NETWORK ANALYSIS FOR ASSESSMENT OF INTEGRATION AND COLLABORATION IN LARGE RESEARCH TEAMS

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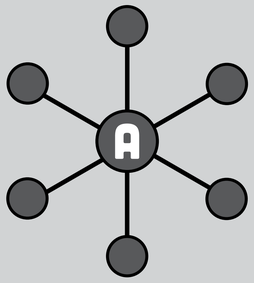
UNDERSTANDING NETWORK ANALYSIS

Network diagrams are used to reveal structures and behaviors within a system. Actors in a system, such as people, goods or organizations, are represented as nodes or vertices. Relationships or transactions between nodes are represented as links or lines. Network analysis is a methodology that assesses the relational patterns across nodes to understanding how individual interactions, give rise to emergent behaviors that characterize the structure of the network as a whole. A fundamental principle of network analysis is that just as the network's structure is influenced by localized behaviors, local behaviors are also influenced by the structure of the network. Within network analysis a class of measurements known as centrality provide methods of assessing the potential influence of a given node based in its relational position within the network.

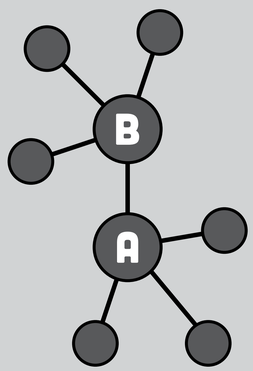


DEGREE CENTRALITY

A node's degree refers to the number of nodes with which it is directly connected. Nodes with high degree centrality, often referred to as *hubs*, are considered central to the network because of their ability to transmit, generate or transform a large portion of network transactions.

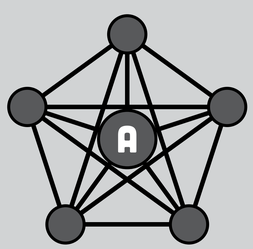
BETWEENNESS CENTRALITY

Betweenness refer to the extent a node is connected to nodes not directly connected to each other, thereby creating an indirect connection between these nodes. Nodes with high betweenness, often referred to as gatekeepers or bridges, are considered central to the network because of their ability to control or influence transactions between indirectly connected nodes, and the overall connectedness of the network.



CLUSTERING COEFFICIENT

A node's clustering coefficient refers to the proportion of links present in the node's ego network—a subset network consisting of only those nodes with which a node is directly connected and the connections between those nodes. The higher the proportion of connections within the ego network the higher the clustering coefficient.



OBJECTIVE

As a method of analyzing relational patterns, Social Network Analysis (SNA) may provide a powerful tool for informing the dynamic collaborative processes common to multi-disciplinary research projects. SNA of the Idaho NSF EPSCoR, Managing Idaho's Landscapes and Ecosystem Services (MILES) Project aims to understand if and how SNA can be an effective tool to assess and leverage communication, collaboration and integration within intellectually diverse and geographically distant research teams.

METHODOLOGY

The MILES 2014 Social Network was constructed from data gathered through a survey conducted at the MILES 2014 Annual Meeting. The survey asked respondents to identify the strength of their interaction with other project participants on a five point scale: (1) Don't know the person; (2) No Direct Contact; (3) Communication; (4) Collaboration; or (5) Integration. These interactions were then mapped as a network diagram where each individual was represented as a node and connections between nodes were represented as a lines with line weight indicated connection strength.

AVERAGE CENTRALITY MEASURE BY MILES COMPONENT: VALUES AND AS PERCENTAGE OF ALL PARTICIPANT AVERAGE

COMMUNICATION NETWORK

	CYBER-INFRASTRUCTURE		DIVERSITY & WORK-FORCE DEVELOPMENT		EXTERNAL ENGAGEMENT		INTEGRATION & STAKE-HOLDER ENGAGEMENT		INTEGRATIVE MODELING		LEADERSHIP		SES CHARACTER & VULNERABILITY		VISUALIZATION & VIRTUALIZATION	
DEGREE CENTRALITY	80%	0.128	131%	0.208	101%	0.161	108%	0.172	113%	0.180	128%	0.204	89%	0.141	75%	0.119
BETWEENNESS	58%	0.005	123%	0.010	46%	0.004	72%	0.006	147%	0.012	313%	0.025	41%	0.003	43%	0.003
CLUSTERING COEFFICIENT	109%	0.732	94%	0.634	100%	0.675	95%	0.673	88%	0.591	86%	0.578	106%	0.713	109%	0.735

COLLABORATION NETWORK

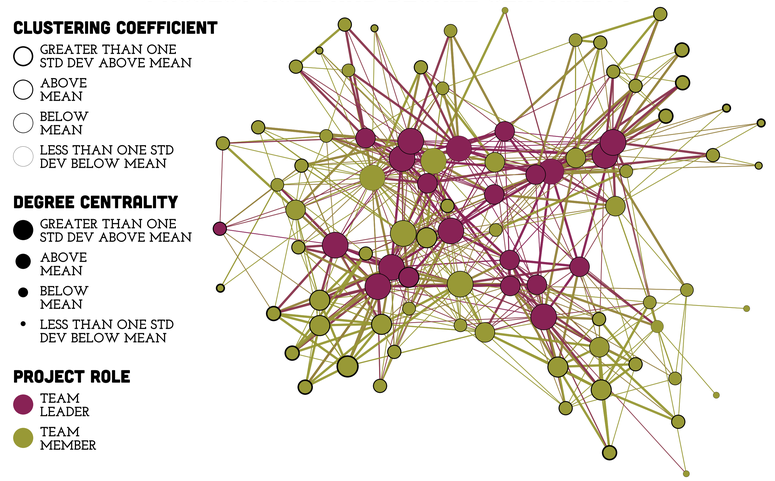
	CYBER-INFRASTRUCTURE		DIVERSITY & WORK-FORCE DEVELOPMENT		EXTERNAL ENGAGEMENT		INTEGRATION & STAKE-HOLDER ENGAGEMENT		INTEGRATIVE MODELING		LEADERSHIP		SES CHARACTER & VULNERABILITY		VISUALIZATION & VIRTUALIZATION	
DEGREE CENTRALITY	76%	0.078	163%	0.168	112%	0.116	102%	0.105	109%	0.112	107%	0.110	93%	0.095	60%	0.061
BETWEENNESS	73%	0.011	239%	0.035	79%	0.012	103%	0.015	129%	0.019	86%	0.013	103%	0.015	23%	0.003
CLUSTERING COEFFICIENT	93%	0.441	97%	0.459	117%	0.554	82%	0.387	91%	0.430	100%	0.473	90%	0.424	142%	0.673

INTEGRATION NETWORK

	CYBER-INFRASTRUCTURE		DIVERSITY & WORK-FORCE DEVELOPMENT		EXTERNAL ENGAGEMENT		INTEGRATION & STAKE-HOLDER ENGAGEMENT		INTEGRATIVE MODELING		LEADERSHIP		SES CHARACTER & VULNERABILITY		VISUALIZATION & VIRTUALIZATION	
DEGREE CENTRALITY	78%	0.057	178%	0.131	120%	0.088	91%	0.067	88%	0.065	92%	0.067	90%	0.066	77%	0.056
BETWEENNESS	74%	0.018	343%	0.082	67%	0.016	89%	0.021	66%	0.016	73%	0.017	88%	0.021	41%	0.010
CLUSTERING COEFFICIENT	81%	0.347	76%	0.325	152%	0.653	61%	0.261	99%	0.426	98%	0.422	108%	0.465	107%	0.461

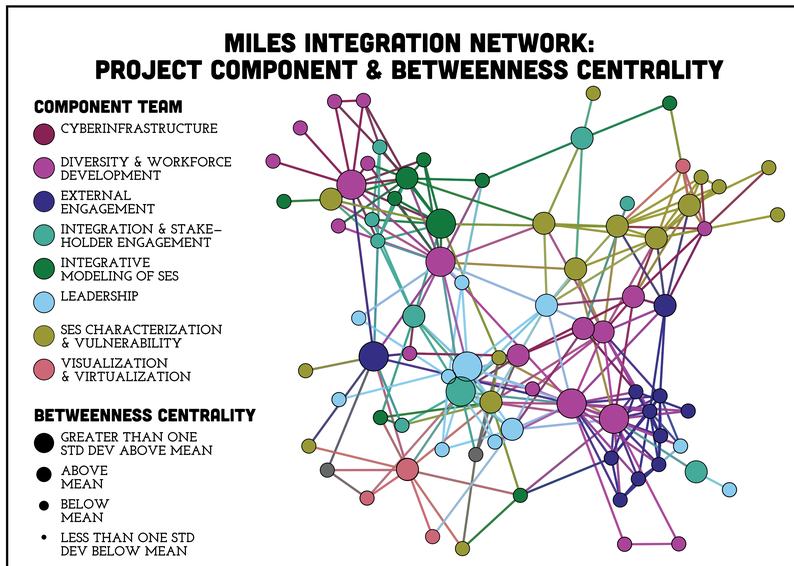
THE COMMUNICATION NETWORK INCLUDES INTERACTIONS BETWEEN PARTICIPANTS REPORTED TO BE AT A COMMUNICATION LEVEL OR HIGHER (SCALE VALUES 3–5). THE COLLABORATION NETWORK INCLUDES INTERACTIONS BETWEEN PARTICIPANTS REPORTED TO BE AT A COLLABORATIVE LEVEL OR HIGHER (SCALE VALUES 4 AND 5). THE INTEGRATIVE NETWORK INCLUDES INTERACTIONS BETWEEN PARTICIPANTS REPORTED TO BE AT AN INTEGRATIVE LEVEL (SCALE VALUE 5).

MILES COLLABORATION NETWORK: PROJECT ROLE AND DEGREE CENTRALITY



THE ABOVE VISUALIZATION MAPS BOTH COLLABORATIVE AND INTEGRATIVE CONNECTIONS BETWEEN MILES PARTICIPANTS. PROJECT COMPONENT TEAM LEADS ARE IDENTIFIED BY NODE COLOR. NODE DEGREE CENTRALITY AND CLUSTERING COEFFICIENT ARE DENOTED BY NODE SIZE AND NODE STROKE WEIGHT, RESPECTIVELY. THE HIGH DEGREE CENTRALITY CHARACTERIZING MANY TEAM LEADS MAY INDICATE THAT TEAM LEADS PLAY A SIGNIFICANT ROLE IN TRANSMITTING INFORMATION THROUGH THE NETWORK, WHILE THE HIGH CLUSTERING COEFFICIENT CHARACTERIZING TEAM MEMBERS MAY INDICATE THAT TEAM COHESION AND GROUP COLLABORATION OCCURS AT A MORE LOCALIZED LEVEL.

MILES INTEGRATION NETWORK: PROJECT COMPONENT & BETWEENNESS CENTRALITY



THE ABOVE VISUALIZATION MAPS INTEGRATIVE CONNECTIONS BETWEEN MILES PARTICIPANTS. NODE COLOR INDICATES THE PRIMARY COMPONENT TEAM OF EACH INDIVIDUAL. NODE SIZE INDICATES THE BETWEENNESS CENTRALITY. NODES WITH HIGH BETWEENNESS CENTRALITY MAY INFLUENCE THE OVERALL NETWORK BY FUNCTIONING AS EITHER TRANSMITTERS OF INFORMATION TO DISTANT AREAS OF THE NETWORK, OR BOTTLENECKS IN COMMUNICATION FLOW.

COMMUNICATION NETWORK

	PROJECT ROLE				GENDER				RESEARCH SITE					
	TEAM LEAD		TEAM MEMBER		MALE		FEMALE		COEUR D'ALENE		POCATELLO		TREASURE VALLEY		OTHER	
DEGREE CENTRALITY	162%	0.258	80%	0.128	99%	0.157	102%	0.162	103%	0.164	90%	0.164	88%	0.143	112%	0.179
BETWEENNESS	165%	0.013	79%	0.006	71%	0.006	137%	0.011	68%	0.005	47%	0.004	78%	0.006	165%	0.013
CLUSTERING COEFFICIENT	80%	0.573	106%	0.716	100%	0.676	99%	0.669	101%	0.678	106%	0.710	101%	0.678	95%	0.643

COLLABORATION NETWORK

	PROJECT ROLE				GENDER				RESEARCH SITE					
	TEAM LEAD		TEAM MEMBER		MALE		FEMALE		COEUR D'ALENE		POCATELLO		TREASURE VALLEY		OTHER	
DEGREE CENTRALITY	171%	0.176	77%	0.079	100%	0.103	99%	0.102	100%	0.013	93%	0.096	89%	0.092	111%	0.114
BETWEENNESS	243%	0.035	54%	0.008	103%	0.015	97%	0.014	104%	0.015	103%	0.015	114%	0.017	87%	0.013
CLUSTERING COEFFICIENT	70%	0.392	110%	0.519	99%	0.468	101%	0.479	89%	0.419	80%	0.379	115%	0.545	110%	0.518

INTEGRATION NETWORK

	PROJECT ROLE				GENDER				RESEARCH SITE					
	TEAM LEAD		TEAM MEMBER		MALE		FEMALE		COEUR D'ALENE		POCATELLO		TREASURE VALLEY		OTHER	
DEGREE CENTRALITY	166%	0.122	75%	0.055	101%	0.074	99%	0.073	85%	0.062	103%	0.075	99%	0.073	106%	0.078
BETWEENNESS	260%	0.062	40%	0.010	112%	0.027	84%	0.020	78%	0.018	102%	0.024	116%	0.028	101%	0.024
CLUSTERING COEFFICIENT	73%	0.312	110%	0.473	95%	0.409	106%	0.455	70%	0.301	98%	0.419	120%	0.517	105%	0.450

THE COMMUNICATION NETWORK INCLUDES INTERACTIONS BETWEEN PARTICIPANTS REPORTED TO BE AT A COMMUNICATION LEVEL OR HIGHER (SCALE VALUES 3–5). THE COLLABORATION NETWORK INCLUDES INTERACTIONS BETWEEN PARTICIPANTS REPORTED TO BE AT A COLLABORATIVE LEVEL OR HIGHER (SCALE VALUES 4 AND 5). THE INTEGRATIVE NETWORK INCLUDES INTERACTIONS BETWEEN PARTICIPANTS REPORTED TO BE AT AN INTEGRATIVE LEVEL (SCALE VALUE 5).

CONCLUSION

The MILES 2014 SNA reveals a relatively centralized network in which institutions are clustered around a central administrative group. Underlying collaborative networks reflect a more decentralized structure that may allow for agile management conducive to long-term planning. However, it is possible that removal or loss of some of these nodes could fragment the network.

NETWORK ANALYSIS OF SOCIAL–ECOLOGICAL SYSTEMS (SES)

Network Analysis has been applied to a broad range of disciplines contributing to greater understanding of social, ecological and physical networks. Recently, network analysis has been applied to the management of ecosystem services through networks of governing organizations or stakeholders influential in resource management and planning. Currently, MILES is attempting use network science as a guiding field from which to draw baseline assumptions for inquiry into the structural and interactive characteristics of coupled social and biophysical networks to identify the presence of central points at which feedbacks between social and ecological networks are most sensitive.

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THIS PROJECT SUPPORTED BY IDAHO NSF EPSCOR GRANT NUMBER IIA–1301792 – MANAGING IDAHO'S LANDSCAPES FOR ECOSYSTEM SERVICES (MILES)