Online Resource A: Analyzing Dynamic Network Charts

This Online Resource provides further methodological details about dynamic network charts. Part 1 discusses three types of charts: Type I charts, Type II charts, and network intervention charts. Part 2 provides a summary of the equations used in dynamic network charts. Part 3 illustrates some procedures for evaluating the interrater reliability of proposed dynamic network charts. Part 4 shows how dynamic network charts can be represented in prediction-based and structure-based matrices.

PART 1: TYPES OF DYNAMIC NETWORK CHARTS

This section illustrates the types of dynamic network charts researchers can build to portray dynamic networks systems. These include Type I charts, which show network motivation role linkages (G and S), and Type II charts, which extend the charts to include network resistance and network reactance role linkages (G, S, G`, S`, R, and R`). Type I and Type II charts can be further extended to show peripheral role linkages (e.g., I and O links) and multiplex role linkages (e.g., an SIO role bundle). These methodological issues are discussed in turn and illustrated with a hiking example that shows all the technicalities involved. Network intervention charts are also illustrated after presenting Type I and Type II charts.

Type I Basic Dynamic Network Charts

Dynamic network theory refers to *basic dynamic network charts* as Type I charts. These charts show network motivation through goal strivers (G) and system supporters (S). Goal striver roles are shown by drawing a solid arrow from goal striving entities to the goal. Researchers can explicitly label these linkages "G," if desired, although this can be implied without labeling. System supporter roles are shown by drawing a solid arrow from the system supporting entities to the other entities that they are supporting (e.g., other goal strivers or other system supporters). These linkages can be labeled "S," although this too can be implied in the charts. Subscripts can explicitly denote the exact level of role activation, if desired. For example, S_1 would indicate significant levels of system support while S_2 would indicate extreme levels of system support. When lines do not exist between entities, it implies a value of 0 activation.

Online Figure A1 illustrates a Type I chart for a dyad's goal of going on a picturesque hike over the weekend. The time frame for this goal includes both the planning and implementation phases of the entire hike.[1] In this hypothetical example, Hiker A is a goal striver who worked extremely hard planning for and implementing the hike (G_2). Hiker B is the other goal striver who exerted significant effort on the entire hike (G_1), although relatively less than Hiker A. The two hikers also provided mutual support to each other throughout the hiking process, which is shown by the reciprocal system supporter role activations between them (i.e., they are partner goal strivers). Moreover, Hiker B provided relatively more support (S_2) to Hiker A, because Hiker A needed more assistance on the difficult trails. Furthermore, a Friend provided Hiker A considerable support and encouragement to go on the hike (S_2) with Hiker A being supportive and receptive during these conversations (S_1). The Friend provided some moral

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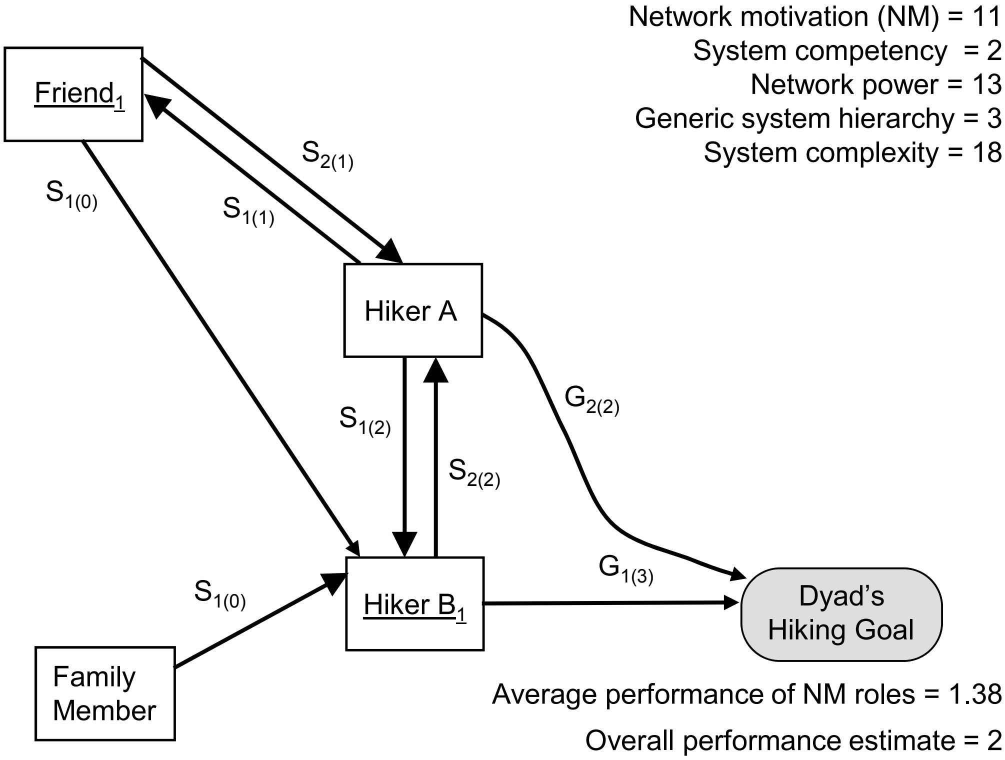
[1] This chart could also be broken down into a network script to show all subgoal or event sequences, if detailed data were available over time; see Chapter 3 for details.

support to Hiker B as well (S_1). Lastly, the Family Member provided some support to Hiker B when initially thinking about the weekend hike (S_1).

The overall network motivation (NM) in this Type I chart is 11, given the value of 3 for the activation level of goal striving on two paths ($G_2 + G_1$) plus the value of 8 for the activation level of system supporting on six paths ($S_2 + S_2 + S_1 + S_1 + S_1 + S_1$).



Online Figure A1. Type I basic dynamic network chart for a dyad's hiking goal [without peripheral roles and without multiplex linkages]. Only network motivation roles shown. G = goal striver. S = system supporter. Level of path activation shown on first subscript (i.e., 1 = significant activation; 2 = extreme activation). Role performance shown on 2nd subscript indicator in parentheses: range = -3 (*evidence strongly suggests that this linkage is negatively influencing overall goal achievement*) to 3 (*evidence strongly suggests that this linkage is positively influencing overall goal achievement*). Underlined entity names denote high system competency (SC) and are scored 1 in this example. Network motivation (black paths without circles) = $\sum G + \sum S$ linkages. Network power (NP) = $NM + \sum SC^{\text{for NM entities}}$.

Although not necessary to create Type I charts, system competency and role performance indicators can also be displayed, if the data is available. System competency indicates which entities have high competence, skill, ability, or efficacy in achieving the target goal. This is visualized in the chart by underlining the name of the entities with significant levels of system competency. Underlined names are scored 1 and non-underlined names are scored 0. Subscripts can be placed next to each entity's name to denote significant system competency levels (extreme levels can be scored 2). In the hiking example, Hiker B and the Friend are hiking experts, while other entities in the system are not. Hence, the overall level of system competency is 2. Network power, which can be portrayed as an additive function of network motivation and system competency among NM entities, is 13 (i.e., 11 + 2), although as recommended in Chapter 2 of the book, research should examine other configurations, such as a multiplicative rule, to see if they better predict overall performance. The system complexity in this Type I chart is 18 (i.e., 4 entities + 1 goal + 11 role activations + 2 system competencies).

Uniquely extending methodologies used in causal analyses, causal maps, concept maps, and Markov chains (Gopnik et al., 2004; Lord, Desforges, Fein, Pugh, & Lepper, 1994; Snijders, 1996; Wolff, 2007), dynamic network charts can also show role performance, when the data is available. A role performance indicator represents the degree to which evidence suggests that the social network role linkage is positively or negatively influencing overall goal performance in the system (directly or indirectly). Role performance can be scaled in various ways, although the following bipolar anchors may suffice in many situations, given their ability to demonstrate valence (Monroe & Read, 2008): -3 (*evidence strongly suggests that this linkage negatively influences overall goal achievement or performance in the system*) to +3 (*evidence strongly suggests that this linkage positively influences overall goal achievement or performance in the system*). A score of 0 would reflect no performance effect (e.g., *evidence suggests that this linkage neither positively nor negatively influences overall goal achievement or performance in the system*). These indicators are shown within subscript parentheses next to path activation indicators. To illustrate, $G_{2(0)}$ indicates that a goal striver is having no positive or negative effect on goal achievement or performance, despite an intense effort.

In the hiking example, Hiker A has a somewhat weaker direct effect on the dyad's goal ($G_{2(2)}$) than Hiker B ($G_{1(3)}$), despite Hiker A's greater effort. This likely results in part from Hiker B's previous hiking competence. Role performance indicators can also be estimated for entities in non–goal striver roles. For example, the Friend's support helped Hiker A maintain motivation for a picturesque hike, which positively contributed to the overall hiking experience ($S_{2(1)}$). In this hypothetical case, without the Friend's support, Hiker A would have lost interest in pursuing the hike. In contrast, the moral support that the Friend provided to Hiker B had little effect on role performance for the overall goal ($S_{1(0)}$). In other words, Hiker B would have performed the same with or without the moral support from the Friend.

As discussed in Chapter 1, it is important to note that role performance indicators are always evaluated in relation to their effect on the target goal. For example, if an entity has a nice interaction with someone he or she is trying to support, but evidence suggests that the support had no effect on the other person's ability to achieve the goal, the role performance indicator for this support linkage would be scored 0, despite the nice interaction.[2] Overall, the average performance of the network-motivated entities in the Type I chart example is 1.38, which is calculated from the numbers in subscript parentheses (i.e., $[G_{2(2)} + G_{1(3)} + S_{2(2)} + S_{1(2)} + S_{2(1)} + S_{1(1)} + S_{1(0)} + S_{1(0)}] / 8$).

In this example, a hypothetical expert evaluated all available information about the hike and provided an overall performance judgment about overall goal accomplishment (i.e., the degree to which evidence suggests that the dyad's goal of going on a picturesque hike over the weekend was fully achieved). The expert estimated an overall performance value of 2, indicating a moderate level of overall goal achievement (i.e., a moderately picturesque hike was accomplished in the dynamic network system). Reasons for its lack of complete accomplishment will become clearer when examining the Type II chart below. To note, as discussed in Chapter

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[2] Other attribute indicators could also be placed on dynamic network charts, such as likeability linkages, if researchers are interested in extending the analysis beyond parameters in dynamic network theory.

1, overall performance can be assessed on a seven-point scale with the following anchors (with 0 serving as the midpoint): -3 (*evidence strongly suggests that the goal or behavior is not achieved/there is extremely poor performance*) to +3 (*evidence strongly suggests that the goal or behavior is achieved/there is excellent performance*).

Type II Dynamic Network Charts with Resistance (and/or Reactance)

Dynamic network theory refers to *dynamic network charts with resistance or reactance* as Type II charts. As explained in Chapter 2 of the book, Type II charts are particularly useful for researchers interested in competitive, conflicted, or negative climates in which network motivation (NM), network resistance (NR), and network reactance exist as underlying causes. Thus, Type II charts extend Type I charts by showing network motivation roles (G, S), network resistance roles (G`, S`), and network reactance roles (R, R`). If there is little resistance, conflict, competition, negativity, or negative interpersonal reactions in a system (Deutsch, Coleman, & Marcus, 2006), a Type I chart can often suffice in research applications.

In some situations, a researcher may decide to focus the analysis only on NM roles (Type I charts) or on NM and NR roles (e.g., a special type of Type II chart without network reactance indicators), if most relevant to the analysis or focus. This also allows dynamic network theory to realistically model some systems that would be otherwise too complex, which fits in with recent scholarly approaches: "a model that seeks to incorporate all the complexity of the real world risks becoming so complex that its behavior is no more transparent than the real-world effect under investigation" (Smith & Collins, 2009, p. 352). However, oversimplifying a system by excluding network reactance when, in fact, it saliently exists runs the risk of inaccurately portraying the system and the underlying determinants of performance. In these contexts, focusing on a smaller subsection of the network (or construing the goals and/or entities at a higher level of abstraction) may help resolve the dilemma and allow for the further modeling of very complex systems, such as those at the national and international levels (See Chapter 1, this volume).

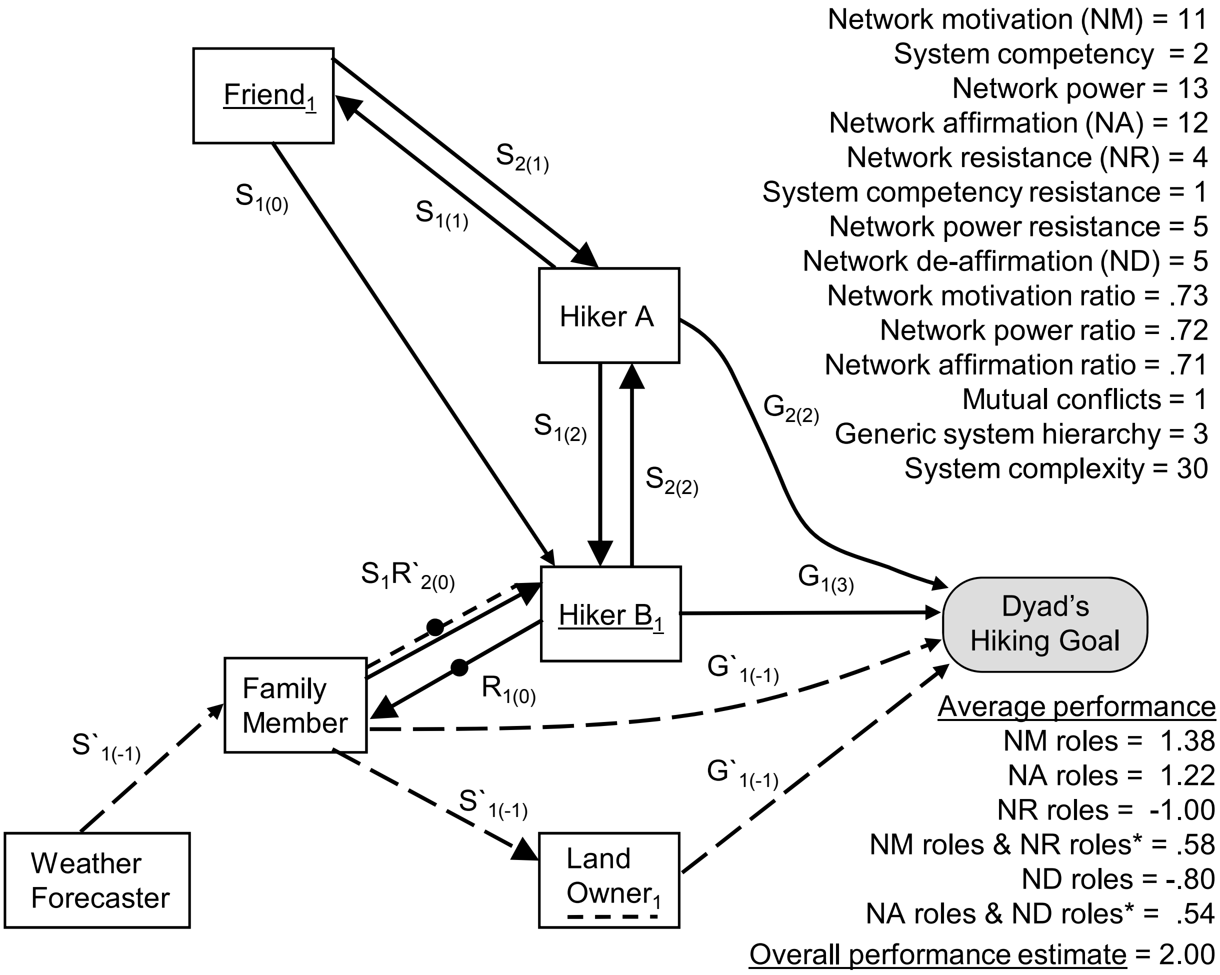
Further, Type II charts can delineate network affirmation (NA) role categories, which represent the combination of G, S, and R roles. Theoretically, these roles explicitly or implicitly provide a conformation of the goal pursuit, as discussed in Chapter 2. Type II charts can also show network de-affirmation (ND) role categories, which represent the combination of G`, S`, and R` roles. Researchers can use these breakdowns to infer the overall network affirmation ratio in the dynamic network system (i.e., $[NM + \sum R] / [NM + \sum R + NR + \sum R`]$), which shows the affirmational balance for the goal pursuit versus against the goal pursuit.

As shown in Type II charts, goal preventers are directly trying to make the goal difficult to achieve in the system. These linkages are shown by drawing a dashed arrow from the goal preventer entities to the goal (- - -►). Researchers can also explicitly label these linkages "G`," if desired, although this is implicitly understood in the chart. Supportive resistors (S`), who often help goal preventers or other supportive resistors in their efforts, are shown by drawing a dashed arrow from them to the other entities that they are assisting in the network resistance (- - -►). These paths can be labeled S`. In all, the dashed paths (without circles) symbolize the network resistance from G` and S` roles, which allows researchers to visualize network resistance levels in comparison to network motivation levels, which are manifest through solid black G and S paths (without circles).

As for network reactance, the system negator roles (R`) are shown by drawing the dashed path with the embedded black circle from the system negator entities to the other entities that they are negatively reacting to in terms of their goal pursuit or facilitation process (‒ ● →). In contrast, system reactor roles (R) are shown by drawing the black line with the embedded black circle from the system reactors to the other entities that they are negatively reacting to in terms of their working against or obstruction of the goal (—●→). Additionally, these special lines allow researchers to quickly visualize where mutual or one-sided conflicts exist between dyads in the social network (e.g., a circle on a line shows a negative social linkage).

It is important to note that goal preventer links (G`) are always drawn to the goal node only, which perfectly parallels how goal striver (G) links are only drawn to the goal. In cases where one entity is trying to prevent someone else from pursuing the goal, such as by arguing with them in a negative or hostile way, this would be typically modeled by showing an R` (or R`IO) linkage to the other person and then a direct G` linkage to the goal. One would not draw a G` link to the other person, because the underlying negative relationship and connection is already accounted for in the R` (or R`IO) linkage on the chart, which is likely motivating the goal preventer (G`) effort.

Online Figure A2 illustrates the Type II chart in the context of the hiking example. This chart shows that although a senior Family Member provided some initial support for the hike, he or she demonstrates strong system negation ($R`_2$) toward Hiker B's goal pursuit over much of the weekend because of an inclement weather warning. Hence, a multiplex linkage is shown from the Family Member to Hiker B (i.e., $S_1R`_2$). A multiplex linkage is also referred to as a "role bundle." To provide a little more context, in the above example, the system negation resulted from the Family Member listening to a Weather Forecaster's thunderstorm and mud slide warning for the weekend, which could result in treacherous hiking on steep trails. Hence, the Weather Forecaster served as an indirect supportive resistor in the context of the hiking goal ($S`_1$). When the Family Member shared his or her negativity about the original hike plan to Hiker B, Hiker B activated a system reactor role (R) by negatively reacting to the Family Member's disapproval. This resulted in a mutual conflict in the system (i.e., a joint R and R` linkage between the dyad). In contrast, the Family Member did not express negativity toward Hiker A's goal striving because Hiker A was perceived to be less accountable for choosing the final trail, given his or her lower system competency.



Online Figure A2. Type II dynamic network chart [without peripheral roles and without full multiplex linkages]. Network motivation, network resistance, and network reactance roles shown. G` = goal preventer. S` = supportive resistor. R = system reactor. R` = system negator. Dashed underlined names have high system competency resistance (SC`) and are each scored 1. Network resistance (dashed paths without circles) = ∑G`+∑S` linkages. Network power resistance = NR+∑SC`$^{\text{for NR entities}}$. Network affirmation roles = all solid black paths (G, S, & R). Network de-affirmation roles = all dashed paths (G`, S`, & R`). *Positive scores imply greater average performance toward goal achievement than against it among linkages in the Type II chart. See Online Figure A1 for additional code terminology.

Because the Family Member did not think he or she could persuade Hiker B to choose a less picturesque trail that was safer, the Family Member instead decided to not give Hiker B access to the family's hiking equipment for steep trails in an effort to prevent a steep hike over the weekend. This goal prevention effort had a slight negative effect on the overall goal ($G`_{1(-1)}$), because Hiker B decided to not pursue the steepest and most picturesque trails without this equipment. Thus, with this effort the Family Member had a slight negative effect on overall goal achievement because the hikers took a somewhat less picturesque trail over the weekend. However, the hikers still engaged in a hike that was somewhat picturesque, thereby partially contributing to their overall goal accomplishment and performance.

To add to the network resistance, because the Family Member was so concerned about the hikers' original goal pursuit, acting as a supportive resistor ($S`$), he or she asked a Land Owner to close a gate leading to the steepest trail, which also had the most scenic views. The Land Owner complied with the request, and this goal prevention effort further contributed to the hikers' regulatory decision to pursue a less steep and somewhat less scenic trail. Thus, the Land Owner ($G`_{1(-1)}$) and Family Member's ($G`_{1(-1)}$) efforts in network resistance reduced somewhat the quality of the originally planned hiking goal. Overall, this storyline implies clear spreading and contagion of network resistance paths over time embedded in the goal pursuit (i.e., Weather Forecaster → Family Member → Land Owner → reduced goal achievement level). In contrast, the system negation and system reactor activation involved in the mutual conflict between the Family Member and Hiker B had no positive or negative effect on the goal overall.

Researchers can also indicate the degree to which system competency resistance exists among members of the social network by placing a dashed line under an entity's name (i.e., "_ _ _ "). This illustrates that the given entity is highly competent at thwarting the goal. In the example, the Land Owner demonstrated system competency resistance by having the ability to close the gate in order to diminish people's goals of enjoying a maximally challenging hike by accessing the steepest trail.

The network resistance level in the hiking example was 4, given the goal prevention on two paths ($G`_1 + G`_1$), plus the value of 2 for the supportive resistance on two paths ($S`_1 + S`_1$). Network power resistance equals 5, which adds network resistance and system competency resistance for NR entities (i.e., 4 + 1). The network motivation ratio ($NM / [NM + NR]$) was .73 with a similar value of .72 for the network power ratio (i.e., $[NM + SC^{\text{for NM entities}}] / [NM + SC^{\text{for NM entities}} + NR + SC`^{\text{for NR entities}}]$). The network affirmation ratio (i.e., $[NM + \sum R] / [NM + \sum R + NR + \sum R`]$), which shows the balance of social network roles affirming the goal versus not affirming the goal, was .71. Overall, these ratios suggest an overall network that was motivated with sufficient competence and affirmation toward the goal, although with some dissent and resistance.

The average performance of entities in network resistance roles was -1.00, which is calculated from the numbers in subscript parentheses (i.e., $[G`_{1(-1)} + G`_{1(-1)} + S`_{1(-1)} + S`_{1(-1)}] / 4$]. The average performance across entities in network motivation and network resistance roles was .58 (i.e., $[G_{2(2)} + G_{1(3)} + S_{2(2)} + S_{1(2)} + S_{2(1)} + S_{1(1)} + S_{1(0)} + S_{1(0)} + G`_{1(-1)} + G`_{1(-1)} + S`_{1(-1)} + S`_{1(-1)}] / 12$). The positive value suggests that the overall role performance linkages in the Type II chart were contributing more to goal accomplishment and performance than against it.

Using a similar mathematical process, one can calculate the average performance of entities in network affirmation roles (G, S, and R) versus network de-affirmation roles (G`, S`, and R`) at 1.22 and -.80, respectively. Combining network affirmation and network de-affirmation roles results in a grand average of .54 (i.e., 7 / 13), again suggesting that role performances are more in favor of goal achievement than against it on average.[3]

Including Peripheral Roles

Researchers can also add significant peripheral role activations to Type I or Type II charts. Chart builders would technically refer to these charts as Type I charts with peripheral role activations or Type II charts with peripheral role activations. This modeling approach has the potential to extend Type I and/or Type II charts by including entities that are exclusively engaged in interactant (I) and/or observer (O) roles.

First, entities engaged in *exclusive interactant roles* are shown with gray paths and are denoted with the letter “I” on the paths. Exclusive interactants and observers in peripheral roles are denoted in dynamic charts with gray lines to distinguish them from network affirmation roles (black lines) and network de-affirmation roles (dashed lines). These entities are not explicitly aware of the focal goal pursuit. For instance, a person may interact with someone else and not realize that he or she is interrupting the other person’s goal pursuit, such as a person walking into another person’s office without realizing that this may have disrupted the other person’s current goal striving or system supporting.

Second, entities in *exclusive observer roles* are shown with the letter “O” on gray paths. These entities observe others in the goal context but are not interacting with them in the system; nor are they involved in any other role in the system. For example, a bystander simply watching another person engaged in goal pursuit represents an exclusive observer. Even though exclusive interactants and observers are not goal striving, supporting, preventing, or negatively reacting to other entities, they are in the real life-space of others in the system and have the potential to influence goal achievement, depending on the context (see Chapter 2).

Online Figure A3 illustrates a Type II chart in the hiking example with peripheral role activations (and partial multiplex linkages). In this case, a Sheriff and Homeowner are included in the chart. These entities were serving various interactant and observer roles. For example, the Sheriff interrupted Hiker A when Hiker A was going to meet Hiker B. The Sheriff engaged in a lengthy conversation with Hiker A about a recent crime in the community (i.e., reciprocal I_1 paths). The Sheriff was not observing (or aware of) Hiker A’s interest in going on a picturesque hike. Thereby, the Sheriff maintained an exclusive I role. A Homeowner also frequently observed Hiker A slipping on the trail (O_2), given the Homeowner’s view of the mountain. Hiker B was not aware of this observation (and hence no bidirectional path is shown).

As for role performance effects, the interactions between the Sheriff and Hiker A had a slight negative effect on the overall goal ($I_{1(-1)}$) by reducing the time Hiker A spent hiking. In contrast, the observing Homeowner had no disruptive effect on goal achievement or performance in the system ($O_{2(0)}$). To sum, the above Type II chart included exclusive interactants and observers.

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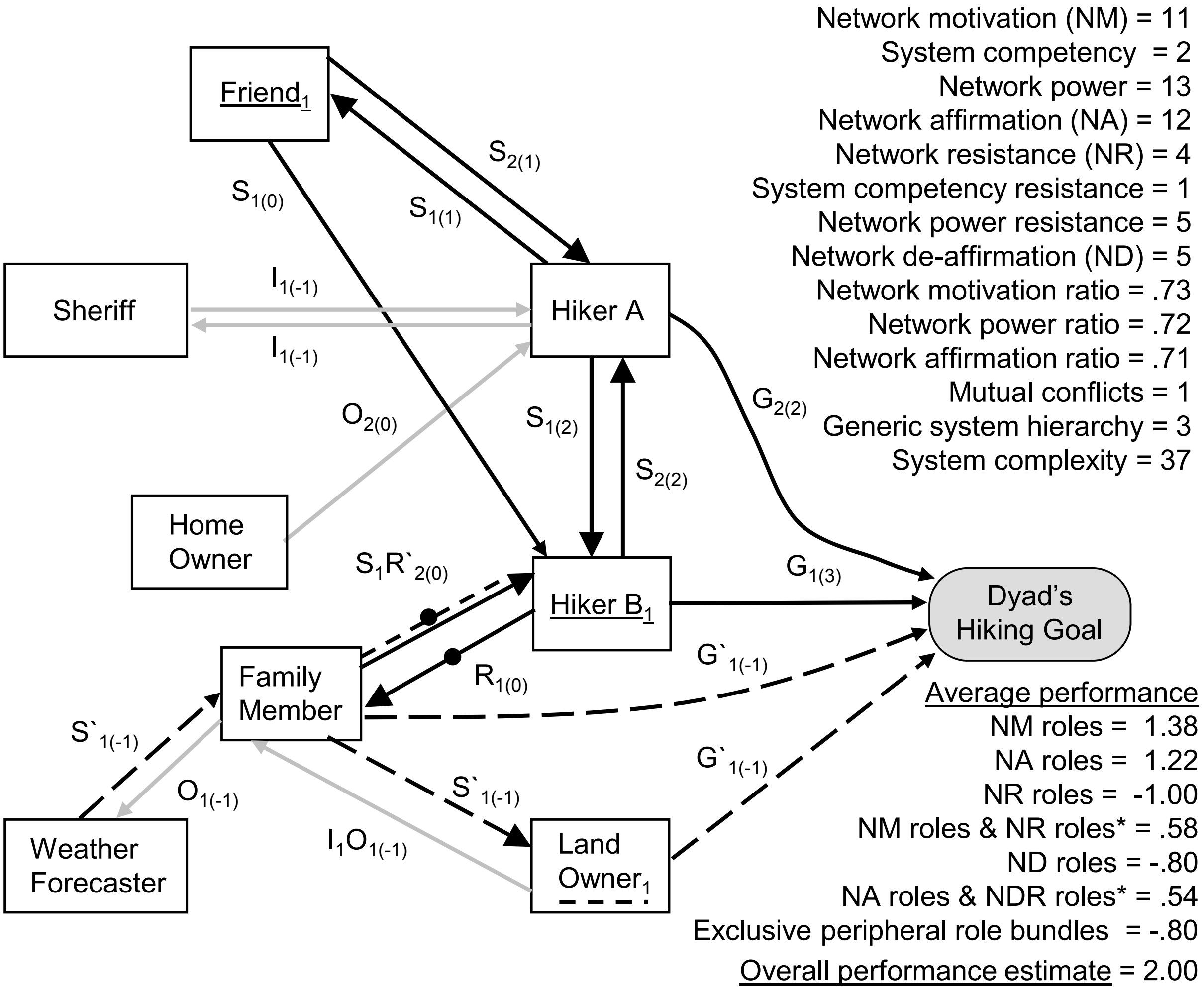
[3] To note, when combining NA and ND roles, because multiplex role linkages (e.g., the mutual R and R` connections between the Family Member and Hiker B) share a single role performance outcome, the single role performance score is used once in the equation (i.e., it is not counted twice).



Network motivation (NM) = 11
System competency = 2
Network power = 13
Network affirmation (NA) = 12
Network resistance (NR) = 4
System competency resistance = 1
Network power resistance = 5
Network de-affirmation (ND) = 5
Network motivation ratio = .73
Network power ratio = .72
Network affirmation ratio = .71
Mutual conflicts = 1
Generic system hierarchy = 3
System complexity = 37

Average performance
NM roles = 1.38
NA roles = 1.22
NR roles = -1.00
NM roles & NR roles* = .58
ND roles = -.80
NA roles & NDR roles* = .54
Exclusive peripheral role bundles = -.80
Overall performance estimate = 2.00

Online Figure A3. Type II dynamic network chart [with partial peripheral role activations but without full multiplex linkages]. Salient network motivation, network resistance, network reactance, and exclusive peripheral roles shown. I = interactant. O = observer. Gray paths = peripheral role linkages among exclusive interactants and observers. *Positive scores imply greater average performance toward goal achievement than against it among linkages shown in this Type II chart. See Online Figures A1 and A2 for additional code terminology.

Including Full Multiplex Linkages

Researchers can also add relevant multiplex linkages to Type I and Type II dynamic network charts. Consistent with the social network literature, dynamic network theory uses the term “multiplex” to denote that each link can have multiple activations of social network roles bundled together (see Chapter 2). For example, a system supporter linkage may be activated when the person is interacting with and observing another other entity in the system (i.e., an “SIO” bundled linkage). Dynamic network theory describes the multiplex linkages going from one entity to another as a *bundle* or a *bundled set of linkages*.

Moreover, researchers can gather information to estimate the role performance of bundled sets of linkages, which is shown in parentheses at the end of the string. For example, $S_2I_2O_{2(3)}$ illustrates that a strong system supporter that is very frequently interacting with and observing another in the goal context is having a very strong effect on goal achievement and performance.[4] An $I_2O_{2(0)}$ linkage, in contrast, illustrates a person that is interacting with and observing another in the system, but is not trying to help or hinder the goal pursuit. This combined linkage has no effect. Symbolically, a single gray line is used to visually represent the multiplex IO role bundle in Online Figure A4, which aids in chart parsimony while being consistent with the theory. (The gray line could also just show an I or an O linkage).

Type I or Type II dynamic network charts with full multiplex linkages would explicitly show all activated multiplex roles on all relevant linkages in the chart. These charts are useful for researchers who want to display all possible social network role activations in a system. In contrast, a Type I or Type II dynamic network chart with partial multiplex linkages typically shows a subset of the most salient multiplex linkages in a system.

Online Figure A4 shows a Type II chart with full peripheral roles and full multiplex linkages in the hiking example. To illustrate, the linkage from the Friend to Hiker A was actually a combination of system support, interaction, and observation (i.e., an “$S_2I_1O_2$” bundle). For example, the supportive information was communicated to Hiker A during a couple of interpersonal interactions at which time the Friend was very aware and observant about how the information was relevant to the hiking goal. Reciprocally, Hiker A was also supportively attending to the helpful information from the Friend about the hike. These mutual multiplex role bundles had slight positive effects on the overall goal; the performance values of the bundles are indicated by the number in subscript parentheses at the end of each string (i.e., “$S_2I_1O_{2(1)}$” and “$S_1I_1O_{1(1)}$, respectively).

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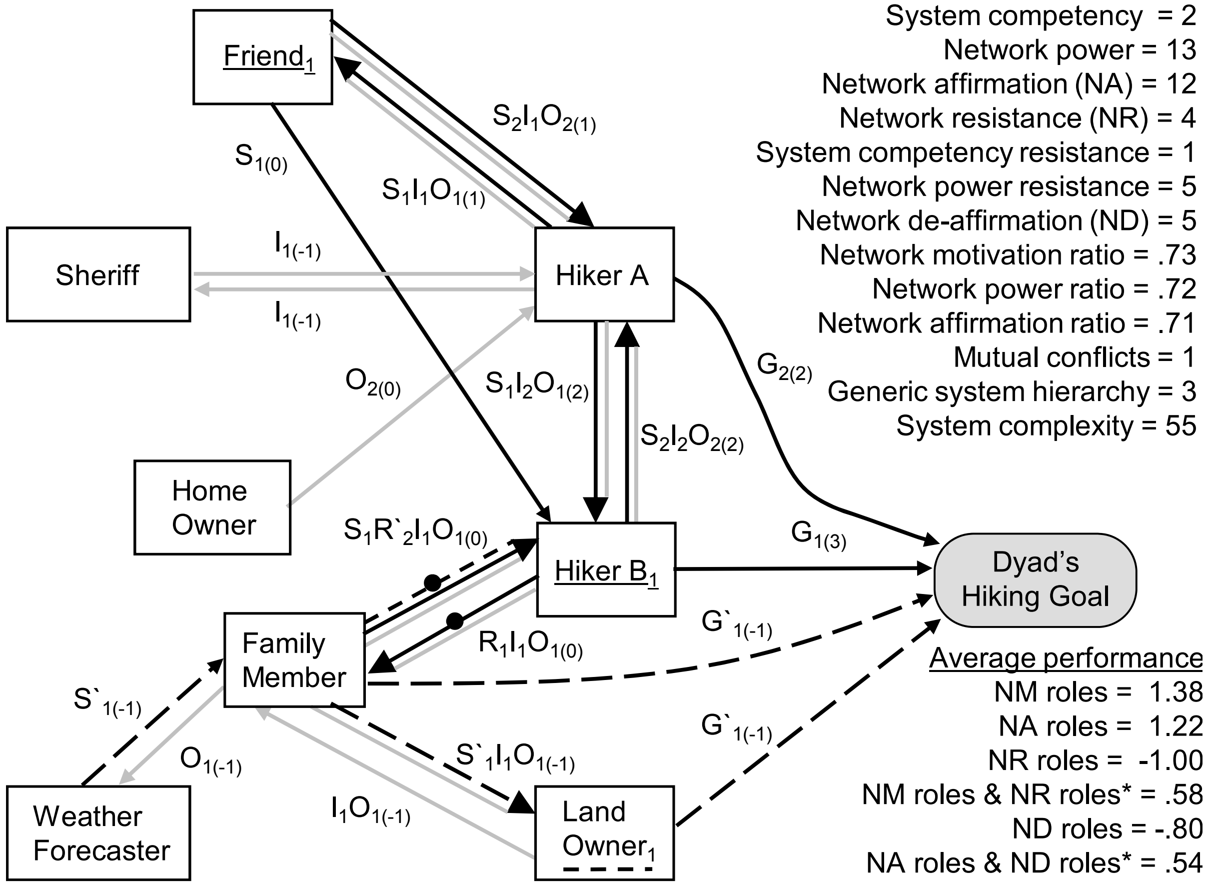
[4] Technically, Type I and Type II charts that show role performance indicators without explicitly denoting multiplex linkages are formally showing how prioritized roles are influencing performance. However, some of these prioritized role indicators exist in a bundled set with other multiplex roles, such as a system supporter that is interacting with and observing the other entity (i.e., an SIO linkage). Researchers should be aware of their assumptions when using prioritized role indicators in charts without multiplex linkages. Moreover, future research could examine whether the bundled role performance indicator could be further de-composed on each role activation indicator and if this provides value-added in predicting performance. If not, the more parsimonious approach presented here may be advised.



Network motivation (NM) = 11
System competency = 2
Network power = 13
Network affirmation (NA) = 12
Network resistance (NR) = 4
System competency resistance = 1
Network power resistance = 5
Network de-affirmation (ND) = 5
Network motivation ratio = .73
Network power ratio = .72
Network affirmation ratio = .71
Mutual conflicts = 1
Generic system hierarchy = 3
System complexity = 55

<u>Average performance</u>
NM roles = 1.38
NA roles = 1.22
NR roles = -1.00
NM roles & NR roles* = .58
ND roles = -.80
NA roles & ND roles* = .54
Exclusive peripheral role bundles = -.80
All role bundles* = .17

<u>Overall performance estimate</u> = 2.00

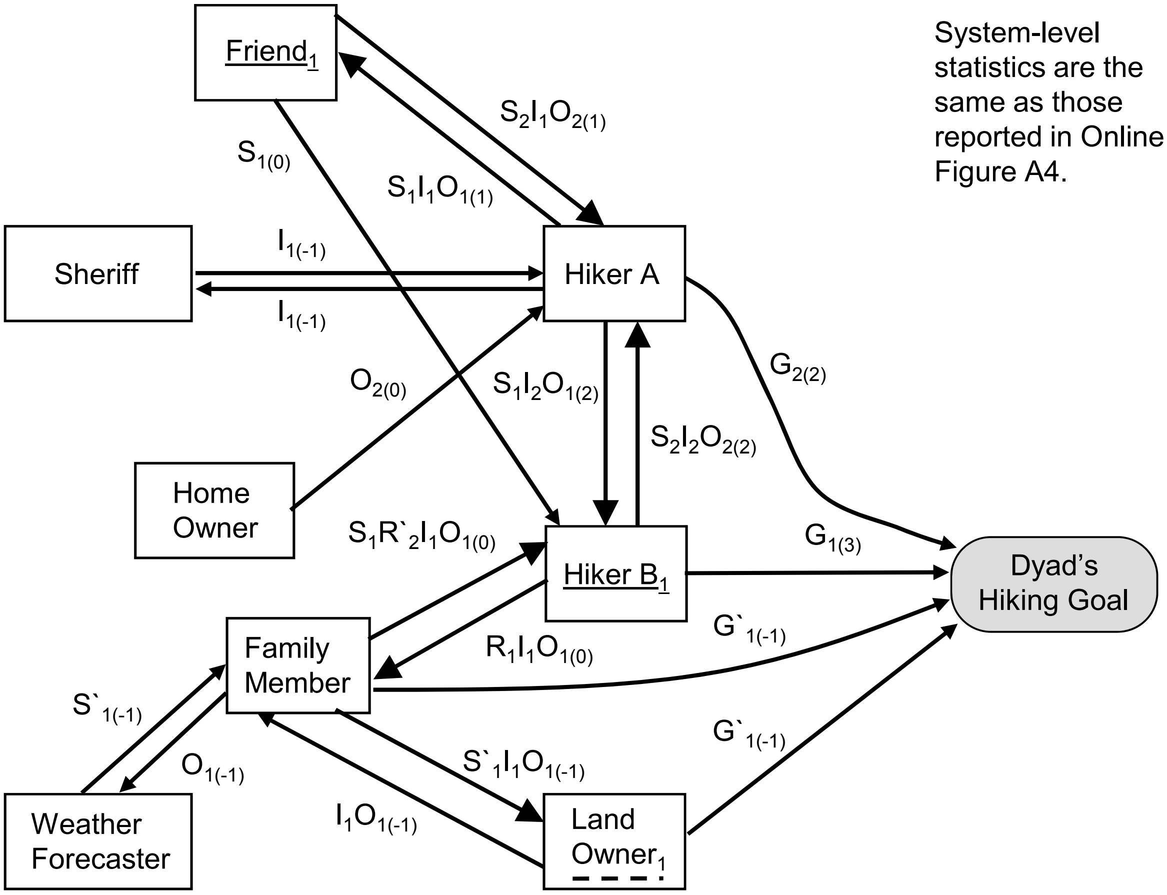
Online Figure A4. Type II dynamic network chart [with full peripheral roles and with full multiplex linkages]. All activated multiplex role combinations shown. *Positive scores imply greater average performance toward goal achievement than against it among linkages in this multiplex chart. See Online Figures A1, A2, and A3 for additional code terminology.

The multiplex linkages further show that Hiker A and Hiker B were interacting a lot during the goal pursuit. Moreover, Hiker B was spending considerably more time supporting and observing Hiker A, likely because Hiker A was having difficulty on steeper portions of the hike. Hiker B needed relatively less attention, given Hiker B's advanced hiking competence. Overall, researchers can also calculate the average and summative performance across all role bundles in the system. In this example, the average performance across all role bundles was .17 (i.e., the sum value of 3 on all role performance indicators across bundles /18 path bundles) and the summative performance was 3 (i.e., the value of the numerator alone). Because both values are positive, it suggests an overall system of linkages favoring the likelihood of goal achievement and positive performance.

A technical advantage of Type II charts with peripheral role and full multiplex linkages is that they can quantitatively represent any combination of the eight activated social network roles in dynamic network theory, along with system competency. These quantitative assessments can then be transposed into prediction-based data matrices for statistical testing of major propositions in the theory, which are illustrated in Part 4 of this Online Resource.

Single Line Technique

Researchers can alternatively use a *single line technique*, if they desire a simpler graphing approach in contrast to drawing the numerous multiplex linkages. This is shown in Online Figure A5 for the hiking example. This chart is technically the same as Online Figure A4. However, instead of drawing multiplex linkages with various line types, researchers would simply show the multiplex role codes on single lines. For example, they could simply place an "SIO" role code on a single black line. The advantage of this technique is that it simplifies the charting of lines. The main disadvantage of this technique is that visual theoretical meaning from the linkages themselves is reduced, such as not being able to quickly visualize network resistance through the dashed paths. Another example of the single line technique is shown in the supplemental figures in Online Resource C (i.e., Online Figure C2).



System-level statistics are the same as those reported in Online Figure A4.

Online Figure A5. Alternative "single line technique" as compared to Online Figure A4. All activated multiplex role combinations are shown, yet only displayed with single lines for all social network role linkages. Although this is a simpler graphing technique than the one shown in Online Figure A4, visual meaning from the lines themselves is reduced.

Network Intervention Charts

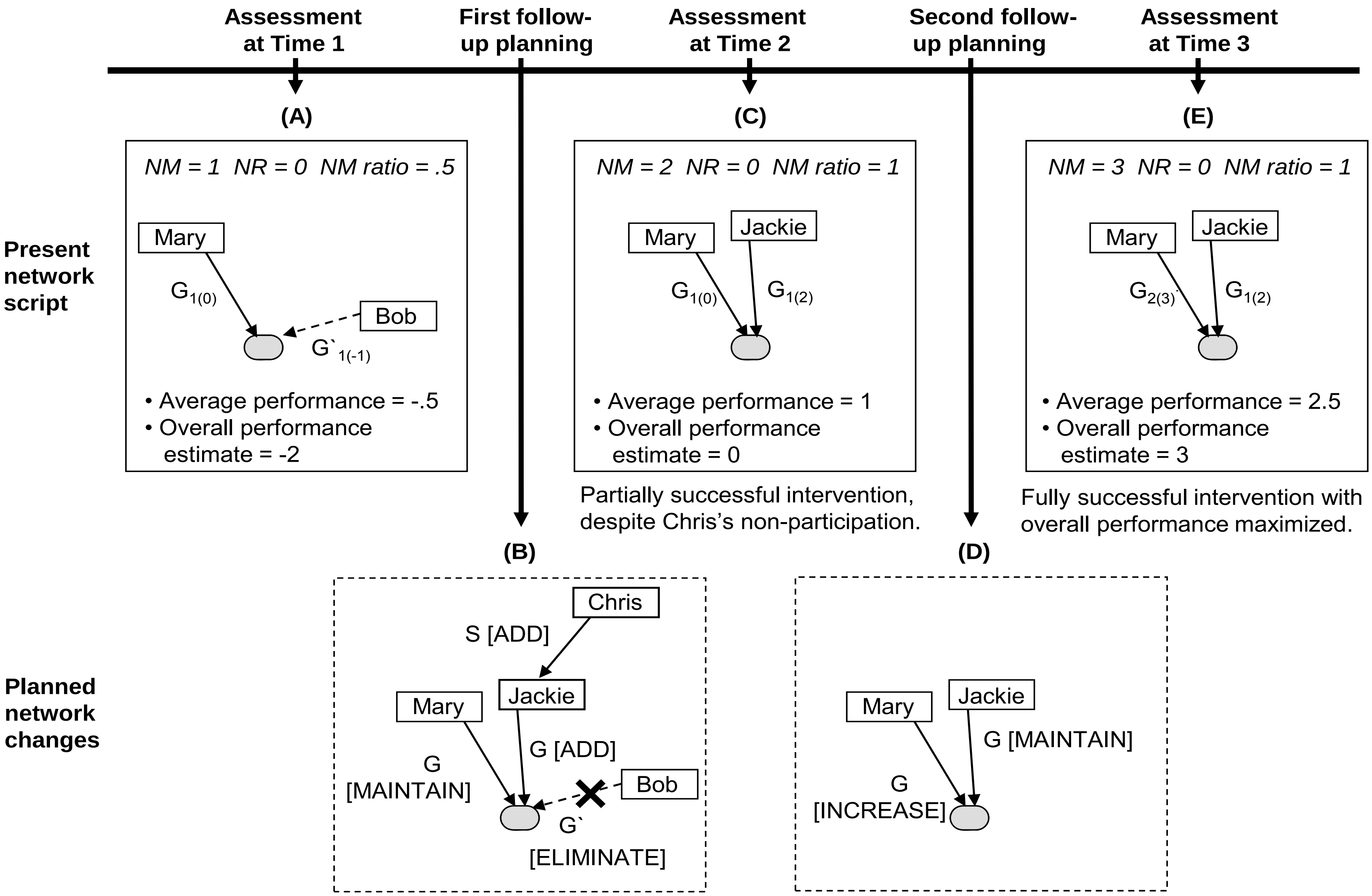
Researchers can also use *network intervention charts* to examine planned changes in social, organizational, and international networks over time, which would extend traditional approaches to the analysis, assessment, and evaluation of change (Burke, 2002; Prochaska, Diclemente, & Norcross, 1992). They can also provide a strategic approach in an effort to model the "stakeholders" that could be proactively targeted in dynamic network systems, in line with stakeholder theories (Donaldson & Preston, 1995; Mitchell, Agle, & Wood, 1997). Extending script concepts (Abelson, 1981), a straightforward approach to visualize network interventions is to compare an unfolding network script (shown on the top of the figure) to the planned network changes over time (shown on the bottom of the figure).

Online Figure A6 illustrates a network intervention chart unfolding in a small dynamic network system. Box A shows the current dynamic network system at a given starting point (Time 1). In this example, Mary is striving for the goal, although not effectively ($G_{1(0)}$). Moreover, there is a goal preventer, Bob, in the system who is limiting goal accomplishment at Time 1 ($G`_{1(-1)}$). The average performance across the system is thus -.5. A broad expert estimate of overall performance is also shown, which has a value of -2 on a seven-point scale. As discussed earlier, this scale ranges from -3 (*evidence strongly suggests that the overall goal is not achieved)* to +3 (*evidence strongly suggests that the overall goal is achieved*).

Aware of the dynamics in the above example, the following changes were planned after the Time 1 assessment: (1) try to maintain Mary's current goal striving, (2) attempt to add Jackie as new goal striver, who would receive support from Chris, a new entity in the system, and (3) try to eliminate the goal prevention from Bob. This planned intervention is shown in Box B in Online Figure A6.

The outcomes of the first intervention are shown in Box C at Time 2. This chart indicates several things. First, the addition of Jackie as a goal striver appeared to take hold in the network. Not only did Jackie commit to the goal as planned, which reflects a positive manipulation check, Jackie had a positive effect on goal achievement processes ($G_{1(2)}$). Moreover, Bob's goal prevention efforts were successfully removed from the system, as planned. This also eliminated the negative role performance indicator from that path (new implied value = 0). The first network intervention had a positive effect on both average performance (which increased from -.5 to 1) and the overall performance indicator (which increased from -2 to 0). This improvement also occurred even though Chris was unable to participate as a supporter as planned.

Given the increase in performance indicators at Time 2, the next planned change maintained the current network intervention, but with an increase to Mary's level of goal striving (see Box D). The outcome of this planned change appeared favorable, because Mary and Jackie's role performance indicators were both positive at Time 3. This in turn helped contribute to the overall performance at Time 3 (see Box E), which was fully maximized at the system level. In other words, the overall goal was fully achieved. Such network scripts and intervention charts could also be used in modeling "event histories" in historical analyses.



Online Figure A6. Example of network intervention chart over time. The “X” in box B denotes planned path elimination.

PART 2: SUMMARY EQUATIONS

There are a variety of metrics that researchers can use to portray dynamic network systems. These metrics are especially useful for understanding large or complex systems that can become unwieldy to understand by chart visualization alone.

Goal Pursuit Metrics

- Network motivation (NM) = $\sum G + \sum S$. This represents the total path activation levels derived from the first subscript indicators on G and S roles (i.e., the activation levels on the standard black paths). See Equation 1 in Chapter 2 for more details.
- Network resistance (NR) = $\sum G` + \sum S`$. This represents the total path activation levels derived from the first subscript indicators on G` and S` roles (i.e., the activation levels on the standard dashed paths). See Equation 2 in Chapter 2.
- Network motivation ratio = NM / (NM + NR). See Equation 3 in Chapter 2.
- Network affirmation (NA) = $\sum G + \sum S + \sum R$. This represents the total path activation levels derived from the first subscript indicators on G, S, and R roles (i.e., the activation levels on all types of black paths). See Equation 4 in Chapter 2.
- Network de-affirmation (ND) = $\sum G` + \sum S` + \sum R`$. This represents the total path activation levels derived from the first subscript indicators on G`, S`, and R` roles (i.e., the activation levels on all types of dashed paths). See Equation 5 in Chapter 2.
- Network affirmation ratio (NAR) = $(NM + \sum R) / (NM + \sum R + NR + \sum R`)$. See Equation 6 in Chapter 2.
- Total system competency (SC) = $\sum$entity SC. This represents the total strength of the subscript next to the underlined names in the social network. See Equation 7 in Chapter 2.
- Total system competency resistance (SC`) = $\sum$entity SC`. This represents the total strength of the subscript next to the dashed underlined names in the social network. See Equation 8 in Chapter 2.
- Overall goal achievement/performance/target behavior (GPB) = f (NM, NR, *Network Reactance*, *PR*, SC, SC`). See Equation 9 in Chapter 2 for more details.
- Network power (NP) = $NM + \sum SC^{\text{for NM entities}}$ (where $SC^{\text{for NM entities}}$ represents the level of system competency for entities with network motivation activations [G or S]). See Equation 10 in Chapter 2 for the more general equation and the importance of testing alternative mathematical formulations (such as multiplicative rules).
- Network power resistance (NP`) = $NR + \sum SC`^{\text{for NR entities}}$ (where $SC`^{\text{for NR entities}}$ represents the level of SC` for entities with network resistance [G` or S`]). See Equation 11 in Chapter 2.
- Network power ratio (NPR) = NP / (NP + NP`). See Equation 12 in Chapter 2.
- Network power reserve = TNP – CNP, where TNP is the total network power from all available sources (utilized and not utilized), and CNP represents the current level of network power being utilized in a system. See Equation 13 in Chapter 2. This calculation would require two dynamic network charts of a system. The first chart would be used to calculate the network power in the current system and the second would be used to calculate the network power in a system that shows all available goal strivers and system supporters and their corresponding levels of system competency.
- General accountability = direct accountability + indirect accountability. See Chapter 3.

Conflict Metrics

- Mutual conflicts = $\sum R`$ and R occurrences between dyads. See Chapter 2 for more details about conflict metrics.

- One sided system negator conflicts = ∑ R` occurrences without R reciprocated between dyads.
- One sided reactor conflicts = ∑ R occurrences without R` reciprocated between dyads.
- Goal conflict = ∑ goal conflict linkages. This represents the total number of waved lines between goals in the system.

Social Structure Metrics

- Generic system hierarchy (GSH) = ∑V + 1, where V represents the number of system supporter linkages from a goal striver entity to the end of the longest system supporter chain in the system. The constant value of 1 accounts for the goal striver role linkage to the goal. See Equation 14 in Chapter 2 for more details.
- System complexity = ∑entities + ∑goals + ∑subgoals + ∑goal conflicts + ∑role activation levels + ∑SC levels + ∑SC` levels + ∑embedded structures. See Equation 15 in Chapter 2 for more potential parameters.
- Density (see Chapter 1 and Wasserman & Faust [1994] for examples).
- Degree centrality (see Chapter 1 and Wasserman & Faust [1994] for examples).

Performance Metrics

See Chapter 1 for a detailed theoretical treatment of the following constructs.

- Overall goal achievement/performance/behavior. This simply represents the overall achievement or performance of the overall goal (or behavior) on the -3 (*Evidence suggests that the overall goal or behavior is entirely unachieved* or *Evidence suggest that there is extremely poor performance overall*) to +3 (*Evidence suggests that the overall goal or behavior is entirely achieved* or *Evidence suggest that there is excellent performance overall*) scale. 0 serves as the middle point. The Appendix in the book presents a full scale.
- Average performance for NM roles = ∑ role performance values across NM linkages / ∑T_{NML} (where T_{NML} represents the total number of NM linkages).
- Average performance for NR roles = ∑ role performance values across NR linkages / T_{NRL} (where T_{NRL} represents the total number of NR linkages).
- Average performance for NM and NR roles = (∑ role performance values across NM linkages + ∑ role performance values across NR linkages) / (T_{NML} + T_{NRL}).
- Average performance for NA and ND roles = (∑ role performance values across NA role linkages + ∑ role performance values across ND role linkages) / (T_{NML} + T_{NRL} + T_{RL} + $T_{R`L}$ (where $T_{RL}$ represents the total number of system reactor linkages and $T_{R`L}$ represents the total number of system negator linkages).
- Average performance for all roles = ∑ role performance values across all social network role bundles.

PART 3: INTERRATER RELIABILITY IN DYNAMIC NETWORK CHARTS

The following steps illustrate a process for testing the interrater reliability of hypothesized dynamic network charts. Such an approach is consistent with assumptions in neural network simulations that use consensus to infer behavioral properties (Read et al., 2010) and the importance of using consensus when building data about social network linkages (Kilduff & Tsai, 2003). This is a tentative framework that could be extended or modified, if appropriate.

Step 1: Propose (or hypothesize) a dynamic network chart

The first step is for researchers to construct a dynamic network chart to represent how a social network is involved in a targeted goal pursuit (or multiple goal pursuits). The construction of the chart is preferably based upon past theory, research, data, or relevant personal experiences. The basic *elements* of the chart include the goal(s), entities, and relevant social network role linkages, such as G and S in simple Type I charts or G, S, G`, S`, R, R`, I, and/or O paths in more complex Type II charts with peripheral role activations and multiplex linkages. System competencies, role performance levels, and embedded sub-groups can also be modeled in the charts, whenever such information is available.

Step 2: Examine the interrater reliability of the proposed chart

The second step is for researchers to assess and report the interrater reliability of the proposed elements in the dynamic network chart. There are various ways to examine this interrater reliability, such as through multiple experts, the sampling of multiple participants in relevant systems, and repeated measures from the same participant (which could include repeated assessments from the original proposer of the chart). Each of these possibilities is considered in turn, followed by an example interrater reliability assessment of a simple dynamic network chart. Such charts can be used to model external dynamic network systems or the internal psychological representation of dynamic network systems (i.e., dynamic network schemas).

In the *expert method*, a researcher would present the proposed (or hypothesized) dynamic network chart to other experts of the system and ascertain the degree to which they agree or disagree with each proposed element in the hypothesized chart (e.g., its goals, entities, social network role linkages, system competency levels, and role performance levels, if relevant). These experts are also presumed to call upon relatively more objective observations, information, or evidence to support their judgments (as compared to nonexperts). Interrater reliability statistics, such as Cohen's kappa, could also be reported to indicate the degree of agreement among the expert raters of the proposed system. If sufficient reliability is demonstrated, researchers could summarize their findings and then move to Step 3 to examine the proposed chart's sufficiency. For elements that demonstrate poor interrater agreement, the researcher may consider dropping those elements from the model, especially if experts provide valid evidence to suggest that the hypothesized elements are not justified.

Regarding the *sample method*, a researcher could assess the interrater reliability of the chart among entities that are actually involved in the system, instead of using expert assessments of a system. In this design, the researcher would select a random sample, stratified random sample, or justified convenience sample of entities that are involved in the system/goal context. These entities would then indicate the extent to which they agree or disagree with each element in the proposed system. However, unlike the expert method, the sample method does not presume that the participants can call upon relatively more objective observations, information, or evidence to support or refute each element proposed in the system.

In contrast, the *repeated measures method* would ask an individual (or the chart composer) to assess the reliability of the elements in the chart over several instances of time. Technically, this approach represents a repeated-measures, test-retest, or within-person design. This method is particularly relevant for researchers trying to assess the reliability of an individual's perceived dynamic network schema in a specific domain (or the reliability of their own perceived charts). For example, a researcher or practitioner may be interested in mapping a person's dynamic network schema associated with his or her long-term goal of losing weight. Alternatively, a therapist may be interested in reliably portraying a client's dynamic network schema associated with his or her major goals in life. In all, researchers would assess the degree to which the same individual (or the researcher) agrees or disagrees with the elements of the hypothesized chart over multiple points in time to assess the psychological reliability of the hypothesized system.

Researchers could combine the above methods in different ways to provide additional reliability evidence about a system, such as doing repeated measures across multiple participants in a sample. Additionally, researchers could compare elements of an individual's perceived dynamic network schema to an expert assessment of the same system. For instance, Person A may indicate that Person B has never supported his or her career goal. However, an expert may find evidence that Person B not only reports being supportive of Person A, but Person B also engaged in several unambiguous behaviors that helped support Person A's career. These findings suggest that Person A's perception is inaccurate, which theoretically could be due to various cognitive biases, memory limitations, or incomplete information about the system. See Chapter 5 for more details about *dynamic network intelligence*.

The following provides an illustration of the interrater reliability assessment process in Step 2. For this illustration, imagine that a proposed dynamic network chart has the following simple characteristics: one goal (i.e., "Goal A"), two entities (i.e., "Entity X who has high system competency" and "Entity Y who does not have high system competency"), and two social network role linkages ("Entity X is goal striver" and "Entity Y is a system supporter of entity X"). Also imagine that the overall performance in the system is strong and the specific role performance indicators for both social network role linkages are strong. In this example, researchers could ask each expert, participant, or individual to agree or disagree with each of the following statements:

(1) Goal A is an important goal in this system.

(2) Entity X exists in this system.[5]

(3) Entity Y exists in this system.

(4) Entity X is highly competent at the goal.

(5) Entity Y is not highly competent at the goal.

(6) Entity X strives for goal A in this system.

(7) Entity Y is a system supporter of entity X in this system.

(8) Evidence suggests that entity X's goal striving is positively influencing overall goal achievement.

(9) Evidence suggests that entity Y's system supporting of Entity X is positively influencing overall goal achievement.

(10) Evidence suggests that the overall goal is being accomplished.[6]

The level of agreement across raters could then be calculated and reported. As a practical matter, researchers could use interviews or surveys to assess agreement levels for each element of the hypothesized system. Alternatively, if the experts or participants understand the

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[5] If researchers are concerned about the homogeneity assumption in the entity abstraction process being violated in the proposed chart, as discussed in Chapter 1, they could ask participants to respond to a question such as the following: "This entity is portrayed at reasonably correct level of analysis in relation to the goal."

[6] The researcher proposing the model could further provide his or her formal level of agreement with each question. Multiple items and/or reverse scored items could also be used.

methodology and language of dynamic network charts, they could review the chart and indicate where they agree or disagree with each of its elements. Researchers could then examine agreement levels across the raters' assessments of the elements in the chart. It is important to note that experts or participants may legitimately have incomplete information about some elements of the hypothesized model. Thus, researchers could assess confidence levels for each estimated element, if feasible in the study. In all, if poor reliability of the hypothesized chart is demonstrated on Step 2, a researcher should consider either (1) abandoning the current model, (2) eliminating or changing elements with poor agreement, or (3) returning to Step 1 to reconceptualize a new hypothesized model, preferably based upon new, credible data provided by the experts or participants in the system.

Step 3: Examine the sufficiency of the proposed chart

Just because a dynamic network chart is reliable does not mean it is a sufficient representation of a dynamic network system. Thus, researchers could also ascertain from other relevant experts or knowledgeable participants in the system whether or not additional elements are critically needed in the chart (e.g., additional goals, entities, or social network roles). For example, if multiple experts agree that an additional supervisor exists in an organizational system and plays an important system supporter role to another employee, the researcher may be justified in modifying the originally proposed (or hypothesized) chart to include the new entity and linkage. Alternatively, in the repeated measures design, an individual may realize at Time 2 that an important entity and linkage is missing from the chart. In contrast, if the experts or participants in the reliability study do not identify other needed elements or they significantly disagree upon which new elements should be added to the chart, it suggests that no further changes are justified.

Optional extended analyses: Conduct prediction-based analyses, if data are available

An optional step is also possible for researchers interested in testing the underlying motivational propositions in the theory, such as the hypothesis that goal striver and/or system supporter roles predict goal achievement and performance across systems. However, this requires data from prediction-based matrices, which collect data from multiple dynamic network charts. These matrices are illustrated in the next section of this Online Resource, and their analyses are described in the "reliability and validity" section in Online Resource B. If researchers have access to other observable behaviors or objective outcome data across the multiple systems, the validity of the dynamic network charts could be further tested in light of these objective data (e.g., a study examining volunteerism behavior could examine whether individuals actually engaged in volunteer events over time).

PART 4: PREDICTION-BASED AND STRUCTURE-BASED ANALYSES

Prediction-based analyses examine how the activation of social network roles, system competencies, and goal achievement are interrelated, such as proposed in the causal motivation models shown in Figure 1.2 in Chapter 1 and Figure 2.2 in Chapter 2 of the book. Structure-based analyses describe the structure of specific social networks, such as the density and centrality of a social network embedded within a dynamic network system.

Prediction-Based Analyses

Prediction-based analyses allow researchers to examine a variety of hypotheses and relationships in dynamic network theory, such as the prediction that goal striver and system supporter activations are positively related to each other. They also allow researchers to examine other motivational dynamics, such as discerning whether network reactance and peripheral role activations are helping or hurting goal achievement and performance in specific domains. To conduct these analyses, a prediction-based data matrix is required, which can be used to represent data in dynamic network charts or surveys.

In prediction-based matrices, the columns reflect the theoretical variables (e.g., the eight social network role activations, system competencies, performance levels, and relevant situational moderator variables) and the rows reflect each system under analysis. In Table A1, the rows would reflect either within-system data (e.g., repeated measures of variables within the same dynamic network system over time) or between-system data (e.g., measures assessing variables across independent samples of dynamic network systems involved with the targeted behavioral/goal domain). Theoretically, goal striver, goal preventer, and goal achievement/performance variables serve as the key endogenous (or dependent) variables in the prediction-based matrix, according to the mediation model in Figure 2.2 shown in Chapter 2 as well as Online Figure B1 in Online Resource B.

There are several ways that researchers can input data for these matrices. For instance, researchers can use dynamic network charts or dynamic network surveys. To illustrate the case of dynamic network charts, the data for each social network role variable in the matrix are derived from summing respective role activation levels across the chart. For example, the total level of goal striving in the hiking example was 3, which was derived from the variable role activation levels on two goal striver paths (i.e., $G_{2\text{ for the goal striver path for Hiker A}} + G_{1\text{ for the goal striver path for Hiker B}}$). A similar summation process is used for the remaining social network roles. For example, the total level of system support in the hiking example was 8, which was derived from activation levels on six different paths (i.e., $S_{2\text{ for link from Hiker B to Hiker A}} + S_{1\text{ for link from Hiker A to Hiker B}} + S_{2\text{ for link from Friend to Hiker A}} + S_{1\text{ for link from Hiker A to Friend}} + S_{1\text{ for link from Friend to Hiker B}} + S_{1\text{ for link from Family Member to Hiker B}}$). Average path activation scores could also be created for each role. Second, the system competency (SC) variable is derived from summing the total level of system competency indicators across the system. In the hiking example, the total level of system competency was 2 ($SC_{1\text{ for Hiker B}} + SC_{1\text{ for Friend}}$). The same process would apply for system competency resistance (SC`). Variables assessing relevant situational moderators could also be included as additional columns in the matrix as well as sociometric data about the system, such as the overall density and centrality in the social network (see below).

Various performance indicators can be represented in the matrix, which provide additional criteria for testing propositions in dynamic network theory. To illustrate in the hiking example, the average performance across all path indicators was .17. (Average performance for NM, NR, NA, and ND roles could also be used.) Additionally, the overall goal achievement score was estimated as 2 on the seven-point scale, which ranged from -3 (*evidence strongly suggests that the goal of going on a picturesque hike was not achieved*) to +3 (*evidence strongly suggests that the goal of going on a picturesque hike was achieved*). For research examining systems with individual behavioral goals, overall performance indicators would simply represent whether a person conducted the behavior or not (or the frequency and/or duration of the behavior). In organizational and national goal pursuits, other common overall indicators of goal achievement and performance could include business and economic performance indicators, respectively.

A similar process would be used for inputting data from egocentric dynamic network surveys, which are shown in Online Resource B, although the process is simpler. That is, the data from each survey could be entered as a unique case on each row of the matrix. See Online Resource B for statistically testing the data observed in prediction-based matrices, such as through correlation, regression, path analyses, structural equation modeling, and hierarchical linear modeling (Anderson & Gerbing, 1988; Hofmann, 1997).

	Network Motivation		Network Resistance		Network Reactance		Peripheral Roles		System Competency		Performance	
	G	S	G`	S`	R	R`	I	O	SC	SC`	Avg.	Over-all
System 1	3	8	2	2	1	1	12	14	2	1	.17	2
System 2												
…												
System n												

Table A1. Prediction-based data matrix for hiking example. Data in columns 1 through 8 represent the summed total of role activation levels in each system. The first row of data is based upon chart indicators from Online Figure A4 or A5. Remaining rows would represent data from other dynamic network systems toward the target goal (i.e., a between-system analysis) or from the same system (i.e., a within-system analysis, such as using repeated measures over time). G = goal striver. S = system supporter. G` = goal preventer. S` = supportive resistor. R = system reactor. R` = system negator. I = interactant. O = observer. SC = system competency. SC` = system competency resistance. Avg. = average role performance across all social network role bundles. Overall = overall performance estimate of goal achievement or performance (e.g., 3 = complete goal accomplishment, full behavioral execution, or maximal target performance).

Structure-Based Analyses

Structure-based analyses are grounded in the sociological tradition of sociometrics (Newman 2003). In dynamic network theory, these analyses focus on describing the social network structure itself within each dynamic network system, such as the social network's density and centrality as illustrated in Chapter 1. These analyses are often referred to as *relational analyses* in the social network literature to indicate how entities in the social network are related to one another (or not). However, in dynamic network theory, these analyses are explicitly referred to as "structure-based analyses" to avoid potential confusion with "prediction-based analyses" that examine relations among concepts. Ironically, relational analyses in sociometry do not examine how the relationship between variables/attributes are related to one another statistically. Social network scholars often refer to these analyses as *attribute analyses*.

To conduct structure-based analyses, an *adjacency matrix* can be used. Adjacency matrices show whether or not each entity is connected to other entities in the social network (Wasserman & Faust, 1994). The columns and the rows display the same ordering of social network entities (e.g., entity A, B, C, etc.). In the matrix, a value of "0" represents no social network connection between a given set of entities/goals and "1" represents the presence of a connection.

Table A2 illustrates a structure-based data matrix for the hiking example shown in Online Figures A4 or A5. This matrix shows how the social network members are linked to each other (as well as the goal in the last column). For simplicity, the data in each cell are first scored 0 if linkages are not present or 1 if linkages are present between the entities (or goal). If there are linkages, the specific coding of the roles and performance indicators are denoted after the equal sign. To interpret the direction of the linkages in the matrix, the row represents the "from" source and the column represents the "to" recipient. For example, the data in the first row and second column (i.e., $1 = S_1I_2O_{1(2)}$) represents the activated path from Hiker A (in the row) to Hiker B (in the column), which can be seen in Online Figures A4 or A5.

When data is structured in adjacency matrices, researchers can examine a variety of traditional sociometric statistics, such as centrality and density metrics. See Chapter 1 and the equations from Wasserman and Faust (1994) that illustrate the calculation of such metrics. The density and centrality statistics can be based entirely upon linkages between the social network entities; they do not need to include data from the last column of goal linkages (and system competency data). This focus is consistent with traditional sociometrics, which focus on the structure among entities in social networks. The last column of goal striver activations (and system competency level) is included in the adjacency matrix, because it allows researchers to create dynamic network charts from matrix data. Future research needs to examine the implications of including the goal linkages in sociometrics when describing the structure of dynamic network systems.

	Hiker A	Hiker B	Land Owner	Friend	Family Member	Weather Forecaster	Sheriff	Home Owner	Goal (and SCs)
Hiker A	---	1 = $S_1I_2O_{1(2)}$	0	1= $S_1I_1O_{1(1)}$	0	0	1= $I_{1(-1)}$	0	1= $G_{2(2)}$ (SC=0)
Hiker B	1 = $S_2I_2O_{2(2)}$	---	0	0	1= $R_1I_1O_{1(0)}$	0	0	0	1= $G_{1(3)}$ (SC=1)
Land Owner	0	0	---	0	1= $I_1O_{1(-1)}$	0	0	0	1= $G`_{1(-1)}$ (SC`=1)
Friend	1 = $S_2I_1O_{2(1)}$	1 = $S_{1(0)}$	0	---	0	0	0	0	0 (SC=1)
Family Member	0	1 = $S_1R`_2I_1O_{1(0)}$	1= $S`_1I_1O_{1(-1)}$	0	---	1= $O_{1(-1)}$	0	0	1 = $G`_{1(-1)}$ (SC=0)
Weather Forecaster	0	0	0	0	1= $S`_{1(-1)}$	---	0	0	0 (SC=0)
Sheriff	1 = $I_{1(-1)}$	0	0	0	0	0	---	0	0 (SC=0)
Home Owner	1 = $O_{2(0)}$	0	0	0	0	0	0	---	0 (SC=0)

Table A2. Adjacency data matrix for the hiking example. G = goal striver. S = system supporter. G` = goal preventer. S` = supportive resistor. R = system reactor. R` = system negator. I = interactant. O = observer. SC = system competency. SC` = system competency resistance. --- not applicable. Cell values are derived from linkages shown in Online Figure A4 or A5. The first data point in each cell indicates the overall absence (0) or presence (1) of any type of linkage between the given nodes. If the link is present, its exact characterization is shown after the equal sign. To interpret the direction of the linkages, the row represents the "from" source and the column represents the "to" recipient. For example, the data in row 1 and column 2 (i.e., "1 = $S_1I_2O_{1(2)}$") represents the activated path from Hiker A (in the row) directed toward Hiker B (in the column), which can be seen in Online Figure A4 or A5.

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