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Building the Multiplex: An Agent-Based Model of Formal and Informal Network Relations

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AGENDA

1 Introduction

2 The Agent-Based Model

3 Results & Analysis

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INTRODUCTION

ORGANIZATIONS ARE CHARACTERIZED BY:

Increased dynamism

- communication emerges from the behaviours and interactions of heterogeneous individuals
- mechanisms that mediate social networks

Complexity

- the formation of ties between actors
- relationships are likely to be complex

Conditions make organisations and the behaviour within them difficult to examine

- Calls for newer methods

COLLECTIVE (GROUP) DECISION MAKING

- Collectives are complicated structures that include individuals, groups, functional business units and even larger industry alliances and networks (Dansereau, et al, 1984)
- Collective decision making implies a clustering of individuals with interdependency based on shared expectations or hierarchy.
- Literature highlights that collective decision making in such situations is poorly understood:
- Participants and their social and/or organizational structure may influence the final outcome of decision making processes
- Process is more complex when the participants are heterogeneous and are embedded in a network with differential distribution of power

COLLECTIVE DECISION MAKING

In sum, within a networked organizational structure, studies seldom account for (1) the dynamical processes that take place, or (2) the informal social networks where interactions occur

- Decision making processes may be viewed by shifting the viewpoint from members' attributes to dynamical exchanges of ideas being discussed within the group, where ideas evolve via the conduct by participating members
- The collective decision making occurs not just through the interactions of individual decisions but also through the more active, dynamic interactions and exchanges of actors with incomplete ideas and mental models (Dionne et al 2010).

SOCIAL NETWORK THEORY

Large body of work on organizational social networks (Kilduff and Tsai, 2000; Burt 2000)

White et al. 2016 – informal network relations

- Formal and informal
- Mutual and entrainment

Stylized informal relationships (White et al. 2016)

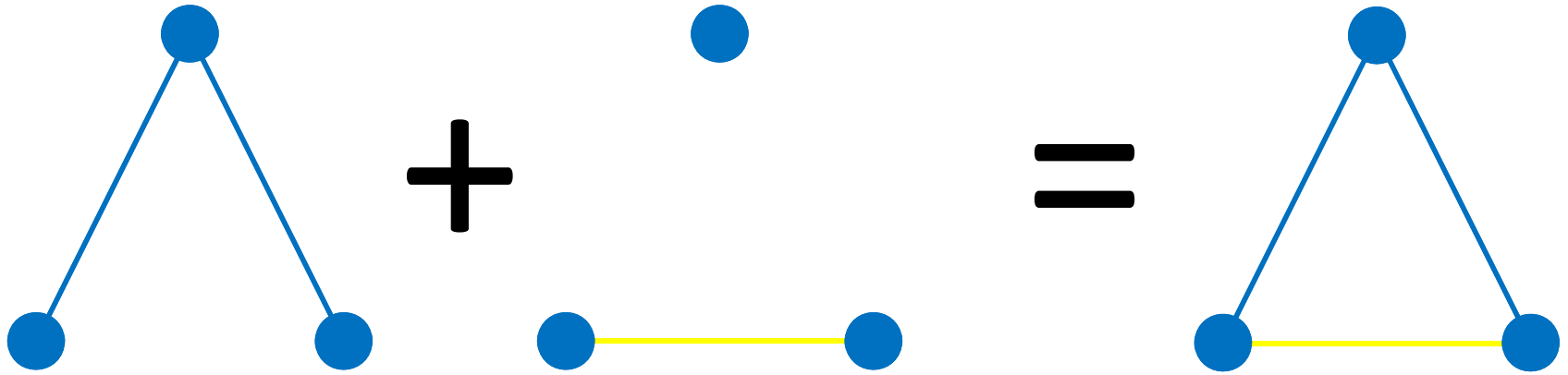
- Advice relationships
- Support relationships

Robertson and Franco 2016 – dynamic network relations

- Emergent properties, need for closure driving decisions

MULTIPLEXED RELATIONSHIPS AND TRIADS

Shipilov (2014), Shipilov and Li (2012), White et al. (2016)



Traditional Hierarchy Informal Relationship Multiplexed triad

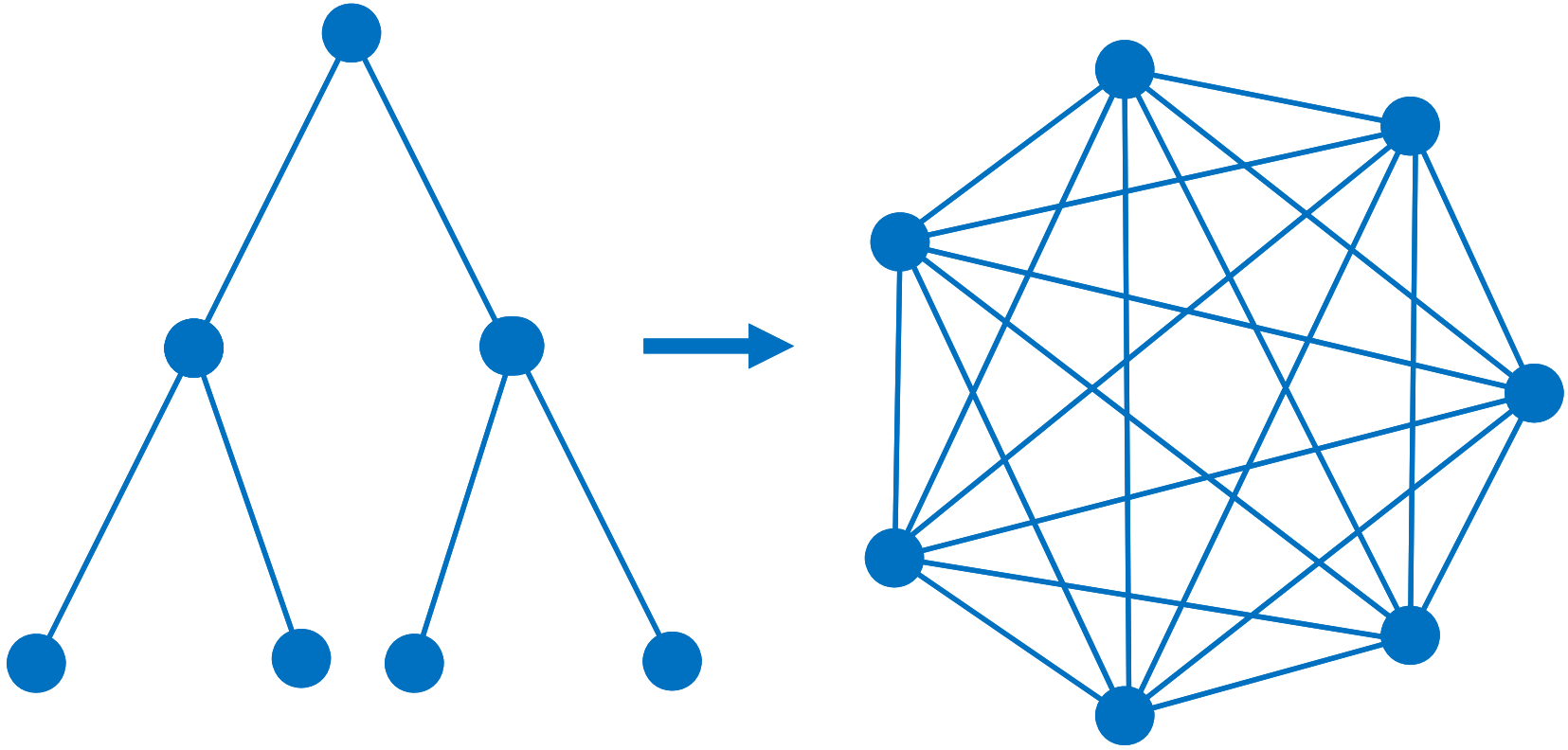
AGENT BASED MODELS AND SOCIAL NETWORKS

Sayama et al. 2013, 2015 – agent-based models of collective decision making

- Scholars have revealed fascinating dynamics about collaborative organizational social networks, including the mechanism of preferential attachment as a structuring factor.
- i.e. Actors in networks who have a large number of ties are often considered to be highly local, influential and popular... the well-known “Matthew effect” in social science (the ‘rich’ get richer)

HEIRARCHIES TO FULLY CONNECTED NETWORKS

e.g. Hierarchy levels = *h* (= 2); span of control = *s* (= 2)

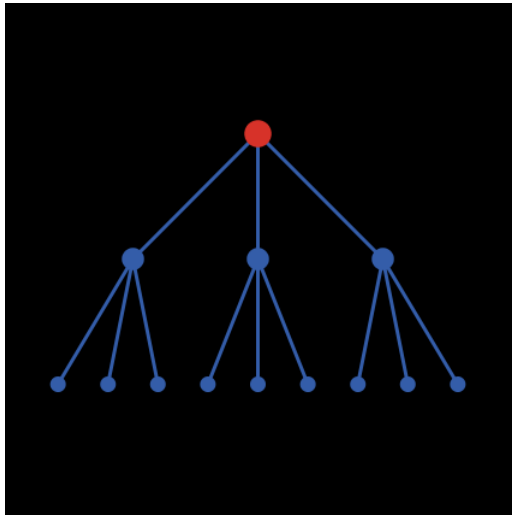


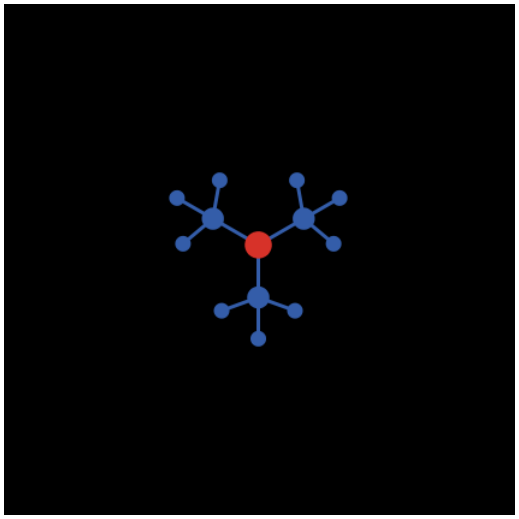
total nodes (individuals) = $\sum_{i=1}^{h} s^i = 2^1 + 2^2 = 6 = n$

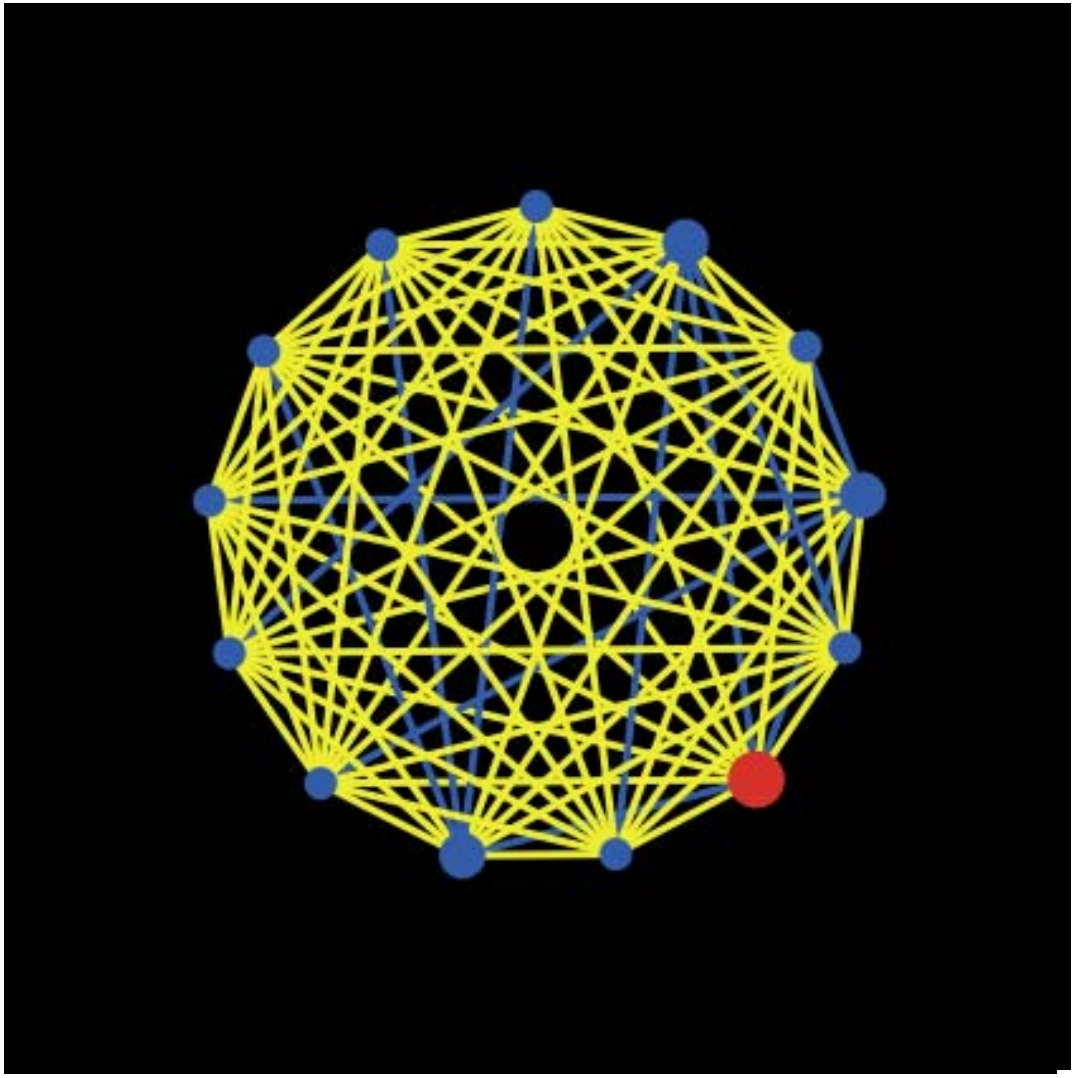
total possible connections = $\frac{n(n-1)}{2} = \frac{6(6-1)}{2} = 15$

Density = $\frac{connections}{possible\ connections} = \frac{6}{15} = 40\%$ $= \frac{15}{15} = 100\%$

INCREASING CONNECTIVITY (H = 2, S = 3)







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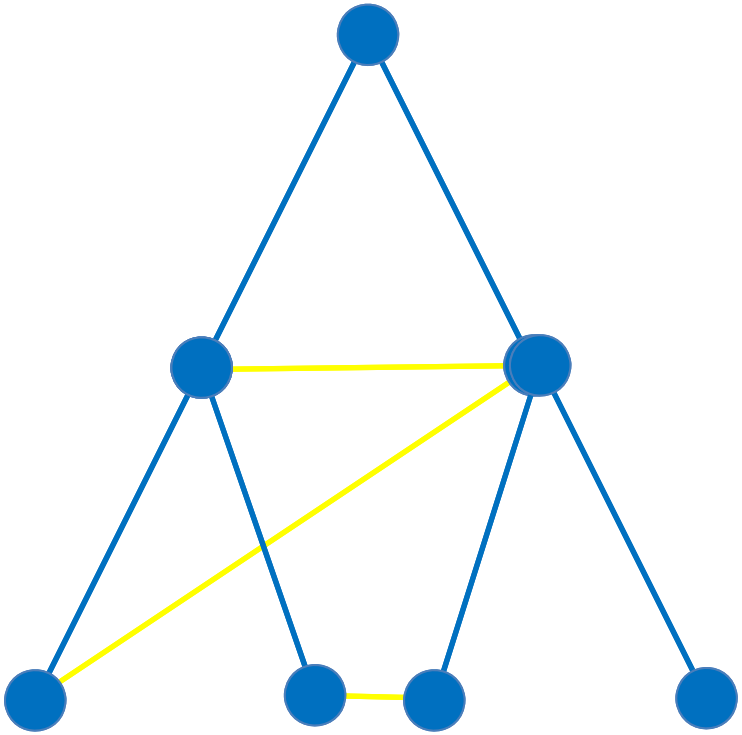
THE AGENT-BASED MODEL

PREVIOUS WORK

- Growing interest in **computational social science** to explore where social processes are studied using a mathematical/computational modeling approach (Axelrod 1981; Epstein and Axtell 1996; Bar-Yam 2004; Gilbert and Troitzsch 1999; Sterman 2000; Miller and Page 2007; Robertson and Caldart 2010)
- We apply the tools from agent based models to examine whether collective decision making and the effects of informal social networks

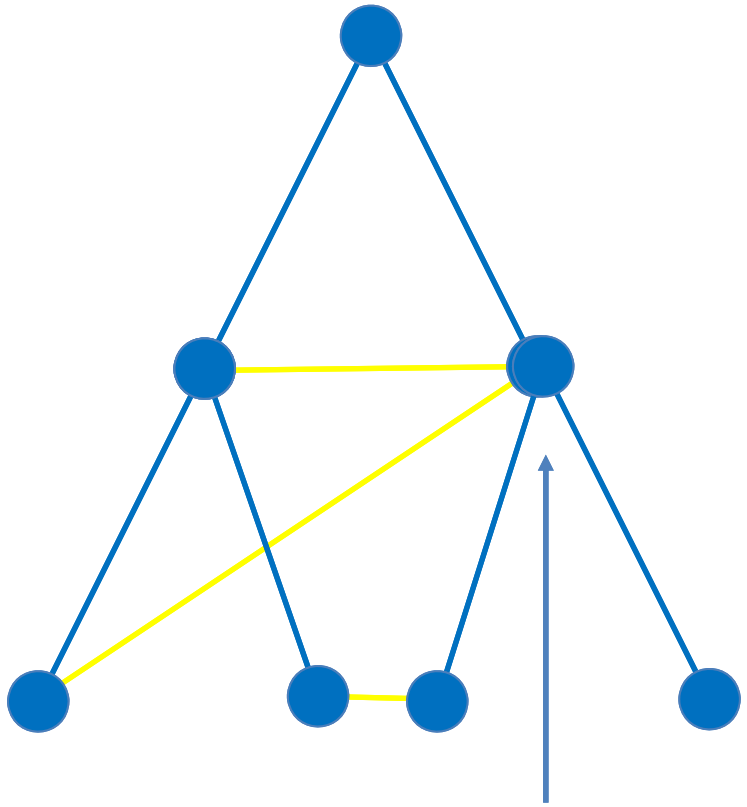
THE MODEL



We set up a hierarchy (blue) with *h* hierarchy levels each with a span of control of *s*.

We add in an informal network (yellow) through random connections between nodes.

THE MODEL: INFORMAL NETWORK - PREFERENTIAL OR RANDOM



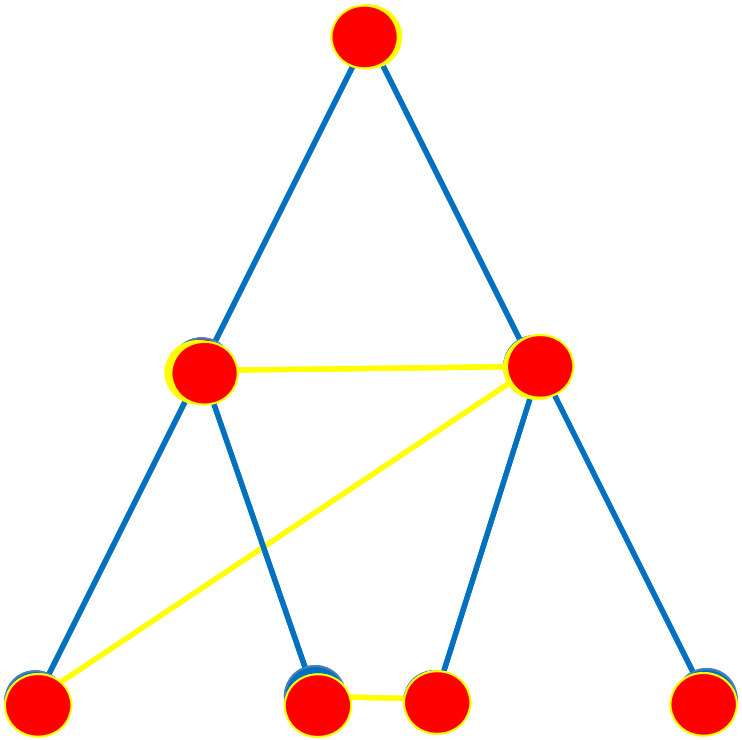
Under preferential attachment, this node now has a higher probability of being connected next round

The informal network can be constructed randomly (equal probability of any two individuals being connected).

Or we can weight the probability of attachment according to the number of connections – this is a 'preferential attachment' mechanism.

We repeat this until we have a desired network density ρ

THE MODEL



- We seed the network by turning one individual red at a particular hierarchy level
- A red individual is randomly chosen who then chooses a neighbour (who may be red or blue) and if they are blue, they become red (they are actually highlighted in yellow when they become infected to help visualization).
- We continue the simulation until all nodes are red. We then record the number of time steps taken.

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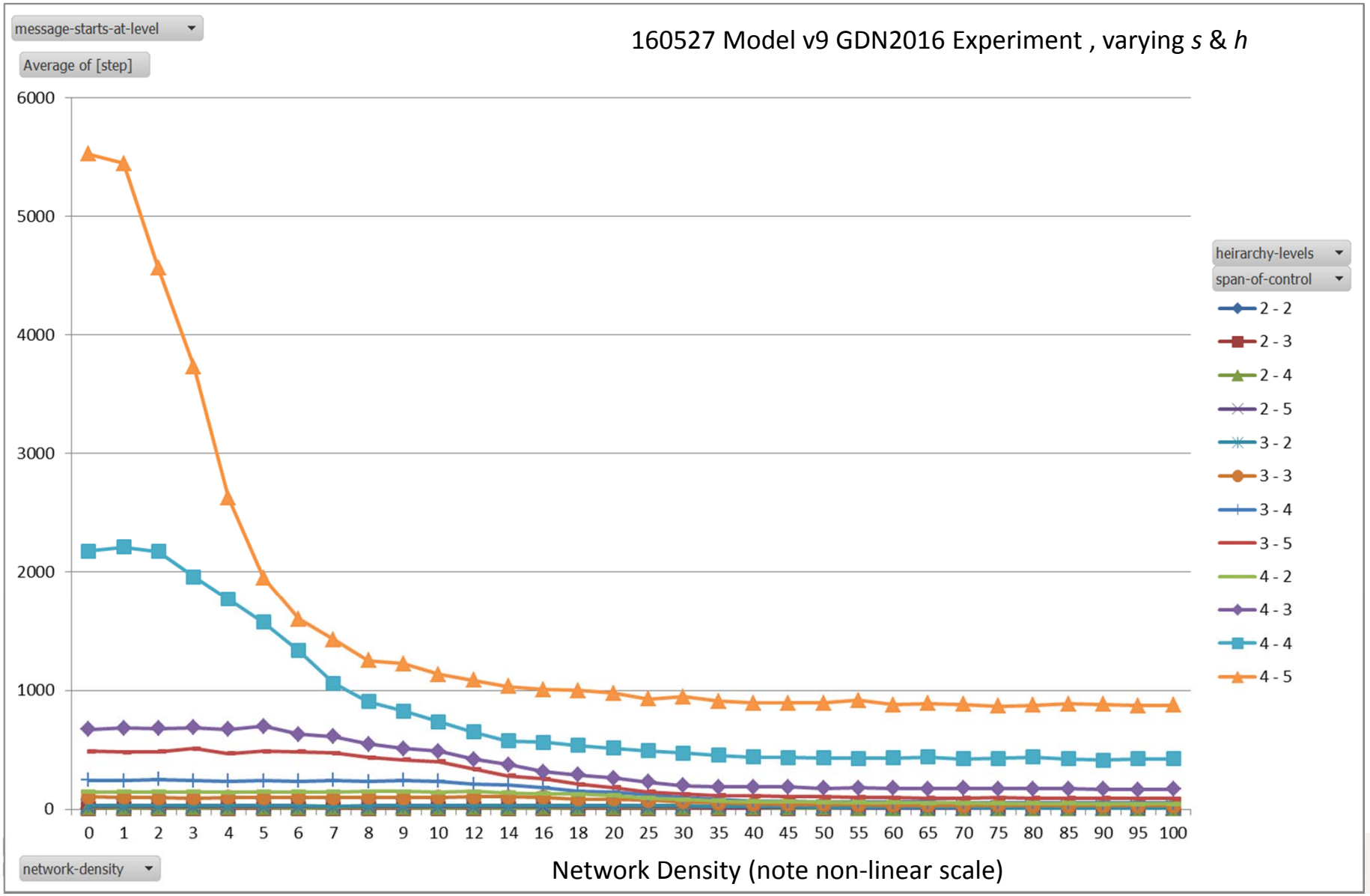
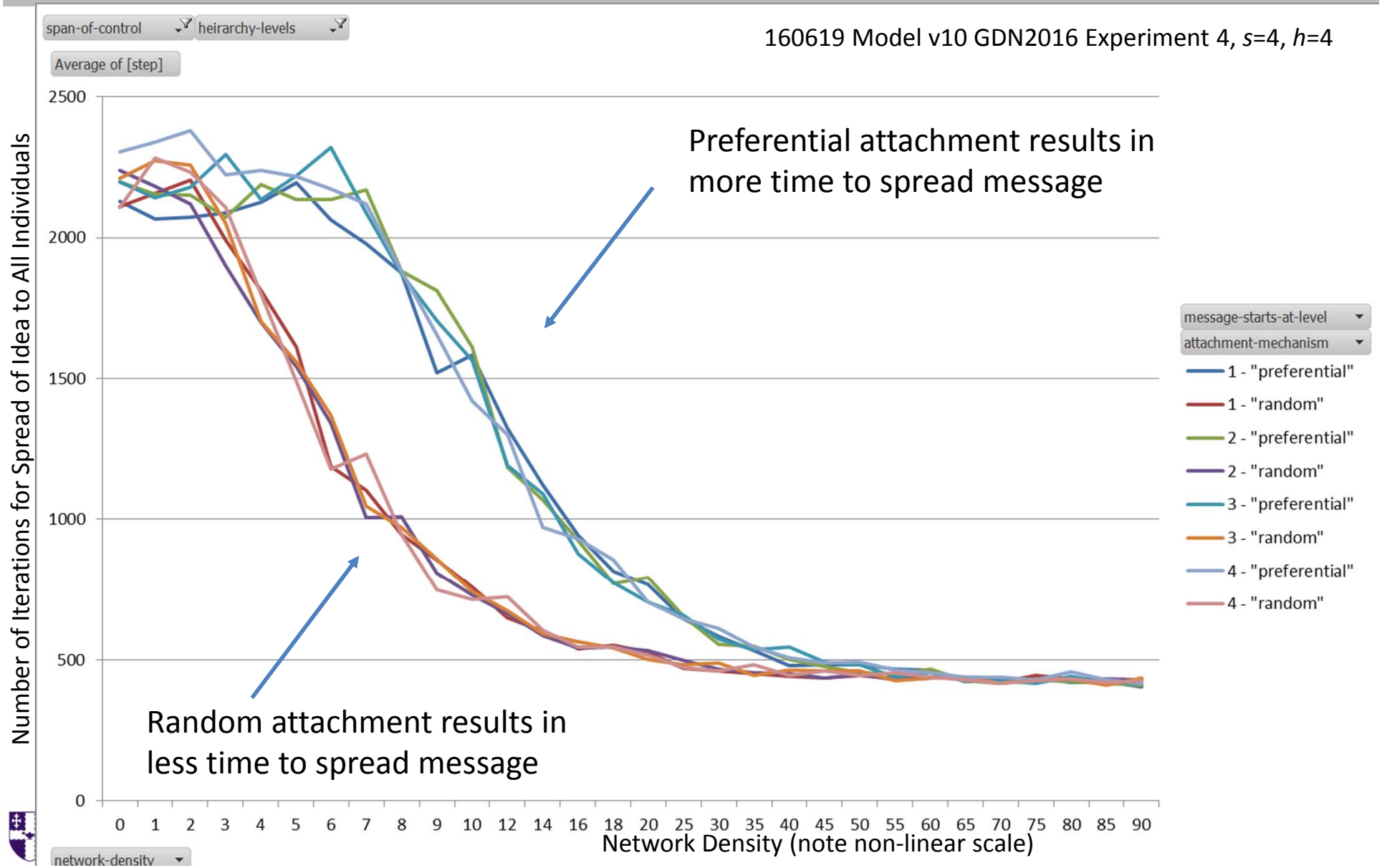
RESULTS & ANALYSIS

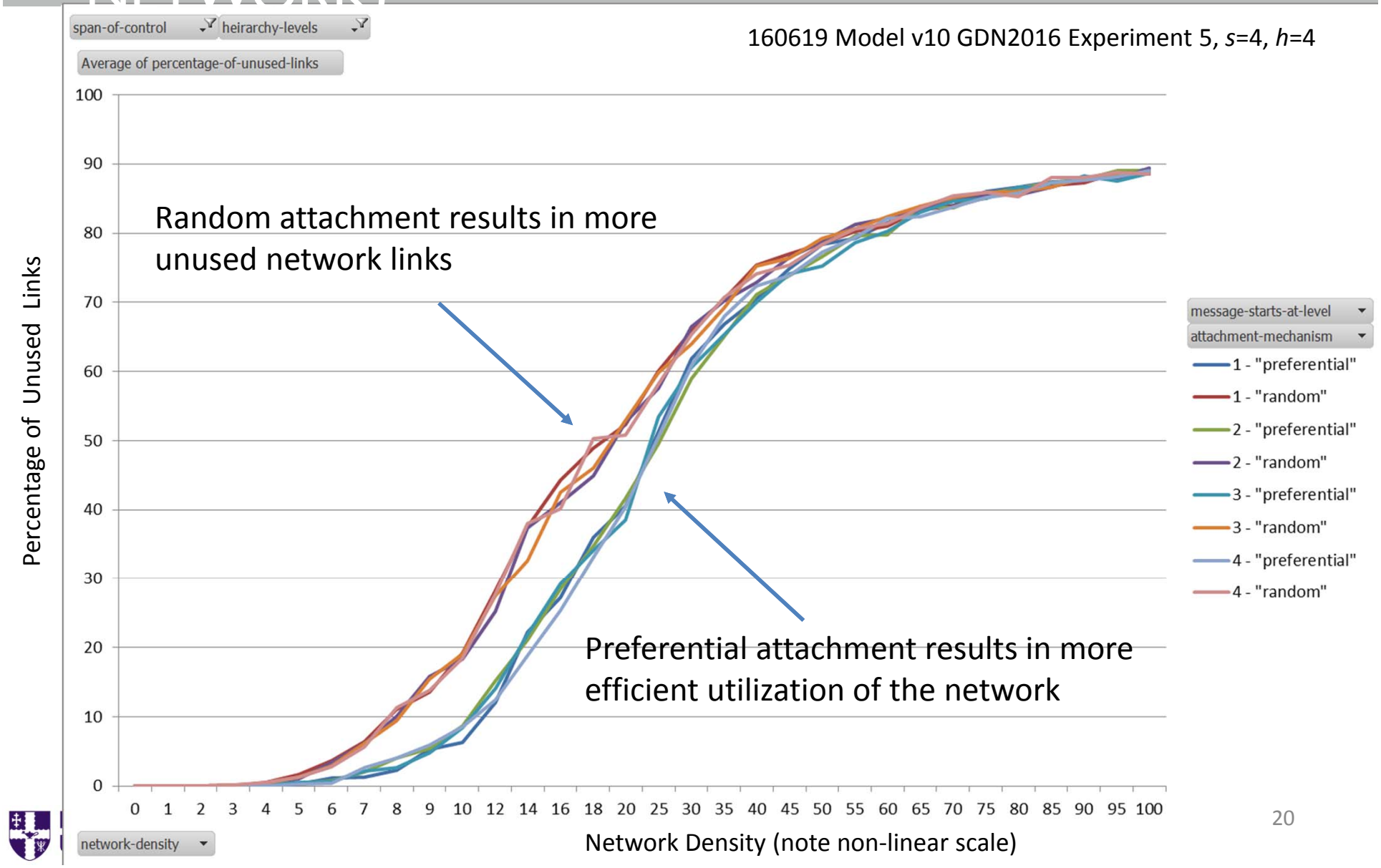
ADDING FEW INFORMAL CONNECTIONS IMPROVES SPREAD OF INFORMATION BUT DIMINISHING RETURNS



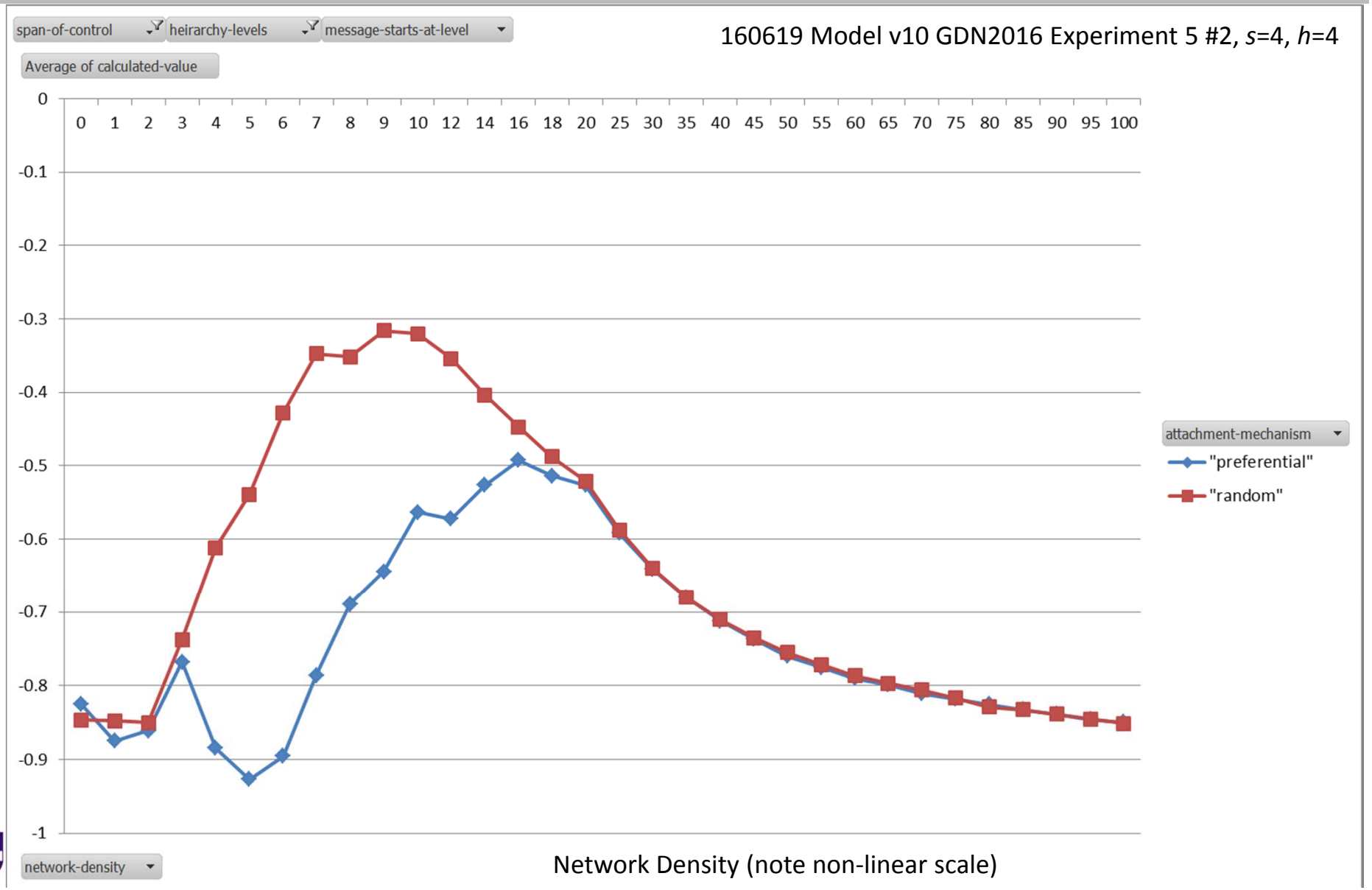
PREFERENTIAL ATTACHMENT VS RANDOM ATTACHMENT



EFFICIENCY OF NETWORK USAGE (HOW MANY RED LINKS = COST OF MAINTAINING NETWORK)



TOWARDS A CONTINGENT OPTIMAL LEVEL OF INFORMAL CONNECTIVITY



DISCUSSION

Early results from the model

- Informal network links help the dissemination of ideas around a group network
- However, only a relatively small increase in informal network connections causes a significant decrease in dissemination time
- Further increases in informal network links has very little increase in dissemination efficiency
- Counter-intuitive findings that preferential attachment actually causes *longer* for message to be assimilated around social network

DISCUSSION

Optimal Level of Informal Network

- Optimal level depends on informal network structure (random vs preferential)
- Can investigate alternative informal network scenarios

Next year's EURO

- Combining with Robertson and Franco dynamic network model
- Dynamism *on* the network + dynamism *of* the network

Feedback

- Interested in hearing feedback, extensions to the model, and potential for further experiments

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