

TURNING METCALFE ON HIS HEAD: THE MULTIPLE and GROWING COSTS OF NETWORK EXCLUSION

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US Network Exclusion

(Philadelphia WiFi in Jeopardy)
NYTimes March 22, 2008 :

"For Cesar DeLaRosa, 15, however, the concern is more specific. He said he was worried about his science project on global warming.

'If we don't have Internet, that means I've got to take the bus to the public library after dark, and around here, that's not always real safe,' Cesar said, seated in front of his family's new computer in a gritty section of Hunting Park in North Philadelphia. His family is among the 1,000 or so low-income households that now have free or discounted Wi-Fi access through the city's project, and many of them worry about losing access that they cannot otherwise afford.'

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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

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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- *Unpublished material indicates completion rates in other experiments by Milgram were closer to 5%, with more hops (Kleinfeld, 2002)*

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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

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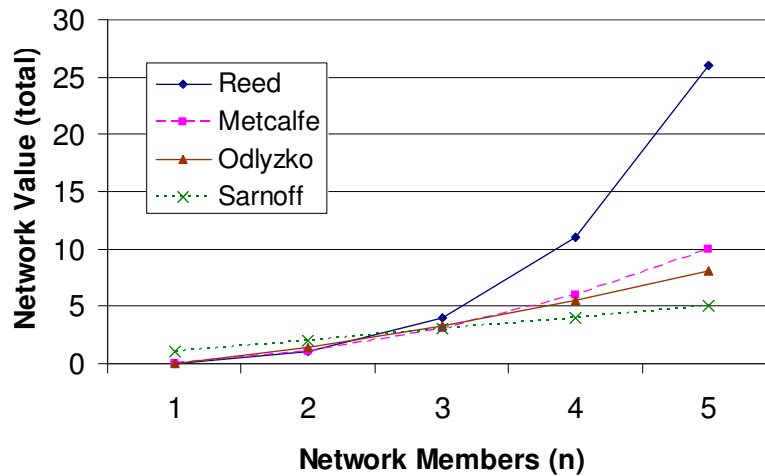
Selected Network Value Framings



Value (proportional to)	Chronology	Originator	Model	Example
n	1	Sarnoff	Broadcasting	TV
$n \cdot \log(n)$	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

Adapted from: “Between Metcalfe and Reed” (Nivi, 2005) 6

Network Values



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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 ($\equiv 0$)

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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

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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*

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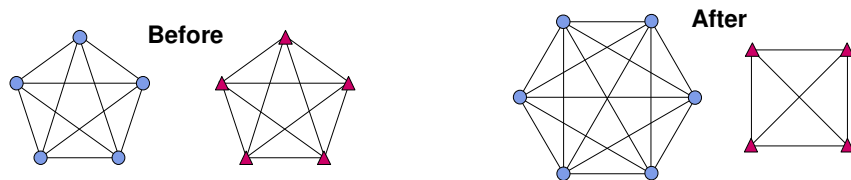
Networks, Equality, and Externalities



- 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?

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Network Effects are Strong



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?

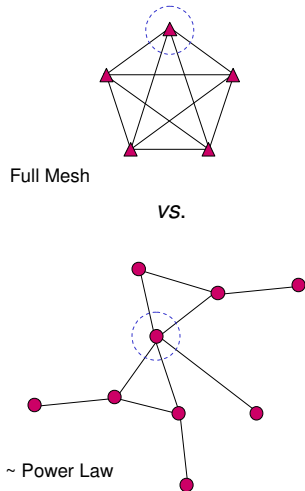
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Possibilities for Comparative Network Exclusion



<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



- 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

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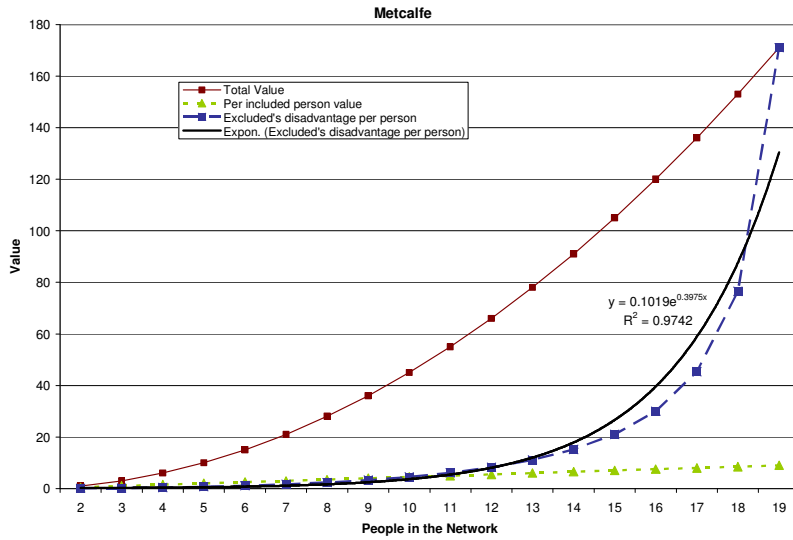
Proposed: Exclusion Framing of Disparity (“Cost”)



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

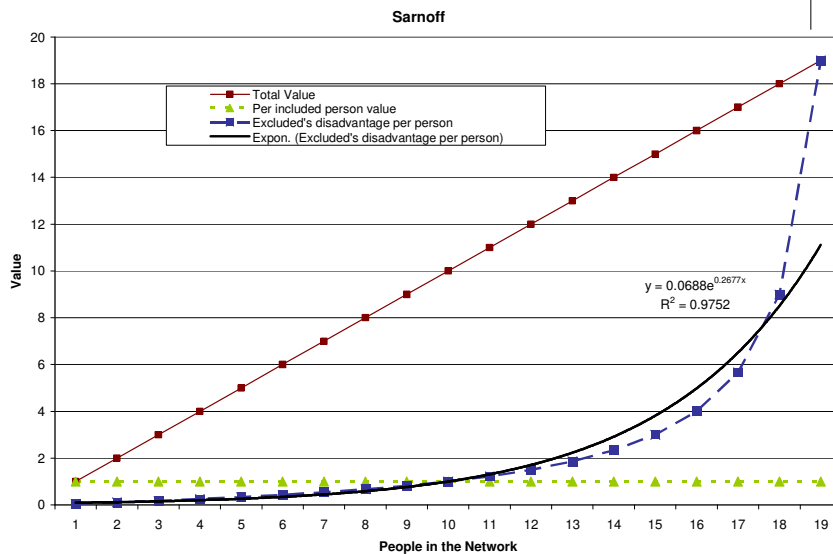
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Metcalfe – Exclusion vs. Inclusion Disparity



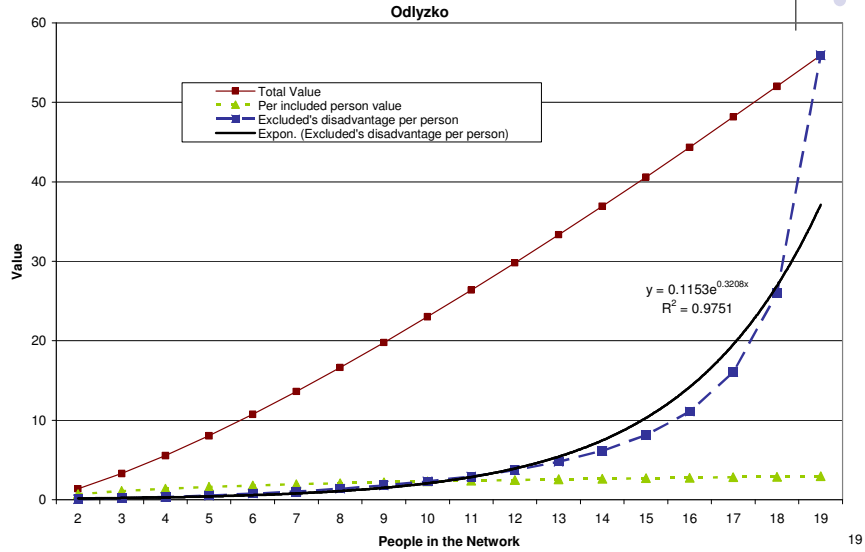
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Sarnoff – Exclusion vs. Inclusion Disparity

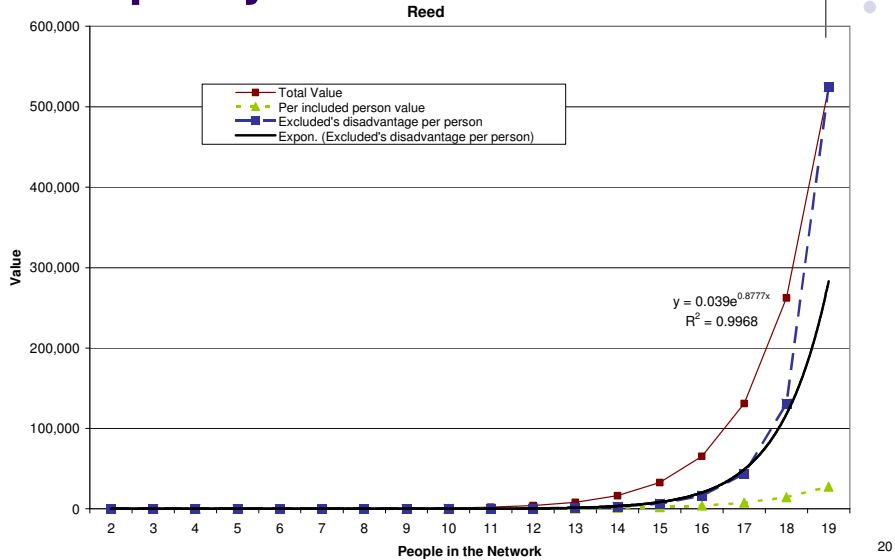


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Odlyzko – Exclusion vs. Inclusion Disparity



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)

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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**

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“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:

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

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

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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

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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

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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

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Implications and Directions for Future Research



- Conceptual
- Theoretical
- Empirical
- Practical