's experiments sending letters from Nebraska/Kansas to a particular person just outside Boston
 - “Random” people were asked to forward the letters only to someone they knew well (first name basis)
 - The average number of hops was under 6
 - Led to the famous phrase that has entered the layperson lexicon
- *The average number of <6 was only for those letters that made it (44/160)!*
- *Unpublished material indicates completion rates in other experiments by Milgram were closer to 5%, with more hops (Kleinfeld, 2002)*

Networks – Inclusion, Exclusion, and Values



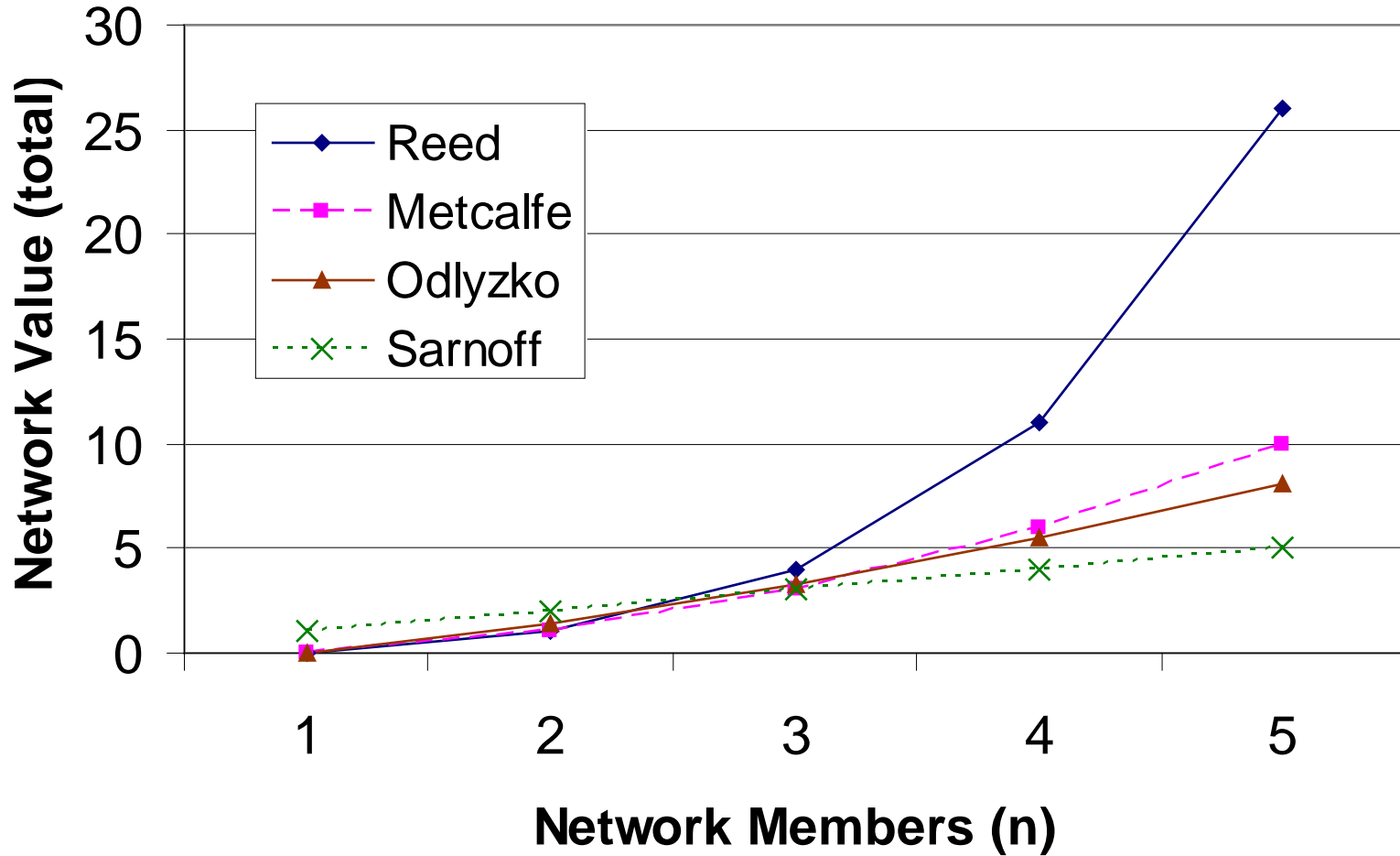
- Most scholarly attention is on network inclusion or participation
 - Issues include granularity, externalities, and even binary modes of participation (“do you have a phone”?)
- Few frameworks of exclusion
- Need: a combined view of inclusion and exclusion
- Definitions themselves may be contentious
 - Cost vs. value
 - Exclusion
 - What about available but not included?

Selected Network Value Framings



Value <i>(proportional to)</i>	Chronology	Originator	Model	Example
n	1	Sarnoff	Broadcasting	TV
$n*\log(n)$	5	Odlyzko	A practical Metcalfe's Law	Telephone
n^2	2	Metcalfe	Networks	Telephone
n^c	6	Nivi	A practical Reed's Law	Google Groups
2^n	3	Reed	Communities	Google Groups

Network Values

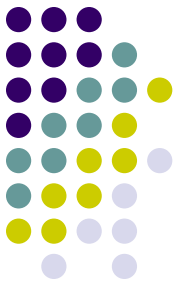


What about those NOT in the network?



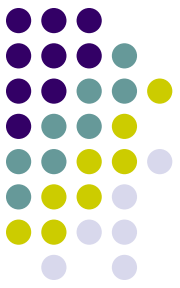
- Total network values as per the Laws all show increasing value
- Intuitively, those outside the network would then face growing disparity of exclusion
 - Is this disparity a cost?
 - How do we value it?
 - One simple metric, which is based on an *inclusion framework*, takes the value of inclusion per person included and compares it with those outside ($\equiv 0$)

Inclusion Framework for Disparity



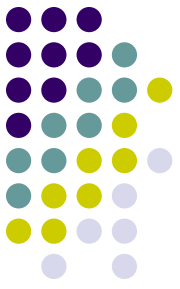
- Taking Metcalfe's Law as an example
- If $n=19$, total network value is $\sim n^2 = 361$
- Per person, the value is $\sim 361/19 = 19$
 - The disparity is ~ 19 then compared to those outside
 - *But surely disparity is different if only 1 person is outside the network versus 181!*
 - Total applicable populations are 20 vs. 200

Other Limitations of Inclusion Framing



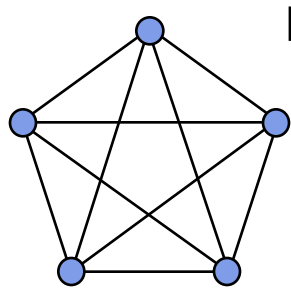
- Under an inclusion framing, as the “included” network grows towards superiority, society overall is always better off (for all monotonically growing network value formulations)
 - Loss of value of diminishing network is more than offset by growth of included-network valued
- But this only examines total social welfare (value), without examining impacts on the excluded network or the excluded *individuals*

Networks, Equality, and Externalities

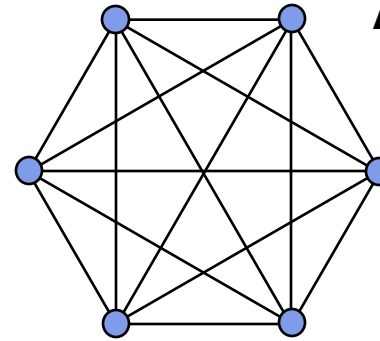
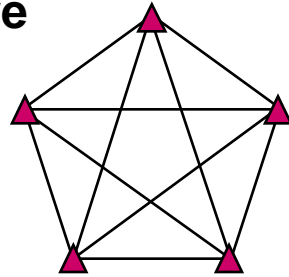


- Network effects have been well-understood in many domains (communications, industry, standards, etc.)
- So is network exclusion simply an issue of competing options, e.g., Betamax vs. VHS?

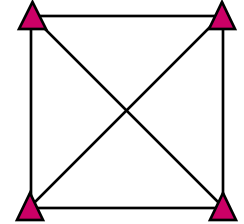
Network Effects are Strong



Before

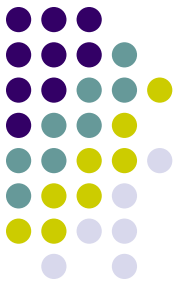


After



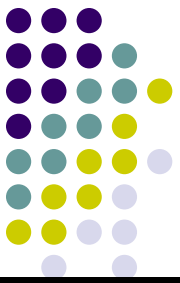
Network A	Network B		Network A	Network B
5	5	Number of nodes	6	4
25	25	Total value (approximated Metcalfe, full mesh)	36	16
50%	50%	Share of total nodes	60%	40%
50%	50%	Share of total value	69.2%	30.8%

“Network Effect” can be an Incomplete Explanation

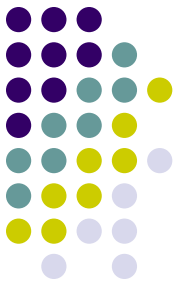


- One network can be superior due to several reasons
 - Intrinsic nature
 - E.g., Broadband > dial-up; immunized > non-immunized
 - Dynamics
 - Sends signals to potential participants and complementary networks (e.g., housing markets, operating systems, etc.)
- What happens to the other network?
 - Is there even another “network” (that too, being measured)?
 - Does it change?

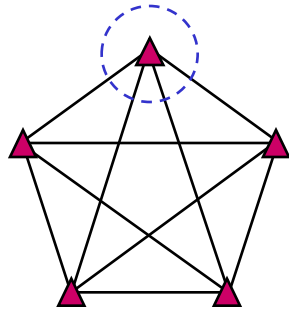
Possibilities for Comparative Network Exclusion



<i>A and B are two networks; A is growing</i>		Option 1	Option 2	Option 3
Network	Network A (Superior Network)	“Network” B has zero value* (* Special case of a constant value)	Network B is a Network of Diminishing Value	Network B’s structure (dynamics) causes disproportionately decreasing value
Value	Value grows as per Network Law (e.g., Metcalfe’s)	Value remains 0	Value falls as per Network Law (e.g., Metcalfe’s)	May be shifts as per changing network structure and size
Disparity		Disparity is <i>relative</i> to A	Absolute loss of value is because of fall in intrinsic network value	Intrinsic loss of value PLUS loss due to network dynamics

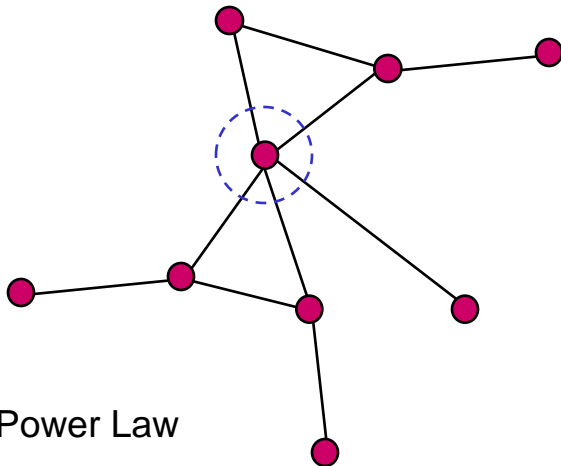


Losing Nodes in a Network



Full Mesh

vs.

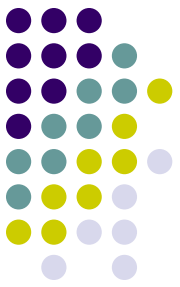


~ Power Law

- Thus, comparative measures between A and B show examining A (“included”) network is insufficient
- Even examining Network A vs. Network B using a single Network Law (e.g., Metcalfe’s) may understate the impacts of exclusion

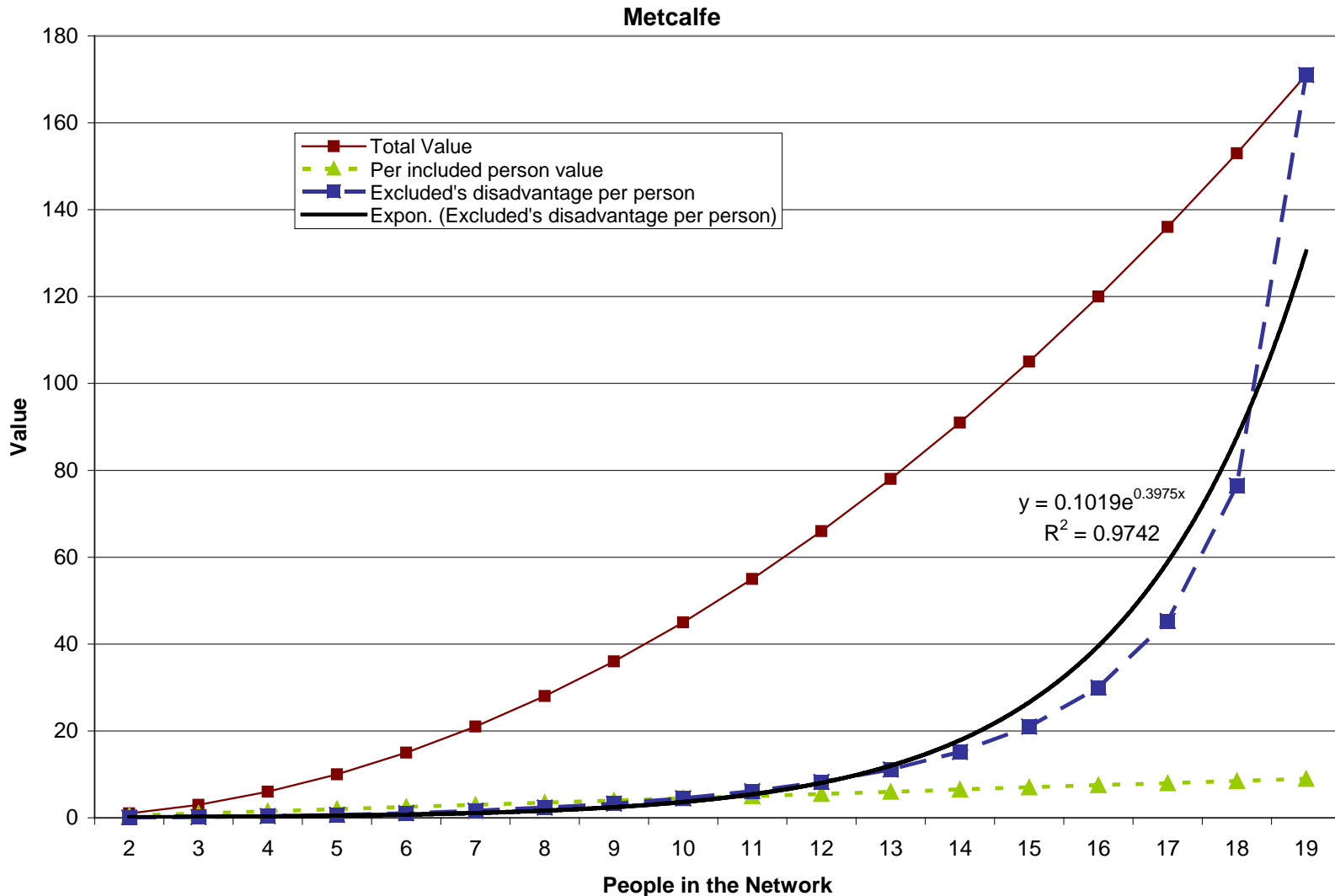
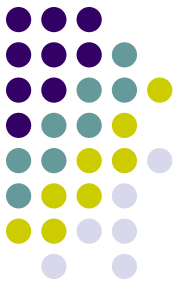
Ultimately, we may care about individuals as well

Proposed: Exclusion Framing of Disparity (“Cost”)

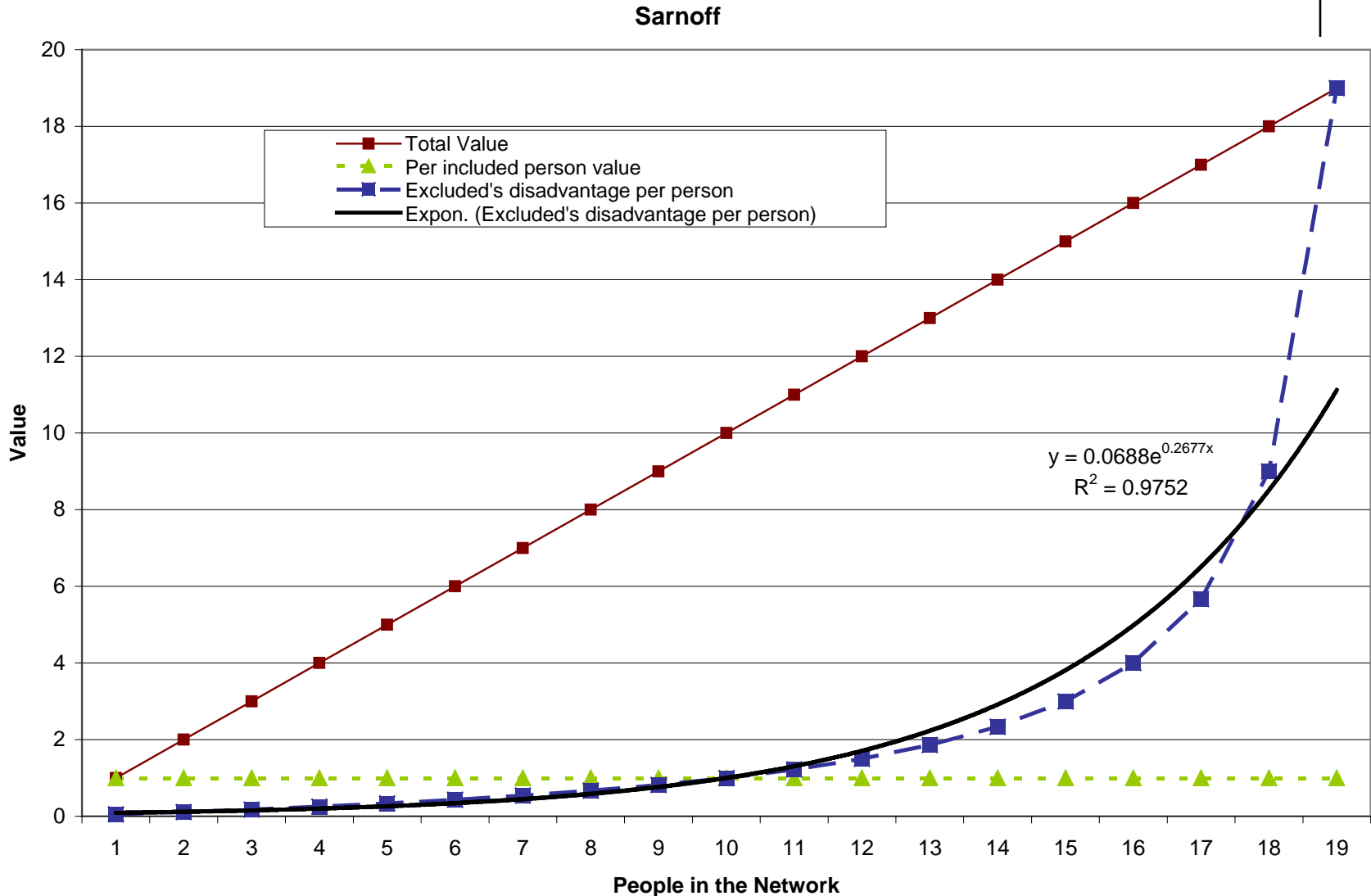


<p>Existing Exclusion cost formulations = per person included value</p>	$\frac{[\textit{Network Value as per any Law}]}{\textit{Members in the Network (= n)}}$
<p>Proposed Exclusion Cost formulation = total (included) network value divided by number of people excluded</p>	$\frac{[\textit{Network Value as per any Law}]}{\textit{Members outside the Network (= N - n)}}$ <p>(Where N = total applicable population)</p>

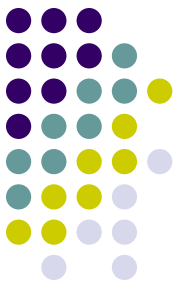
Metcalfe – Exclusion vs. Inclusion Disparity



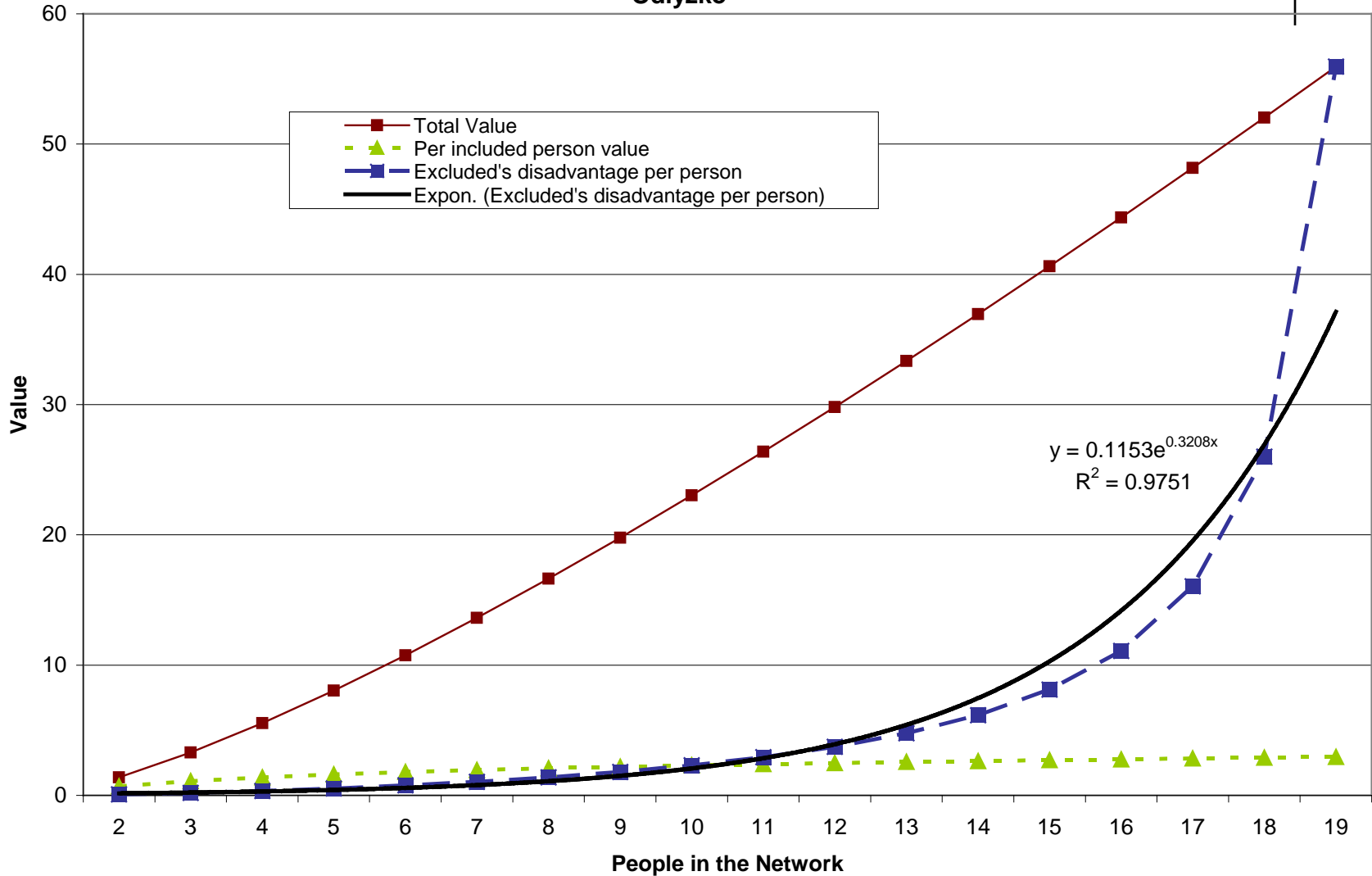
Sarnoff – Exclusion vs. Inclusion Disparity



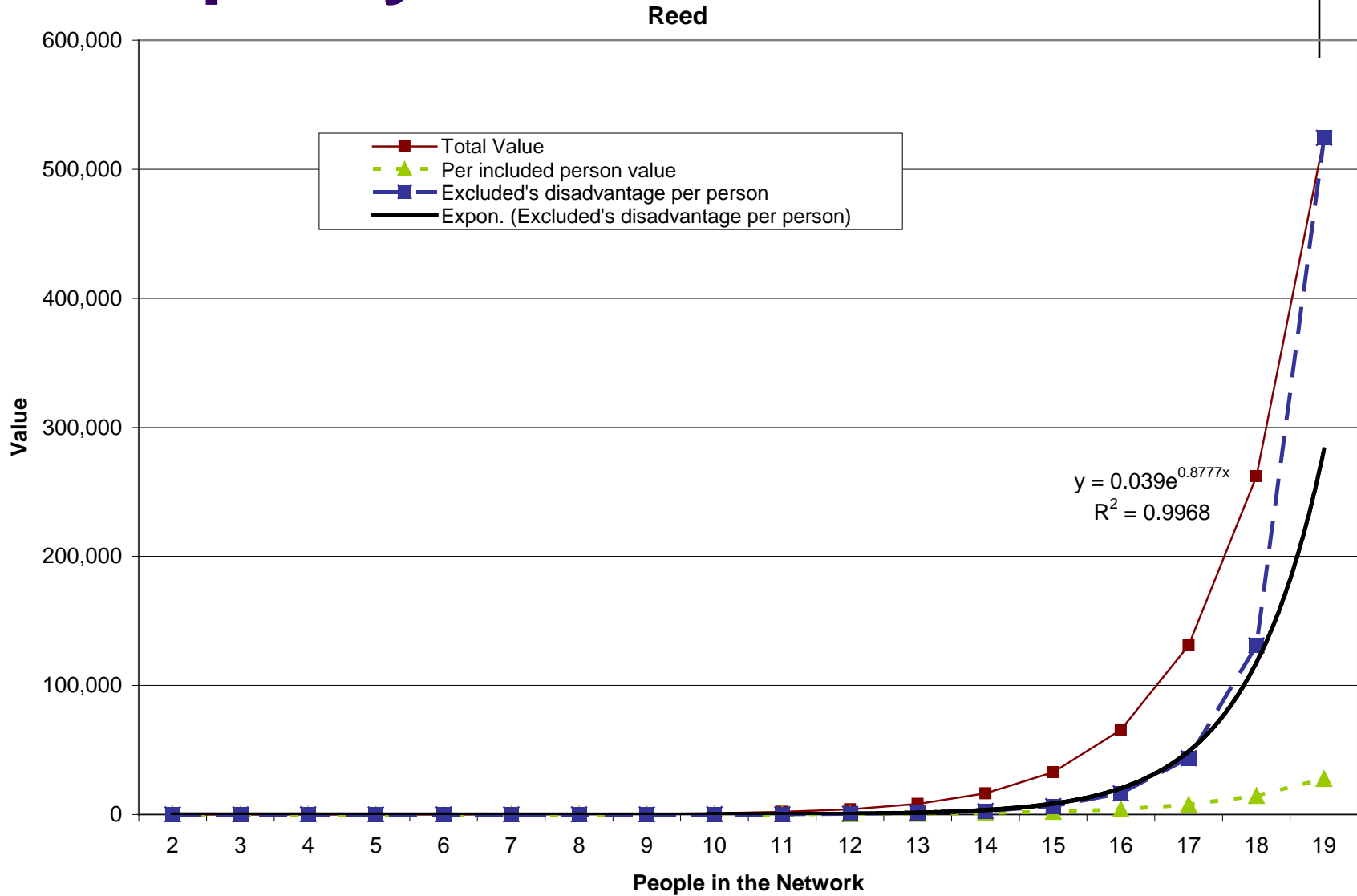
Odlyzko – Exclusion vs. Inclusion Disparity



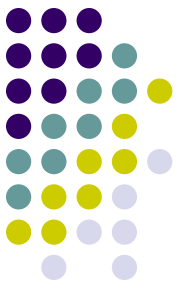
Odlyzko



Reed – Exclusion vs. Inclusion Disparity



Early stages of networks also matter

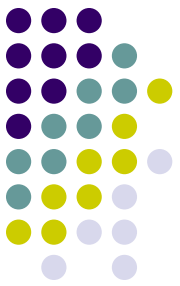


- Network value inclusion framings themselves fail to capture the importance of new networks
 - First mover advantage
 - Positive feedback and lock-in issues (Arthur, 1989)
 - Set up rules of the game
 - Capture disproportionate portion of growth (e.g, the few broadband users in a developing country)

Both Framings may be appropriate...with more importance at different points



- In the initial period, network membership (or a technology, e.g.,) offers a *competitive advantage* (having it helps)
- When it becomes the norm, network membership becomes a *competitive necessity* (not having it is what hurts) (IT systems - Clemons, 1986)
- The difference in framings (without normalization) is greatest *when only a few people are excluded*
- **Ultimately, we need a framework that captures both inclusion and exclusion**
 - There may be a phase transformation at hand



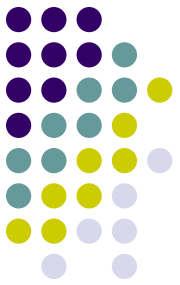
“Costs” of Exclusion

- Applying new parameters to existing laws of networks shows *exponential* costs to the excluded
 - Regardless of underlying network law (structure)
- Our proposed model for exclusion can capture issues of both network structure and dynamics in a simplified form

Future refinements might include:

$$\frac{[\textit{Included Network Value as per any Law}]^\alpha}{[\textit{Members outside the Network (= } N - n)]^\beta}$$

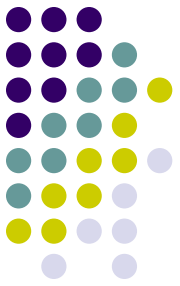
Where α , β are parameters depending on exclusion network structure and dynamics



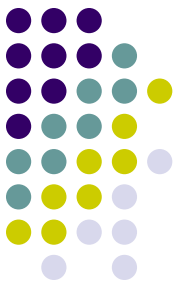
Revisiting Exclusion

- Exclusion from the measured (“included”) network is inherently difficult to measure
 - Inclusion is not just binary (e.g. cell phones per 100 people)
 - There may be many (infinite) possible alternatives
 - E.g., If I cannot download a form off the web, I might
 - Call
 - Fax
 - Write
 - Travel
 - Car
 - Bus
 - Walk
- Differing requirements and impacts
(in time, money, skills, etc.)
- Many statistics (and even studies) fail to capture such multi-modal networks, let alone their intersection

Exclusion/Alternative Networks can Raise Costs Overall



- Need to maintain dual/parallel networks
 - Touch tone and pulse telephony
 - Digital and Analog broadcast TV
- Older systems may not be maintained/patched
 - Windows 98 machines are responsible for an enormously disproportionate number of Internet attacks
 - Affects Windows XP and Vista users
- Those lacking healthcare insurance end up in the emergency room
 - We all pay for these patients



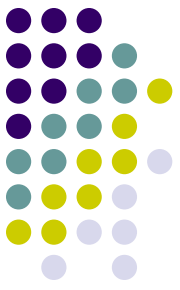
Policy Implications and Qs

- Rethinking Universal Service
 - Landlines today – Internet (or broadband) tomorrow?
 - Supply-side economics (free markets) unlikely to lead to universal deployment
 - Public Utility models?
 - Cross-subsidies vs. subsidies
- Revisiting integration of multiple networks and their interactions
- Revisiting issues of networks vs. individuals

Implications and Directions for Future Research

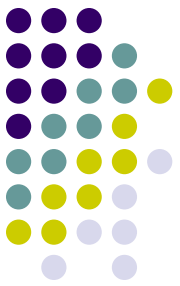


- Conceptual
- Theoretical
- Empirical
- Practical



Theoretical and Conceptual

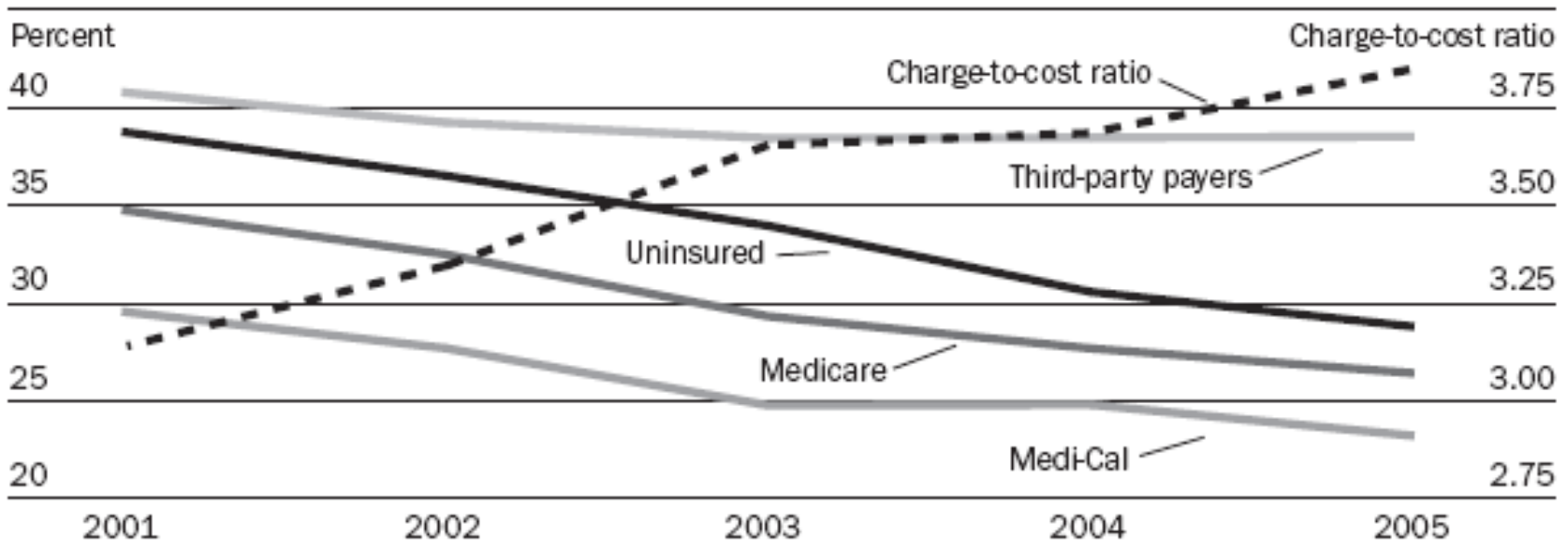
- How much of this is simply membership into a network more than details of the network distribution?
 - I.e., “in” vs. “out”?
- What happens if exclusion is treated as a non-binary phenomenon?
 - Strength of Weak Ties (Granovetter, 1973)
- What happens when we postulate not all individuals are equal?
 - E.g., Producers vs. Consumers
 - Is this only due to network phenomenon or other reasons as well?



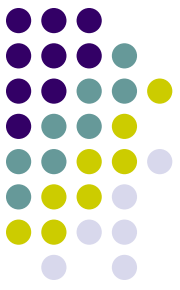
Empirical

- One of the few empirical studies on healthcare monies versus insurance type (Melnick and Fonkych, 2008) showed counter-intuitive results for the payments for the same procedure

Trends In Average Hospital Collection Ratios, By Payer, California, 2001–2005

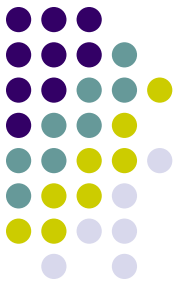


(“Hospital Pricing And The Uninsured: Do The Uninsured Pay Higher Prices?”
Melnick and Fonkych, 2008)



Empirical (Cont.)

- Healthcare example (cont.)
 - The missing detail was this was costs realized by the providers, excluding factors like
 - Those who do vs. do not pay
 - Transaction costs for collection agencies (maybe some 25-30%)
- We need to improve measurements of alternative and parallel networks
 - CONCEPTUAL ISSUE: were choices unavailability or unaffordability or something else, e.g., usability



Practical and Policy

- Moving from 50% to 85% penetration (of any positive technology) might be a good thing but the impacts on the remainder are disproportionately worse
 - Maybe we need to subsidize the transition, e.g., the digital TV coupons

Discussion

