Social Network Analysis Applied to Language Planning in the Morehead District, Papua New Guinea

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SOCIAL NETWORK ANALYSIS APPLIED TO LANGUAGE PLANNING IN THE MOREHEAD DISTRICT, PAPUA NEW GUINEA

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ABSTRACT

Social network analysis is applied to three data sets collected from villages speaking languages of the Nambu Sub-Family in Papua New Guinea: reported speech similarity, bride exchanges, and basic vocabulary similarity. The bride exchange data led to substantially the same conclusions as the sociolinguistic data, supporting the proposition that sociolinguistic community structures are revealed in non-linguistic social data as well as they are in linguistic data. Furthermore, the proposition that the analysis of social networks will reveal groups of actors who will work well together in language development activities was supported by correspondence between this analysis and the activities of participants at the 2002 Morehead Alphabet Development Workshop. Additionally, analysis of the bride exchange data provided evidence, which the reported and measured linguistic data did not, that the Tonda Sub-Family of languages should also be included in a common language development program with the Nambu Sub-Family of languages. [In the interest of making this work available without further delay, no additional editing has been done. It has not been peer reviewed].
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CHAPTER 1
INTRODUCTION

With 300-400 languages possibly needing development in Papua New Guinea (PNG), programs that engage more than one language community at a time in the development of their languages may be a promising strategy for achieving the development of all of them in a timely manner. This raises the question of which languages may be grouped together in joint development programs. It may be better to group some sets of languages together than others, both for the harmony and efficiency of the working groups and for the quality and acceptability of their products.

Traditional linguistic survey techniques such as the collection and comparison of word lists and texts are helpful for defining language boundaries in terms of lexical and structural similarity. Furthermore, intelligibility testing (Casad 1974) provides an estimate of how well speakers of various dialects can understand one another so that language borders may be drawn around all communities who can understand a common speech form to a specified degree (Grimes 1995). However, intelligibility does not ensure that people will actually be willing to use a common literature, as Barbara Hollenbach (2002) points out:

In Oaxaca, Mexico, ethnic identity is very strongly with a town, rather than with a country, a region, or a language. Although neighboring towns are usually quite able to understand each other, language identity is not the point; ethnic identity is. Outsiders (such as SIL and the government) are interested in efficiency in producing literacy materials. However, the sociolinguistic hyperfragmentation that is a reality of contemporary Oaxaca transcends efficiency—it is the mark of
an Insider. This horizontal hostility (between indigenous towns) and vertical
dependence (on the dominant culture and its language) create major challenges
[for Outsider language developers] among the Mixtec.

I have observed similar language attitudes throughout PNG in the course of
cconducting sociolinguistic surveys of 29 language communities throughout the New
Guinea mainland and on New Britain Island over the last five years. Furthermore, none
of these measures helps reveal which speech communities are likely to be willing to work
together in a joint language development program. It appears that the social factors
involved in language development may be more important than the linguistic ones,
especially if one conceives of a language development program in which members of
different language communities join together in cooperative efforts for the mutual
development of all of their languages.

Steve Graham (2000:163) has suggested that “social network analysis may
warrant some consideration in the design and implementation of a language development
assessment strategy, as well as a structure for language development planning in
language contact situations.” I present, here, my explorations into how to apply social
network analysis to the problem of identifying groups of language communities who may
work well together in the joint development of their languages. This kind of study could
also prove useful in identifying the best approaches for implementing innovations of any
kind.

While I am aware that sociolinguists including William Labov, Lesley Milroy,
and others have proposed social networks as an explanation for various kinds of linguistic
variation, I take Stephen Murray’s (1993:161) criticism of their work, in particular, to heart as not being genuine social network analysis:

Instead of using continuous measures of network density or frequency of interaction to contrast networks or network clusters, sociolinguists have treated the networkness of individuals as a categorical variable, frequently with dichotomous values. They have contrasted the speech of locally un- or relatively under-affiliated individuals with that of those who are more affiliated with some (class or ethnic) category, and have exaggerated (even, in some cases, misrepresented) the differences between those categories.

I have sought to understand what social network analysis is, not just its application to language studies, and to apply it to the problem of identifying cohesive groupings of language communities and the central actors within those groupings.

Taking as my point of departure Graham’s (2000:159) suggestion that “the development of language development assessment which builds on the similarities between the acts of identity and social network analysis . . . could prove very helpful,” I begin the discussion with an explanation of Language, inspired by R. B. LePage and Andrée Tabouret-Keller (1985), which I believe shows why social network analysis is perhaps the most appropriate tool for its analysis.
CHAPTER 2

PHILOSOPHICAL MATTERS

2.1 The nature of Language

2.1.1 Languages do not have a life of their own

As a student of linguistics, I tend to think of languages as independent entities that have properties of their own that can be analyzed. Apparently, I am not alone in this supposition. The genetic model of languages, on which much historical-comparative linguistic analysis and linguistic classification is based, makes it easy to imagine that languages have a life of their own—that they are organisms that reproduce by division into two or more “daughter” languages. S. A. Wurm and Ken McElhanon (1975:146) attribute “considerable merit” to A. Pawley’s comments regarding “the fact that most linguists are reluctant to believe that extensively mixed languages might exist.” They (Wurm and McElhanon 1975:146) explain, “This is of course largely attributable to the fact that the genetic model does not allow for mixed languages which therefore constitute an unacceptable concept as such.”

However, my supposition is not strictly true. Although I may speak and act as if there were such an organism as a “language” that I could spread out on a lab table and dissect and analyze, in fact, no one can pull a language out of a specimen jar. Although sociolinguists write metaphorically about “language viability,” “language vitality,” and
even “language death,” a language does not have a life or consciousness of its own. I believe this metaphor is misleading.

Languages are simply codes by which people communicate with one another. Speaking, listening, gesturing, reading, writing, and otherwise signaling are all types of human behavior. In particular, “language” is social or relational behavior.

2.1.2 Languages carry both semantic and social significance

The field of sociolinguistics has grown out of the recognition that language use is a type of social behavior that, like all human behavior, is not entirely or precisely predictable. We each have our own unique way of using the language(s) which we use, and it is rare indeed that we conform completely to the standard form of our common code of communication, which we call “Language X” (e.g., “the English language,” “la langue française,” “Tok Pisin,” etc.). Not only does each person have unique things to say, but each finds a unique way to say them. Sociolinguists propose that the social situation in which a language is used is as important as the abstract, idealized, standard code in understanding what people say and, especially, in how they choose to say it. “All linguistic tokens [are] socially marked – that is, [they are] used by an individual because they are felt to have social as well as semantic meaning” (LePage and Tabouret-Keller 1985:247).

LePage and Tabouret-Keller propose that languages (and ethnic groups) only exist as abstractions in people’s minds. “For LePage it is essential to stress that groups or communities and the linguistic attributes of such groups have no existential locus other than in the minds of individuals” (1985:4). That is, each individual tends to divide up the
world or categorize people in his/her mind as belonging to certain groups to which he/she assigns stereotypical characteristics. These characteristics may include origin, location, occupation, interests, wealth, physical or “racial” features, age, sex, culture, and intelligence, among others, but they almost always include linguistic features as well.

We each understand the world slightly differently from one another, and we use language to express our view of both what the world is like and, implicitly, by how we choose to speak, how we want to fit into it.

Neither ‘race’ nor ‘ethnic group’ nor ‘language’ turns out to be a clearly-definable external object. Rather, each is a concept we form as individuals, and the extent to which, and the manner in which, we project our concepts on to those around us and establish networks of shared suppositions determines the nature of the groups in our society and their mode of operation (LePage and Tabouret-Keller 1985:247).

2.1.3 Languages are relational

2.1.3.1 We define our relationships with others by them

Using a cinematic metaphor, LePage and Tabouret-Keller (1985:14) regard each individual production of language as an “act of identity,” in which each individual is projecting his world view onto the mind(s) of his interlocutor(s) and inviting them to share it: “the concept . . . of linguistic behaviour as a series of acts of identity in which people reveal both their personal identity and their search for social roles.” As one receives positive feedback, indicating agreement with his worldview, his ideas and his projection of them become more focused. Negative feedback causes one’s concepts and language to become diffuse for a time, until modifications to his worldview and language bring them back into focus.
We see speech acts as acts of projection: the speaker is projecting his inner universe, implicitly with the invitation to others to share it, at least insofar as they recognize his language as an accurate symbolization of the world, and to share his attitude towards it. By verbalizing as he does, he is seeking to reinforce his models of the world, and hopes for acts of solidarity from those with whom he wishes to identify (LePage and Tabouret-Keller 1985:181).

Language is not our sole means of expressing our understanding of the world and our place in it. We also express ourselves through clothing, dining habits, and every other pattern of our behavior, but language is our means of self-expression par excellence.

Language however has the extra dimension in that we can symbolize in a coded way all the other concepts which we use to define ourselves and our society. It is true we do this unconsciously in our eating habits, more consciously perhaps in other rituals and practices. In language however we are offered, by the society we enter, and we offer to others, a very overt symbolization of ourselves and of our universe, not only in the various grammars and lexicons and prosodies we can create for various domains of that universe, but also through the social marking which each occasion of use carries. Language is . . . itself the focal centre of our acts of identity (LePage and Tabouret-Keller 1985:247-8).

Languages are not stable, static systems either. As one grows and learns more about the world his language also continues to change. “Positive and negative motivation to identify with groups . . . appears to be by far the most important of the constraints governing linguistic behaviour” (LePage and Tabouret-Keller 1985:184). As one is exposed to more groups and becomes motivated in some way to be like them, “one adopts the supposed rules of those groups one perceives to be socially desirable, to the extent that one wishes to be identified with them” (LePage and Tabouret-Keller 1985:184). William Foley (1986:8-9) gives this tendency (along with the rugged terrain) credit for the persistence of the amazing linguistic diversity of PNG:
Papuans have conflicting attitudes toward their languages, viewing language traits as trade items to be borrowed as one sees fit for reasons of prestige and novelty, but also as indispensable badges of a community’s unique identity. The inherent contradiction in these views results in languages converging toward each other only so far, and the remaining differences between them being accentuated. This simultaneous process of convergence and divergence results in a high linguistic diversity remaining intact, if not actually being increased.

As individuals change their identity and convince others to change theirs as well, they reshape their society. If LePage and Tabouret-Keller are correct in their views, then language is the primary means of social change.

2.1.3.2 We relate to others by them

Language, then, is perhaps the most social of all types of human behavior. Not only is each utterance a more or less implicit act of identity by which we establish our place in society—and even, as we find solidarity with other speakers, the very nature of our society—but the explicit function of language is to communicate with or relate to another person. Our linguistic behavior serves the explicit purpose of establishing links with other people. In fact, language is, in and of itself, a link between persons. Rather than one or several languages existing primarily as abstractions in our minds, language is primarily relational.

2.2 The nature of social network analysis

2.2.1 Different types of analysis for different types of data

Since language is primarily a form of social behavior, that is to say, it is primarily relational in function and in nature, then perhaps theoretical approaches which treat language as an independent object, or a controlling notion, or even as an attribute of one person, are not the best approaches for understanding the properties of communication or
the flow of information in general, of languages in particular, and how these are related to
one another. John Scott (1991, 2000), in his accessible introduction to social network
analysis, breaks social science data into three broad types—attribute, ideational, and
relational—and describes three different means of analysis, each of which is
appropriately applied to a different type of data. It is contrast between the first and third
of these that concerns me here.

2.2.1.1 Variable analysis

Attribute data, which describes properties of individual units of analysis—
whether they are persons, households, villages, ethnic groups, cities, nations, or
alliances—is appropriately analyzed by variable analysis. Variable analysis is by far the
most common type of analysis in the physical sciences and the social sciences as well. It
assumes that each unit has certain properties unto itself, independent of the properties of
other units. Examples include a person’s shoe size, gender, yearly income, or level of
education. In the social sciences, these may also consist of attitudes, opinions, or
behaviors, such as the number of people sharing a common dwelling, a people’s staple
food, the number of hours spent working per week, or a tendency to vote for a certain
political party. Hypotheses are formed about which variables (called independent) have
what effects on which other variables (the dependent ones). For example, one might
hypothesize that average household size is inversely proportional to average yearly
income or that a nation’s political structure depends on the staple food of its people.
Populations are delineated, and tests are then performed on randomly chosen samples of
the population. Based on the assumption of the independence of the properties of each
unit, powerful inferences can be made about causes and effects using probabilistic
statistics.

2.2.1.2 Network analysis

“Relational data, on the other hand, are the contacts, ties and connections, the
group attachments and meetings, which relate one agent to another and so cannot be
reduced to the properties of the individual agents themselves. Relations are not the
properties of agents, but of systems of agents” (Scott 1991:3). “The relationship between
a pair of units is a property of the pair and not inherently a characteristic of the individual
unit” (Wassermann and Faust 1994:8). For example, in a marketplace, people act as
buyers and sellers. Each sale must involve both a buyer and a seller. One cannot sell
something unless someone else is buying it, and vice versa; so the sale is a relationship
between the two parties. Furthermore, “seller” and “buyer” are not properties inherent to
particular actors. Roles are determined by which side of a particular transaction an actor
is on, and the same actors may switch roles from one sale to the next.

Methods of analysis which assume the independence of units or actors, or which
even see the individuals as the units to be analyzed, are inappropriate for the analysis of
relational data. Rather, what is needed are methods for analyzing the relations or links
between actors, the kinds and properties of the structures they result in, and the
implications these have for how these systems function. This is precisely what social
network analysis is about. “The unit of analysis in network analysis is not the individual,
but an entity consisting of a collection of individuals and the linkages among them”
(Wassermann and Faust 1994:5).
The fundamental difference between a social network explanation and a non-network explanation of a process is the inclusion of concepts and information on relationships among units in a study. Theoretical concepts are relational, pertinent data are relational, and critical tests use distributions of relational properties (Wassermann and Faust 1994:6).

“Both statistical and descriptive uses of network analysis are distinct from more standard social science analysis and require concepts and analytic procedures that are different from traditional statistics and data analysis” (Wassermann and Faust 1994:5). In social network analysis, actors and their actions are viewed as interdependent, rather than independent; relational ties (or links) are seen as channels for transfer (or flow) of resources, both material and informational; and network structures are understood as providing opportunities and constraints on action. Structures, whether they be social, economic, political, or of other types, are conceptualized as lasting patterns of relations.

Rather than thinking about how an actor’s ties with other actors describes the attributes of “ego,” network analysts instead see the structure of connections, within which the actor is embedded. Actors are described by their relations, not by their attributes. And the relations themselves are just as fundamental as the actors they connect (Hanneman 2001:3).

2.2.2 Philosophical stances of social network analysts

2.2.2.1 Structures constrain the individual

There is disagreement in the literature as to how strict and deterministic the constraints and opportunities upon the actors in a social network are. Barry Wellman and S. D. Berkowitz are self-proclaimed “structuralists” who, in the tradition established by Lévi-Strauss, take their departure from the assumption that social structures determine to a great extent what can and will happen at both the micro-level of individual people and the macro-level of societies. They define structuralism as a “scholarly movement away
from the Aristotleian-Linnean [sic] tradition of analyzing things in terms of the intrinsic characteristics of their individual parts” (Wellman and Berkowitz 1988:4-5). They decry sociologists who use individualistic analyses, proclaiming, “Their analyses treat persons as automata, moving like compass needles, in response to internalized norms,” and they further point out, “Such analyses, which are based upon an inferred vocabulary of motives, can detect social structure only indirectly” (1988:3). Of the authors included in their anthology, they say,

Unlike some network analysts they do not assume that the world is rife with voluntarily chosen, symmetrical relations. Instead, they are primarily concerned with how relationships structure resource allocation under conditions of scarcity and how these often asymmetrical relationships concatenate into complex, hierarchical and quasi-hierarchical networks of power and dependency (Wellman and Berkowitz 1988:6).

They also acknowledge, “The underlying assumption of their analyses is that norms and values are byproducts of structural changes, not their source” (Wellman and Berkowitz 1988:10). Their enthusiasm for social network analysis should come as no surprise since it allows the direct observation and analysis of social structures.

2.2.2.2 Individuals create communities

Graham (2000:132), on the other hand, sees social network analysis as a response, advanced by the anthropologist Clyde Mitchell, to the structural functional, deterministic view of Emile Durkheim. His thinking falls more in line with LePage and Tabouret-Keller’s acts of identity.

The introduction of the social network concept resulted in the notion that individuals create communities, and Mitchell (1986) suggests that they do so to create a meaningful framework for solving the problems of everyday existence. This is quite a change from the structural functional view in which the individual
was viewed simply as a constituent of a class that sustained a coglike function in the structure of a society (Graham 2000:132).

### 2.2.2.3 Structure and individuals affect each other

Edward Laumann, Peter Marsden, and David Prensky (1983:18) take a less extreme tack than Wellman and Berkowitz, “From a network perspective, individual behavior is viewed as at least partially contingent on the nature of an actor’s social relationships to certain key others. Likewise, the outcomes of events are seen to be partially dependent on the presence of a specific network configuration.”

Duncan Watts observes that many social network analysts treat social networks as static systems and levels this criticism at them:

Instead of thinking of networks as entities that evolve under the influence of social forces, network analysts have tended to treat them effectively as the frozen embodiment of those forces. And instead of regarding networks as merely the conduits through which influence propagates according to its own rules, the networks themselves were taken as a direct representation of influence. In this way of thinking, the network structure, regarded as a static set of metrics, is thought to manifest all the information about social structure that is relevant to the behavior of individuals and their ability to influence the behavior of the system (Watts 2003:50).

He argues that the result of an event in a network depends not only on the structure of the network, but also on what was going on in the network when that event began, which he refers to as the “dynamics on the network.” He contrasts this with the “dynamics of the network,” which is the fact that social network structures themselves are constantly changing as the actors in them make new ties and break old ones (Watts 2003:54-55). Watts calls for a paradigm shift in order to take both kinds of network dynamics into account. “Networks are dynamic objects not just because things happen in networked
systems, but because the networks themselves are evolving and changing in time, driven by the activities or decisions of [the actors in them]” (Watts 2003:28).

2.2.3 Social network analysis focuses on relations

Regardless of the differences in their underlying philosophical assumptions, all social network analysts agree that it is the regularities or patterns in relations between individuals that give rise to structures rather than any particular properties of the individuals themselves. “Whether the model employed seeks to understand individual action in the context of structured relationships, or studies structures directly, network analysis operationalizes structures in terms of linkages among units” (Wassermann and Faust 1994:6).

Robert Hanneman (2001:3) highlights two main emphases of social network analysis. The first is to see how an actor is located or “embedded” in the overall network. The second is to see “how the whole pattern of individual choices gives rise to more holistic patterns.” Mark Granovetter (1973:1360) expands on this second emphasis, explaining that social network analysis can link sociological observations and theories about micro-level (small group) interactions to the macro-level phenomena observed such as social mobility, community organization, and political structure. It is my hope that, as Graham (2000:159) has suggested, it can also help explain language shift and the spread of linguistic innovations. It seems to me that social network analysis can probably explain a lot about the diffusion of innovations in general.
CHAPTER 3
PRACTICAL MATTERS: HOW TO DO SOCIAL NETWORK ANALYSIS


3.1 The basic building blocks

A social network has two basic elements: the “actors” or “nodes,” and the “relations” or “links” or “ties” between them (Hanneman 2001:4).

3.1.1 Actors

The “actors” in a social network are those units that are capable of relating to one another. Individual persons, households, clans, villages, language communities, nations, and alliances could all be considered actors in a social network. In studying American economic networks, the actors might be corporations or sub-divisions or sections or employees. When diagramming a social network, the actors are represented as points in the diagram and the term “node” is borrowed from mathematics and physics to refer to them.

As the preceding lists imply, social network analysis can be applied at many different tiers of society. Each of these different tiers of actors is said to be a different “mode” of the network, and each actor in one mode (e.g., a village) might actually consists of an entire network in another mode (e.g., persons). So, one mode of a social
network can be thought of as being nested in successively higher modes (Hanneman 2001:6). It is important to identify the mode of a network one wishes to analyze.

3.1.2 Relations

According to Hanneman (2001:10), the relations or links or ties between actors may be considered to fall into one of two broad domains: exchange or flow of material, and exchange or flow of information. The basic distinction between these two types of flow is that material, such as cars, people, or money, is “conserved” in that it can only be counted in one place at any given time, whereas information is “non-conserved” in that it can exist in more than one place at a time. (If you share your knowledge, you don’t end up with less knowledge than you started with.) Two villages can have relations which fall into either of these domains. For example, intermarriage would be a material link while sharing news would be an information link.

Relations may be either undirected, such as “is a sibling of,” or directed, such as “gives orders to” or “borrows money from.” On a diagram of a social network referred to as a “sociogram” (see fig. 1), introduced to the public by Jacob Moreno in the 1930s (Scott 1991:10), the actors are usually represented as points and the links are represented as lines between the points. Sociograms are also referred to as “graphs” due to the influence of graph theory (a field of mathematics) upon social network analysis (Scott 2000:13). A sociogram is a very handy way to visualize the relationships that exist and can quickly give one an intuitive sense of the nature of the social structures being studied. If the links are directed, there will be arrowheads at either end of the lines, indicating the direction of flow of material or information (e.g., CB in fig. 1). A line with arrowheads
on both ends (e.g., BD) would represent a reciprocal relation. All undirected links are also reciprocal.

Figure 1. A directed sociogram

3.2 Relational concepts

3.2.1 Paths

A “path” is any series of links and nodes (as long as each is used no more than once) between two actors (Hanneman 2001:48). In figure 1, ABDEG, ADEG, and AEG are all paths from A to G. The number of links in the shortest path(s) between two actors is called the “geodesic distance” between them, by analogy to the shortest distance between any two points on any given geometric surface. The geodesic distance from A
to G in figure 1 is 2. It is often assumed in social network analysis logarithms that actors will choose a geodesic path (AEG, in this case) to pass something to another actor (Hanneman 2001:50).

In some cases, it makes sense to ignore the directionality of the links in a network. Any path that includes a link going the wrong direction is referred to as a “semi-path” (Hanneman 2001:48). In figure 1, there are two paths of length 2 from D to A, DBA and DEA, and the geodesic distance from D to A is 2. However, if the analysis allows semi-paths, then the geodesic distance from D to A drops to 1, since the link DA is a semi-path from D to A.

3.2.2 The adjacency matrix

A social network may also be represented as a matrix. When using variable analysis, due to its focus on the attributes of various actors, a researcher will often study his data in a table where each subject, or actor, has his own row and his attributes are listed under relevant column headings. In social network analysis, the actors are listed as both the row and the column headings of an “adjacency matrix” (see table 1). The links may then be symbolized, in the simplest case, as “1s” at the intersection of actors who share a link, showing that they are socially adjacent to one another. A “0” symbolizes the absence of a link between the two actors whose row and column intersect at that point (Hanneman 2001:27). If the relations symbolized are undirected or reciprocal, the matrix will be symmetric. If, however, the relations are directed, the link will appear as a “1” in the row of the sending or originating actor and the column of the receiving or targeted actor. For example, the link from C to B in figure 1 appears as a “1” in C’s row
B’s column (the position (C,B)) in table 1; however, since B does not reciprocate this link back to C, there is a “0” at (B,C), making the matrix asymmetric. In contrast, the reciprocal link AB appears as a “1” at both (A,B) and (B,A) in table 1.

Table 1. Adjacency matrix for figure 1

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Once an adjacency matrix is constructed, the properties of the network, and especially the way things flow through it, may be studied using matrix algebra. A matrix representation of a social network also enables analysts to use a variety of algorithms and computer programs to study different properties of the network.\(^1\) This makes it feasible to analyze much larger and more complex networks than those that may be reliably analyzed with a pencil and paper.

In addition to the binary links just described, links may be nominal, signed, ordinal (ranked), or interval (scaled). However, “the most powerful insights of network

\(^1\) Scott (2000: 178) recommends Borgatti, Everett, and Freeman’s UCINET as “the best of the currently available programs and the one that is most accessible for the novice user.”
analysis, and many of the mathematical and graphical tools used by network analysts were developed for simple graphs (i.e., binary, undirected)” (Hanneman 2001:14). Accordingly, social network analysts often reduce higher order data to binary data, dichotomizing it by choosing a threshold above which the links are said to exist and below which they are said not to. I do so with ordinal data in section 6.3 and interval data in sections 6.4 and 6.5.

3.2.3 Neighborhoods

An actor’s “neighborhood” consists of all of the other actors to whom he is adjacent (i.e., with whom he has direct links) (Hanneman 2001:47). The actor in focus is referred to as “ego,” and all other actors are referred to as “alters” (Hanneman 2001:24). In figure 2, if we choose B as ego, then A, C, and D are the alters in B’s neighborhood.

Figure 2. The neighborhood of B
3.2.4 Multiplexity

When several different links exist between two actors, their relationship is said to be “multiplex.” For example, two men might be friends, neighbors, colleagues, and cousins all at the same time. Hanneman (2001:10) identifies some of the methods for including consideration of multiplexity in network analysis as network correlation, multidimensional scaling and clustering, and role algebras, but he also says these are not as well developed as the methodologies for working with single relations.

Another way to account for multiplexity in a network is to consider it a type of tie strength between actors. Laumann et al. (1983:31-32) however, caution against simply summing the number of ties between actors and drawing conclusions about the centrality or power of an actor on this basis. The summation of different types of ties may not have any substantive meaning (i.e., one may be adding apples and oranges). They claim it is more appropriate to analyze the entire network as defined by a single tie, then repeat the analysis for each tie of interest, and then draw conclusions based on the correspondence between the various layers of networks that the actors are involved in. When different relations are substantively summable, however, Scott (see section 3.7.2) suggests a means of considering multiplexity in a single analysis.

3.3 Network boundary definition

The validity of many of the conclusions that may be drawn from social network analysis depends upon the assumption that the network is well defined—that is, that the boundaries of the network are clear, and that all of the links that exist are specified (Wasserman and Faust 1994:8). Laumann et al. (1983:19) contend that “carelessness in
system specification is probably a more serious issue for network analysis than for much survey analysis,” and that misspecification of system boundaries in network analysis will cause “a fundamental misrepresentation of the process under study.”

According to Laumann et al., the boundaries of a social network may be defined by fixing one of three basic foci: one or more of the actors’ attributes (e.g., membership in some club); the actors’ relations to other actors in the network (i.e., “snowball sampling,” in which the network is “built up” of all of the actors related to some ego, plus all of the actors related to them, etc.); or the actors’ participation in some activity (e.g., attendance at a meeting). In order to avoid circular reasoning, it is important to state explicitly how the network boundaries were defined. Defining a network as all of the actors who share a certain attribute makes the discovery that all of the actors in the network share that attribute meaningless. If one defines a network by the attributes of the actors, then it is the relations between them and their participation in activities that are free to vary. For example, the fact that all Milne Bay language groups reside in Milne Bay Province is not news, but the fact that three of them intermarry and four attend each other’s church conferences is. If one defines a network as those actors who participate in an event, then their attributes and the relations between them are the things about which one may draw empirical conclusions. (Their geographic locations and whether their children attend the same school are reasonable questions to ask of all the language groups who attend a certain church conference.) If the boundaries of a network are defined relationally, then it is the attributes of the actors and their patterns of participation in activities that may be investigated empirically (Laumann et al. 1983:22-3).
There are a number of network studies, though, in which it is the identification of
the network boundary itself that seems to be in focus. The boundaries may be defined
either according to the presumed viewpoint of the actors themselves—the “realist”
approach—or according to the analyst’s conceptual framework—the “nominalist”
approach. In the nominalist approach, the investigator proposes a boundary based on his
theory and then observes a social network to see how well his conceptual boundary
corresponds to the actors’ subjective awareness of a boundary (Laumann et al. 1983:20-2).

Much SIL language survey work has focused on defining the boundaries of
language groups. Social network analysis focuses on discovering connections, mapping
them, and analyzing them. In a relationally defined network, all actors who are
connected to one another are members of the network. The boundary of such a network
occurs where there are no more connections, or, less strictly, where there is a drop in the
density of connections. To use social network analysis to discover the boundaries of
language groups, individual speakers, or possibly homogenous villages, would be
considered the nodes, and particular linguistic features would be considered the links
(Graham 2000:155).

Almost invariably in Papua New Guinea, speakers of a particular speech variety
are well aware of one or several linguistic features, whether they be phonological,
morphological or lexical, which serve as markers of group identity. It should be
relatively easy to construct short lists of such glosses with which to investigate who uses
these features. One could then gather this linguistic data, plot it as a sociogram in which the links represent co-use of linguistic features, and compare this sociogram to another sociogram showing the naming links between villages reported by the same actors as belonging to their group. Data on the correspondence, or lack thereof, of Papua New Guineans’ actual linguistic behavior and their own reported linguistic boundaries could prove useful to the field of dialectology. The use of recognized identity markers by those not reported to be in the group could signal relatively high prestige for the in-group—since these outsiders are apparently seeking to identify with the group—and possible language shift of other groups towards their speech variety. A certain group of individuals who use the markers of more than one language group could reveal an overlap of language or dialect boundaries.

It could prove useful, as well, to investigate what other links (such as common land ownership) also correspond to these linguistic feature links, as this may reveal motivations for the desire to identify with and maintain the identity of a particular group. Graham (2000:155) suggests that “as modernity and mobility chip away at the distinctions in the multiplex sets of nonlinguistic variables [such as clothing, food, religion, rituals, ceremonies, and music, which serve to identify a group], the linguistic variables may end up carrying a heavier load in maintaining and signaling network identity.” In other words, a group’s language may be the last feature that distinguishes it from other groups.

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2 This is, in fact, a common practice in dialectology.
On the other hand, it is also clearly true that ethnic identity is not inseparable from linguistic identity. LePage and Tabouret-Keller (1985:233) observe that “historical, political, and economic factors seem to be more important than racial or linguistic factors in the choice of one’s ethnic identity.” One example of this from PNG is that each of the Turumsa, Bainapi, and Dibiyaso people, who live to the north of the Aramia River in Western Province (see fig. 3), knows which group he belongs to, although their lifestyles and customs are identical and the Turumsa and Bainapi have abandoned their own languages to speak Dibiyaso (Rueck et al. 2005). As an illustration from closer to home, my own mother, although she does not speak Low German, still considers herself of Mennonite ethnicity, as, to some extent, do I.

Figure 3. Languages of the Aramia, Wawoi, and Guavi Rivers (Rueck et al. 2005)
Linguistic features can also be used to identify sub-groups within a broader language group, as has been demonstrated by Labov (1966, 1968) and others. LePage and Tabouret-Keller (1985:184) point out that even in highly-focused, monolingual communities there are always linguistic changes in progress, and it is possible for individuals to adopt them or not in order to identify or distance themselves from whatever groups they perceive to exist. One might hypothesize that those individuals whose linguistic innovations spread throughout the group are those who are becoming community leaders. Gillian Sankoff (1980:10-17) describes control and emphasis of linguistic group markers as important to achieving status in PNG.

New Guineans often make use of other-language and other-dialect knowledge in rhetoric and verbal art . . . highlighting the known differences between their own and neighboring speech varieties. . . . Big men must know when to speak in public . . . how to harangue and convince an audience, how to hold the floor . . . how to use allusion and metaphor . . . . The system has been described as a highly competitive one involving considerable rivalry among actual and potential big men.

3.4 Density of the network

Once the actors and the links within a specified boundary have been identified, one can begin the structural analysis proper of the network and make predictions both about how the network, as a whole, will respond to various stimuli (the macro view), and about the opportunities and constraints which the network presents to the actors within it (the micro view).

One of the more obvious things that one notices when looking at either the sociogram or the adjacency matrix of a social network is its “density.” Mitchell coined this term to describe the “completeness” of the network, or the extent to which all
possible connections are present (Scott 1991:32). When looking at a sociogram, a dense network will be filled with links (see fig. 4). Likewise, the adjacency matrix of a dense network will consist mainly of “1s,” with few “0s.”

(Hanneman 2001:35,52) claims that networks with high overall density are likely to be robust, egalitarian, and able to respond quickly and effectively to new stimuli. He reasons that a high number of connections within the network means that most actors will have more than one path by which to communicate efficiently with most other actors, and thus, the flow is unlikely to break down even if one actor is missing or unable or unwilling to pass along the message, because the message can still get through via other links and nodes. This makes it difficult for any one actor to be a power broker because the other actors can find other paths to work around him. Also, the flow is likely to reach
every node in the network quickly. Thus, an innovation may spread through a dense network very quickly.

Conversely, “networks that have few or weak connections, or where some actors are connected only by pathways of great length may display low solidarity, a tendency to fall apart, slow response to stimuli, and the like” (Hanneman 2001:35). Innovations will flow through a low-density network slowly, if at all.

Typically, though, some actors in a network will have lots of connections while others will have fewer. “Differences in connections can tell us a good bit about the stratification order of social groups” (Hanneman 2001:37). “Populations with greater diversity in individual densities may be more likely to develop stable social differentiation and stratification” (2001:57). In other words, populations that have greater diversity in the number of connections between actors are likely to develop a hierarchy and a class structure.

These predictions regarding the inverse relationship between social stratification and openness to change do seem consistent with my general observations of language groups during three years in Niger and five years in Papua New Guinea. I observed that most groups in Niger were hierarchical, with well-defined, stable classes. These groups tended to be very resistant to change. Most Papua New Guinean cultures, by contrast, are egalitarian. Papua New Guineans are quick to adopt technological innovations but tend to be very resistant to inequality. Australians, who share a similar egalitarian ideal, refer to this as the “tall poppy syndrome.” Anyone who sticks out above the rest of the group is soon cut back down to a more uniform size. It is relatively rare to find monolinguals in
Papua New Guinea, at least among the adults. My impression is that a large majority of Papua New Guineans learn to speak a trade language to some extent—making language shift (sociolinguistic change) possible.

### 3.5 Degree of individual actors

“The number and kinds of ties that actors have are keys to determining how much their embeddedness in the network constrains their behavior, and the range of opportunities, influence, and power that they have” (Hanneman 2001:40). If a network has directed links, an actor can both receive “in-ties” and send “out-ties.” In an adjacency matrix, in-ties appear in an actor’s column and out-ties appear in his row. The sum or mean of an actor’s row is referred to as his “out-degree,” while the sum or mean of his column is referred to as his “in-degree.”

Hanneman (2001:43) writes that actors with either few or many out-ties are more predictable in their behavior than those with “some” ties.

An actor with a high in-degree, such as B or D in figure 5, is referred to as a “sink.” Sinks are often said to be prominent or prestigious. If the relations in a network show an information flow, to the extent that knowledge is power, a sink may also be regarded as powerful (Hanneman 2001:43). Thus, the adoption of an innovation, such as literacy, by a sink, whether that node represents an individual, a village, or an entire language group, is likely to increase the motivation of the other actors in the network, at least those a short distance from the sink, to also adopt the innovation.

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3 Using the mean rather than the sum allows one to make comparisons between networks of different sizes.
An actor with a high out-degree, such as E in figure 5, is referred to as a “source.” Sources tend to be influential. One might say that sources provide other actors with an opportunity to adopt an innovation. An actor who is sending out more information than he is receiving, though, might actually be an outsider who is trying to wield influence; he may, however, be clueless as to what is going on in the network (Hanneman 2001:43-44).

Actors who are high in both sending and receiving information are likely to be the “facilitators” in the system (Hanneman 2001:43-4). These are the actors who have the best capabilities to spread news and innovations throughout the network.

3.6 Centrality and power

The “centrality” and “power” of any given actor within a social network are topics of obvious interest to network analysts, especially to those with a more deterministic philosophy. One might say that centrality and power are the essence of politics. They have to do with how influence may be wielded within the network. Centrality and power

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**Figure 5. Sociogram and adjacency matrix**

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within a network are closely related but not necessarily equal concepts. Hanneman (2001:60) says that network analysis provides the insight that social power is inherently relational; “An individual does not have power in the abstract, they have power because they can dominate others—ego’s power is alter’s dependence, and vice versa.”

Hanneman (2001:63) describes several different types of centrality, or ways of conceptualizing and measuring an actor’s centrality. The first, and most simple, is “degree centrality.” An actor with a higher degree has direct connections to more other actors. Thus he has more ways to receive things and more ways to distribute them than other actors. In figure 5, E has the highest degree centrality (6). In the theoretical maximally centralized network, known as a “star network” (see fig. 6), the central actor has reciprocal ties with all alters and none of the alters have any other ties. Actor A is the “star” of the network shown in figure 6.

Figure 6. A star network
Thus, the star actor has an in-degree and an out-degree of \(N-1\), where \(N\) is the total number of actors in the network, and the rest of the actors have in-degrees and out-degrees of \(1\) (Hanneman 2001:61). The fact that the star has connections to all of the other actors makes him the most central, but it is the fact that the others have no connections between them that gives him a monopoly on power, because they are all dependent on him and him alone. Even if some of the alters had other connections between each other, the central actor would still have the most power, both because he is able to influence the most other actors and because he is the least dependent on any given alter.

“Closeness centrality” views the actor that is the “closest” to the most other actors as the most central to the network. In this view, the most central actor has the shortest total path to, or is able to pass a message via the least intermediate steps to, all the other actors in the network. The closer one actor is to another, the more likely he is to be able to influence him. So, closeness centrality can also be viewed as a type of power (Hanneman 2001:46). One actually describes closeness centrality, though, as the inverse of “farness.” This is because it is easy to measure an actor’s global farness as the sum of his geodesic distances to all other actors (2001:65). One may construct the geodesic distances matrix for a small network by counting the links in its sociogram. Table 2 is the geodesic distances matrix for the network shown in figures 1, 2, and 5. The sum of
each actor’s geodesic distances, in the right column of table 2, shows that E has the highest closeness centrality (the lowest global farness) in this network.\(^4\)

### Table 2. Geodesic distances for the sociogram in figure 5

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At the upper limit of closeness centrality (the star network), one actor would have direct links to all other actors in the network. In small, dense networks, degree centrality and closeness centrality are likely to be very similar; but as the network size increases, these two measures may diverge simply because there is a limit to the number of relationships an individual can maintain (Hanneman 2001:66). While there may be some practical limit to an actor’s degree, being linked to others who are well connected will make him closer to the rest of the network than the same number of links to random others would. While degree centrality measures the size of ego’s neighborhood, closeness centrality is a gauge of his overall distance from the entire network.

\(^4\) This conveniently ignores the fact that C is actually unreachable by any other actor in this network.
“Betweenness centrality” is a measure of how frequently an actor falls on the geodesic paths between all other actors (Hanneman 2001:67). The most central actor is between the most pairs of alters. Inasmuch as alters depend on ego to connect them with other alters, ego’s betweenness also increases his power (Hanneman 2001:62). Often however, there are other paths by which alters can communicate even without ego’s cooperation, although they may be less efficient. In the example network (see fig. 5), it is E who has the highest betweenness because removing E from the network isolates both F and G. Removing B isolates only C. Removing any other actor does not result in any isolates.

Hanneman (2001:72) credits Bonacich with pointing out that centrality is not necessarily equal to power. Being connected to well connected actors makes you more central, but at the same time, less crucial to your neighbors. Having less well connected neighbors, though, means they are more dependent on you; and you, therefore, are less central but more powerful.

It seems to me that if one hopes to disseminate an innovation, such as a new idea or practice (e.g., vernacular literacy), throughout an entire network as efficiently as possible, so that all actors have the opportunity to adopt the innovation as soon as possible, it would be wise to target the more central actors first.

Marlene Burkhardt and Daniel Brass (1990:104) found, in their longitudinal study of the introduction of technological change (personal computers) to a network (a federal agency), that those who were quick to adopt the change increased their centrality and then their power within the network. Thus, the introduction of a technological innovation
resulted in a change in the network structure, with the early adopters gaining power. Whether they occupied positions of power or were more peripheral before the change, the early adopters of the change ended up in more central and powerful positions after the change. Since those in positions of power tend to work to maintain and build their power, a change agent is likely to see less resistance to the change if he manages to help the powerful adopt the change early in the process, or at the least, lets them take credit for the decision that the network would adopt the change (Burkhardt and Brass 1990:120). Thus, social network analysis has shown that it is efficacious and efficient for a change agent to work in cooperation with those in positions of authority, and has provided some tools to help identify who those powerful actors are.

3.7 Sub-groups

The equation ‘a race = a culture = a language’ is quite patently misleading, both in terms of real biological criteria and in terms of popular stereotypes. One has only to think of linguistic communities such as those who speak English, or French, or Spanish, to see that the linguistic and ethnic boundaries are far from isomorphous. Nevertheless, linguistic nationism is a very common political phenomenon (LePage and Tabouret-Keller 1985:234-5).

Before the advent of “instant” global communication abilities near the end of the 20th century, it was easier to view ethnic or racial or language groups as basically independent entities that multiplied mainly by division, analogously to biological reproduction, although occasionally borrowing selected bits from their neighbors. LePage and Tabouret-Keller (1985:232) state, however,

We view the history of man as a history of more or less continual migration in response to ecological pressures, so that cultural and ethnic ‘focussing’ and ‘re-focussing’ have taken place from time to time rather as eddies and whirlpools form as features of flowing water, affected by geography and the nature of contact between different streams. New streams are formed out of tributaries; new
cultures, new ethnic loyalties, are formed out of the human tides; cultures and civilizations flourish and collapse; ‘racial’ identities change.

This suggests that it may be more appropriate to seek to identify racial or ethnic or language groups by studying the relationships between them than by studying their individual attributes.

The decomposition of networks into cohesive sub-groups has been a focus of social network analysis since the 1930s (Scott 1991:16). Wellman and Berkowitz (1988:8) claim, a bit dramatically, that network analysis has successfully documented the existence of communities in contemporary societies even “given the buffeting of capitalism, industrialization, and urbanization.” Thus, social network analysis should help us to identify significant groupings of actors (such as language communities) even in what, at first glance, appears to be a hopelessly complicated jumble of people and cultures in a high language contact situation. Although LePage and Tabouret-Keller (1985:180) find limited success with it, they write, “The concepts behind cluster-analysis do seem to provide a useful analogue for what is going on in a community as people speak to each other.”

It is not only the identity of sub-groups, but also their sizes and densities, the ways in which they overlap or fail to overlap, and an actor’s position relative to the various sub-groups that concern social network analysts. All of these structural features have implications for both the behavior of the network as a whole and the behavior of individual actors. Networks in which sub-groups overlap may be less likely to have conflicts between the sub-groups than those with little overlap between sub-groups. Where sub-groups don’t overlap, traits and innovations may not diffuse from one sub-
group to another. An individual’s ties may all be within a single sub-group, or he may act as a bridge between sub-groups, or he may be relatively isolated within the network (Hanneman 2001:77).

There are a variety of ways to mathematically describe, and therefore, to discover sub-groups. I will describe several of these here.

### 3.7.1 Top-down approaches

If one has defined a network with either an attribute or activity focus, rather than relationally, then it is possible that not all of the actors have a path of ties to all of the other actors. A “component” is defined as a group in which all of the actors are connected—that is, there is at least one path of links from any member of a component to any other member of the component. A component is also referred to as a “maximally connected sub-graph.” It is “maximal” in that all of the nodes which are connected to it are considered members of it (Scott 1991:104). A component, then, is the same as a relationally defined network. A node that is not part of a component is referred to as an “isolate.” Figure 7 shows a network containing three components and three isolates.
It is straightforward to visualize the components of a graph with undirected links because, since all connections are reciprocal, any connection to the component will create a path from every node in the component to all of the other nodes in the component. Components in undirected graphs may be called “simple components” (Scott 2000:104).

In a directed graph, however, it is possible that a one-way link may cause some portion of the graph to act as a sink or a source to the rest of the graph with no possibility of reciprocation. These portions of a directed graph cannot be considered members of a component by the definition above; so, those nodes that cannot both send to and receive from the rest of the component are excluded and the remainder may be referred to as a “strong component,” as shown in figure 8 (Scott 2000:103). However, since the mere presence of a relationship, regardless of its direction, may be assumed to allow some possibility for communication between nodes, one may simply ignore the directionality of the lines that make up the paths in a directed graph and, thus, identify its “weak
components” (Scott 2000:104). A weak component in a directed graph is the same as a simple component in an undirected graph, and so the same algorithms may be used to find them both (Scott 2000:104).

![Figure 8. Strong and weak components](image)

Within a component, one may identify nested sub-groupings of increasing density. Scott (1991:113) credits Seidman (1983) with the concept of the “$k$-core.” “A $k$-core is a maximal sub-graph in which each point is adjacent to at least $k$ other points: all the points within the $k$-core have a degree greater than or equal to $k$” with respect to the rest of the $k$-core (not with respect to the entire component). Since an actor only needs a single link to join a $1k$-core, every simple component, or the whole of the graph
in figure 9, is a 1k-core. F, with just 1 link, drops off at the 2k level, and the rest of the graph is a 2k-core. At the 3k level, G drops off, leaving E with only 2 links, and so E must drop off too. This leaves ABCD as the 3k-core in figure 9.

3.7.2 Bottom-up approaches

Thus far, I have described top-down approaches to identifying sub-groups, starting from the entire network and then looking for areas of greater density within it. However, one can also take a bottom-up approach, starting from a single actor and expanding to see what nested groups he is a part of. The term “clique” has been used in
various ways by network analysts, but the strongest and most widely accepted definition is that of the “maximal complete sub-graph.” “A **clique** is a sub-set of points in which every possible pair of points is directly connected by a line” (Scott 1991:117). While a ‘component’ is maximal and connected (all points are connected to one another through paths), a ‘clique’ is maximal and complete (all points are adjacent to one another)” (Scott 1991:118). ABD and ADE are both cliques in the network shown in figure 10.

**Figure 10. Cliques in an undirected sociogram**

Clique are the densest possible social structures. Inasmuch as people influence one another’s behavior, cliques are a strong structure for the enforcement of group norms.
As Lesley Milroy (1980:136) points out, “It is now agreed . . . that dense, multiplex networks act as norm enforcement mechanisms.” So, cliques may be thought of as those subgroups that can exert the maximum possible social pressure for their members to conform. This pressure can be applied in either a conservative sense, such that cliques are resistant to change, or an innovative sense, such that an innovation will spread very quickly throughout a clique.

Since such tightly knit groups are uncommon in real social networks (for example, in figure 11, the lack of reciprocity in the link AD means that neither ABD nor ADE are cliques according to the strongest definition), various means of relaxing the definition have been used. The simplest means in a directed graph, suggested by Scott (2000:115), is to ignore the direction of the links, which yields “weak cliques,” analogous to the weak components described above. These are also referred to as “semi-cliques” since they are defined with semi-paths. In figure 11, ABD and ADE could be considered weak cliques.
Another idea, called an “$n$-clique,” is to expand the acceptable path-length to $n$. So, each member of an $n$-clique is connected to each other member by a path of length $n$ or less (Scott 1991:118). In figure 11, ABDE is a 2-clique. In figure 12, there are three overlapping 2-cliques: ABCD, ABDE, and ADEFG. Figure 12 also contains two overlapping 3-cliques: ABCDE and ABDEFG.
Hanneman (2001:82) points out that $n$-cliques can get long and stringy. Scott (1991:119-20) argues that values of 3 or greater for $n$, are very difficult to interpret sociologically and, besides, are no longer close linkages, so one should only use values of 1 or 2 for $n$.

Another way to relax the definition of the clique, proposed by Seidman and Foster (1978), is to maintain the requirement of direct connections between the members, but to allow members to be connected to all but $k$ of the members. They refer to this as a “$k$-plex.” More formally, in a $k$-plex which contains $n$ members, each member is connected to $n - k$ other members. Since there are, by definition, only $n - 1$ other members to

![Figure 12. 2-cliques in an undirected graph](image-url)
connect to, a 1-plex is the same as a clique. As the value of \( k \) increases, a \( k \)-plex becomes a looser grouping. Hanneman (2001:84-5) points out that searching for \( k \)-plexes usually finds a large number of small and overlapping groupings. For example, there are eight 2-plexes in figure 13: ABC, ABDE, AEF, AEG, BCD, DEF, DEG, and EFG. However, seven of them have only three members, which means that each of their members need only have \( 3 - 2 = 1 \) link into the group. Since this is not a dense sub-group at all, Scott (2000:118) suggests \( k \)-plexes should be at least \( k + 2 \) in size. Such a constraint leaves just one 2-plex in figure 13: ABDE.

Figure 13. 2-plexes in an undirected graph
Returning to the concept of the $k$-core from a bottom-up perspective, we may think of it as a maximal group of actors, all of whom are connected to $k$ other members of the group. Hanneman (2001:85) observes that $k$-cores are usually more inclusive than $k$-plexes. He also notes that, as opposed to $k$-plexes, with $k$-cores, as $k$ becomes smaller the group size increases. While the identity of a $k$-plex depends on the immersion of its members, the identity of a $k$-core depends on the connection of its members (Hanneman 2001:85).

Scott (1991:115-6) expands the concept of the $k$-core, which is applied to single-relation graphs, and therefore, necessarily focuses on the degree of each actor, to the “$m$-core,” which is applied to multiplex graphs. “An $m$-core can be defined as a maximal sub-graph in which each line has a multiplicity greater than or equal to $m$.” To put this into familiar linguistic terms, we could consider speech varieties to be actors in a network and each item of the Swadesh 100-item word list to be a potential link between them. Thus, the maximum possible multiplexity of a link would be 100, and this would be realized when every item in one variety had a cognate in a second variety. Adapting Swadesh’s (1954:326) thresholds for linguistic classification to this terminology, the members of an $81m$-core would be considered to be dialects of one language, the members of a $36m$-core would be considered to belong to the same language family, and the members of a $12m$-core would be considered to belong to the same linguistic stock.

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5 Graham (2001) uses such lexical items as links between individuals representing 29 networks of speakers of West African, Portuguese-based creoles, although his analysis does not utilize the concept of the $m$-core.
“Cluster analysis” groups together those actors who are more similar or closer to one another in a network. This similarity might be defined either in terms of attributes of the actors or in terms of their relationships (Scott 1991:129). Once the dimension of interest has been chosen, either an agglomerative (bottom-up) approach or a divisive (top-down) approach may be used to reveal clusters of similar nodes. In agglomerative approaches, such hierarchical clustering, the two most similar or closest nodes are grouped together first, and then the next two most similar or closest nodes are grouped together, and so on (Scott 1991:132). The number of clusters found depends on how many steps of agglomeration one takes (Scott 1991:131), or alternatively, upon the threshold of similarity or closeness that one sets. In divisive approaches, the network is first viewed as a whole and then actors are divided into two groups based on the measure of the attribute or relation of interest. Each of these groups is then divided again, and the process continues until the analyst judges that the significant sub-groupings have been found (Scott 1991:133). Divisive clustering approaches may be thought of as searching for rifts within a network (Hanneman 2001:85). Cluster analysis seems to me to have more to do with identifying actors who are similar to one another, and thereby occupy a certain social role, than with identifying sub-groups. That is to say, it appears to be a way to identify actors who function similarly rather than actors who function together. Since I am more concerned with finding actors who function together, I shall give cluster analysis no further attention here.
CHAPTER 4

PROPOSALS REGARDING THE IDENTIFICATION OF MULTI-LANGUAGE DEVELOPMENT CLUSTERS

I now discuss the social significance of each of the types of subgroups I have described in chapter 3 and consider which of them seems the most likely to identify suitable groups for the implementation of coordinated language development programs.

Lesley Milroy (1980:136-7), citing Mayer and Boissevain among others, writes, “It is now agreed that density and multiplexity usually go together, and that dense, multiplex networks act as norm enforcement mechanisms.” Cliques, with a density of 100 percent (i.e., every actor relates to every other actor), are, therefore, also likely to be multiplex subgroups. It follows that cliques should be the subgroups the most capable of enforcing norms. If this is true in an innovative as well as a conservative sense (i.e., if it holds whether the norm is something new or the established practice), then cliques are likely to either reject or embrace and innovation such as language development as a whole unit rather than individually. Any clique might adopt the motto of the Three Musketeers: “All for one, one for all.”

N-cliques, which emphasize attachment to a subgroup by secondary, tertiary, or n-ary links may indicate those alters to whom actors are most likely to turn first when searching for an innovation. In his 1970 study of the links used in finding a new job, Granovetter (1973:1372) found that 39.1% of links used to successfully locate a new job were first-order ties and 45.3% were second-order ties. If this tendency holds in
searching for any means of improving one’s situation in general, then 2-cliques should reveal the most likely links for their central members to use when searching for innovations. Perhaps $n$-cliques would be useful subgroups to investigate when a language group indicates an interest in language development. Of the other language groups in the area that are or have been involved in language development, the 2-clique should reveal which of these the interested language group would be the most likely to cooperate with or learn from.

Taking his cue from the repeated comment of new jobholders in his 1970 study that they had learned of their new job opportunity from an acquaintance rather than a friend, Granovetter (1973:1372) proposed that innovations are effectively spread between dense sub-groups (and throughout a broader society) via “weak” ties. He defined tie strength for interpersonal ties as “a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie,” and limited his discussion to positive, symmetric (reciprocal) ties for simplicity’s sake (Granovetter 1973:1361). In other words, he proposed that it is via links of acquaintanceship rather than via links of close friendship that innovations spread throughout an entire society. In a subsequent article, Granovetter (1982:129) reported that in a number of empirical studies, his argument had “been useful in clarifying and explaining a variety of phenomena, ranging from effects of social relations on individuals to the diffusion of ideas and innovations to the organization of large-scale social systems.” He also reported that the results of the studies that had set out to
systematically test his argument were “very encouraging but not conclusive” (Granovetter 1982:129-30).

Granovetter’s argument may also be stated, at least partially, as: it is the weak ties that serve as bridges between more cohesive sub-groups. He (Granovetter 1973:1373) suggests that these weak ties may be formed and maintained through occasional meetings at conferences and conventions. Applied to language development efforts, Granovetter’s argument suggests that language development may be encouraged to spread between cohesive subgroups by the attendance of key leaders from a variety of subgroups at conferences or conventions. Hosting such meetings periodically may be a powerful means for language development agencies to facilitate the spread of language development between different language groups.

Granovetter (1982:122-3) also quotes Karweit, Hansell, and Ricks as writing that institutions, such as schools, are more likely to succeed at promoting the formation of weak ties than strong ties between members of insular groups. This should have some bearing on the way that multi-language language development training sessions and workshops are organized.

*K*-plexes, which emphasize immersion in a subgroup, seem, to me, to have the same, basic norm-enforcing quality of cliques, although not to quite the same extent. The immersive quality of a *k*-plex depends not only on the value of *k*, but also on the size of the *k*-plex. By definition, each member of a *k*-plex has ties to all except *k* actors in the *k*-plex. If we let *n* represent the size of the *k*-plex, then each of its members has *n* – *k* ties to its other members. Therefore, a 1-plex is the same as a clique, since there are only *n* – 1
other members to have links with. So, lower values of $k$ mean that the $k$-plex more closely approaches a clique. However, since in a 2-plex each member has ties to $n-2$ other members, letting $n$ be 3 would mean that its members are only connected by a single link, which would not indicate immersion. In a 4-member 2-plex, each actor has links to 2 others, but this is still not a high level of immersion. Scott (2000:118) gives a rule of thumb that the minimum size of $k$-plexes should be $k+2$. On the presupposition that social pressure is proportional to the level of social immersion, I propose that when searching for $k$-plexes with a high enough level of immersion to function as norm-enforcement mechanisms, one should search for sub-groups no smaller than $k+3$ in size.

$K$-cores, which are determined by a threshold of mutual connectedness, seem, to me, to be sub-groups with a good balance between the opportunities to find innovations and the social pressure to maintain group norms. Thus, given the problem of identifying sets of PNG language groups which would work well together in multi-language development projects, I propose that $k$-cores, particularly those with a $k$ value of 4 or higher, are good targets to shoot for. Coincidentally, among the sub-groups discussed here, $k$-cores are also one of the easier types to identify.

I further propose that “closeness” is the best of the centrality measures presented here for identifying the actor from which an innovation could most efficiently spread throughout the entire network. Although the actor with the highest degree (number of direct links) in a network might be able to pass an innovation along directly to the most other actors, it may turn out that these are not the first steps in the most efficient paths to reach the entire network. “Betweenness” indicates those actors one should not offend.
CHAPTER 5
APPLICATION TO PAPUA NEW GUINEA DATA

5.1 The actors

To apply social network analysis to the problem of choosing a Papua New Guinean speech variety in which to begin a language development program, it probably makes the most sense to choose villages as the nodes of a network. One might also think that “language groups” should be the nodes, where a language group would include all of those villages that speak the same language. This, of course, begs a definition for “a language,” which could be specified as all those forms of speech that are similar enough that their speakers can all understand a common dialect. “Understand” could then be defined as the ability to achieve a certain score on an aural comprehension test. However, this ignores the issue of whether all of these villages are willing to share a common identity as speakers of “Language X,” which LePage and Tabouret-Keller (1985) have argued is the very essence of why people choose to speak as they do. Taking this into account results in a definition such as “all those villages that claim to speak the same language and can understand a common form of that language.” In PNG, this often turns out to be a surprisingly small number of villages since, historically, each village may have considered all other villages as enemies. “The fact that linguistic differentiation exists even on the level of neighboring villages speaking the same ‘dialect’ has been
pointed to in several studies of disparate [New Guinean] geographical areas and language groups” (Sankoff 1980:9).

It has proven difficult for sociolinguists to agree on a definition for “speech community,” but Ralph Fasold (1990:62) writes, “most ethnographers would agree that it refers to a group of people who share the same rules and patterns for what to say, and when and how to say it.” William Labov (1968) took “New Yorkers” to be a speech community, and demonstrated that although people’s pronunciation of certain phonemes reflected their social class, they agreed on which was the prestigious pronunciation. John Gumperz (1968:463) defines “linguistic community” as “a social group which may be either monolingual or multilingual, held together by frequency of social interaction patterns and set off from the surrounding areas by weaknesses in the lines of communication.” Such a definition, focusing on interaction, actually requires the use of social network analysis in order to identify a linguistic community. In this case, it appears that the village is a good unit to choose as an actor in a sociolinguistic network that will reveal PNG linguistic communities, whether or not these correspond to groups of villages speaking the same language.

If villages or individual people were taken to be the actors in a network, social network analysis could help to identify dialects and language groups. To an extent, SIL’s current survey procedures for identifying dialects and language groups are not inconsistent with a social network perspective. When surveyors arrive in a village and ask for the group consensus about which other villages speak their language or which other villages’ speech they find easy to understand, they are using what social network
analysts refer to as the nomination technique of identifying a social network. They could easily construct a sociogram or an adjacency matrix of all of the villages visited and named, with each instance of naming represented as a directed link or a “1” in the row of the naming village and the column of the village named. To obtain complete network data of this type, they would need to be sure to visit every village named and ask the same questions there. Each time a village was named, its in-degree would increase by one, and the degree centrality of any given village could be calculated. For that matter, any of the other kinds of centrality discussed in section 3.6 could be calculated, and interpretations made about which villages were the most powerful or prestigious.

Surveyors could also identify cliques of villages reported to use the same speech form, which might be interpreted as dialect groupings. The overall density of such a network might indicate the degree of solidarity or factionalism within the language group.

Equivalency finding techniques not discussed in this paper could also be used to discover if there were certain villages that played similar roles in different sub-groups. All of these techniques could provide valuable clues about which villages to focus language development efforts on.

As mentioned above and demonstrated by Graham (2001), items on a word list could be viewed as potential links between villages. We might also ask people to specify the particular linguistic markers that identify their language and treat these markers as

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6 Reciprocal naming was the network identification technique used by Labov in his study of inner-city gangs and later by Cheshire in her study of truant adolescents (Graham 2000:151). It was the concept of degree centrality which Cheshire used to reveal the structure of the network she studied: “the most frequently named individuals were identified as the central members of a social network, the less named individuals as peripheral members of the social network” (Graham 2000:152).
links between villages. Measurements of the level of aural intelligibility between villages could also be viewed as links in a social network. So, applying some of the techniques of social network analysis to data currently being collected by SIL sociolinguistic surveys might reveal new insights into the boundaries and internal structures of each language group, yielding valuable clues about which villages are most important to work in within a single language group.

5.2 Proposed significant ties

Perhaps the most critical question in setting up this analysis is that of which inter-group relationships to model in this social network. Common geographical boundaries could be seen as links between language groups, but this would not reveal anything more than existing language maps.

The reciprocal naming method of identifying networks would simply be to ask representatives of language groups to name the other groups that they relate to, or wish to relate to, on any of a variety of bases. This, of course, would require a lot of traveling to gather the data. Hanneman (2001:8) suggests that snowball sampling (in which a network is built up relationally starting from a single actor) is likely to locate at least the strongest ties and, therefore, the boundaries of the most significant grouping in which one starts the ball rolling. It seems important to learn what Papua New Guineans perceive to be the most important inter-group ties and then learn how to discover their existence. In other words, analysts need to learn which questions to ask.

The links elicited by each question or category of questions would reveal a different network. Each of these networks could be analyzed separately and then
observations made of where the results of each analysis (in terms of sub-grouping and centrality) correspond or complement each other, like multiple overlays on a map.

Alternatively, the responses to all of the relation-eliciting questions could be modeled as one multiplex network. Hanneman (2001:139) credits Kapferer with the suggestion that multiplexity can be considered a type of tie strength. A simple way of incorporating this idea would be to count the number of different types of ties between each pair of nodes and assign each link a strength of that number. To simplify the analysis, these links could then be reduced to binary data based on a threshold level chosen at the discretion of the analyst (Hanneman 2001:14). However, some types of ties are probably more significant than others, and it may be difficult to arrive at a reasonable means of adequately representing the relative strength of each type of tie.

Since I am thinking particularly about the application of social network analysis to the problem of language development cluster identification in PNG, I propose that questions about intermarriage, trade, common customs, church hierarchy, educational system hierarchy, government hierarchy, and traditional enemies are likely to elicit significant inter-group links in PNG. Other topics may prove to be more useful as network generators in other countries.

5.2.1 Intermarriage

Kinship is the most ancient and basic tie known to mankind. One is naturally inclined to protect one’s offspring, and so the giving of them in marriage to another group has been a custom used throughout the ages to solidify alliances between groups. Thus, intermarriage ties are a natural link between groups, and they are not very difficult to
investigate. They are a standard item on the SIL-PNG sociolinguistic survey questionnaires. While some groups seem a bit hesitant to respond, they all produce a list of at least a few out-group members who have married into their village and a few in-group members who have married outside the group and moved away. Counting the number of spouses exchanged between groups in either direction reveals scaled, directed inter-group links.

LePage and Tabouret-Keller (1985:218-9) claim that groups are more willing to acknowledge intermarriage with other groups of equal or higher status. This is a handy way of learning about the relative prestige of the language groups in the area, as the number of outsider spouses acknowledged is likely to be greater with groups of higher status. It is also likely that the outsider spouses from the higher status groups will be the first to be acknowledged.

5.2.2 Trade

Many language groups in Papua New Guinea have traditional trading alliances with other groups. One of most famous of these is the Kula trade, which consists of a ring of reciprocal trading relationships that encompasses the archipelagoes off of the eastern tip of New Guinea and a few villages on the mainland (Malinowski 1922). Annual voyages are made between these islands in which mwali ‘shell armbands’ are carried counter-clockwise and soulava or bagi ‘shell necklaces’ are carried clockwise between trading partners. The annual Hiri voyages of the Motuans from the vicinity of Port Moresby, in which they would bring clay pots up the coast of the Gulf of Papua to trade for sago are another example. The Dibiyaso, of Western Province (see fig. 3),
informed the survey team that they used to trade bows and arrows, tree wax, sago, and
bird of paradise feathers to the Gogodala in exchange for fish, and then later, clothes and
other goods from the outside world (Rueck et al. 2005). The Dima, of Collingwood Bay,
would trade wallaby meat to the Maisin for clay pots (Rueck and Jore 2001). Such
economic exchanges are commonly studied by social network analysts, and the trading
patterns of PNG peoples should provide fertile ground for research of this type.

Local markets provide another opportunity to observe trading links between
peoples. To get some estimate of the actual economic ties in a local market, we could
also ask people if there are more buyers or sellers from certain other groups, or one could
observe market transactions throughout a day. In October, 2005, I observed that the
Malinguat women, of the Middle Sepik region, carried betel nut and mustard, sago, and
garden produce south to a weekly market where they traded these with the Iatmul
women, of the Sepik River, for fish.

Links representing the supply of manufactured goods would emanate from towns,
which would most likely be represented as nodes of the regional trade language.

Another link related to trade might be called a hospitality link. If a language
group’s territory is further than a single day’s journey from the nearest town, its members
are likely to habitually spend the night in certain villages between their own territory and
the town.

Another economic tie would be from a language group to some local industry,
such as a logging company or mine or plantation. Such an industry might be represented
as a node which speaks the trade language of the area. An alternative view would be to
represent the industry as a type of link between the groups which provide labor to or receive benefits from the industry.

5.2.3 Common customs

Some language groups share the same cultural customs as other groups. These are sometimes celebrated together. The Dibiyaso, Bainapi, and Turumsa, peoples, living north of the Aramia River, in Western Province (see fig. 3), reported that they all shared the same customary practices, such as initiation rites, between themselves and with their neighbors, the Doso and Kamula peoples (Rueck et al. 2005). This should be represented as a link between groups.

The exchange of *singsings* ‘traditional dances’ could also be represented as links between different PNG villages.

5.2.4 Church hierarchy

Likewise, there are usually formal church hierarchies that could also be represented as links in a social network. Various congregations (villages) could be linked under the authority of one priest or circuit president. Different denominations would have different patterns of ties in an area. Some denominations would probably show strong links to gatherings in towns, which should probably be represented as Tok Pisin-speaking nodes, or possibly as English-speaking nodes in the southern provinces.

What is probably more significant in a social network than the ecclesiastical hierarchy is attendance of various congregations at other congregations’ celebrations. For example, in Catholic and Anglican areas, each chapel is named for a saint and each day of the year is designated a certain saint’s day. The main significance of this in Papua
New Guinea seems to be that each congregation hosts a large celebration on the day of the saint to whom their chapel is dedicated. Attending such a celebration or other denominational gatherings could be considered a link between villages in a social network.

5.2.5 Educational system hierarchy

The PNG National Education System provides another set of links between language groups. Each village or group of villages with a sufficient population of children is encouraged by the national education policy to establish elementary schools in the vernacular (of their choice) in order to facilitate the acquisition of literacy during the first three years of schooling (Patton 2000:12). All villages that send their children to a given elementary school would thus, have a link to one another. In most rural settings, these elementary schools would serve a single language group, in the vernacular. However, in order to continue their schooling, children from the smaller villages must travel to larger villages, which may not speak the same vernacular, to attend a primary school, which is taught in English. This would be represented in a social network as a link from each student’s village to the village where the primary school is located. Those students who pass the grade 8 examinations would then attend high school in yet another location, where it’s almost certain that another language will be spoken.

5.2.6 Government hierarchy

We may also discover formal political ties between groups by observing the official government hierarchy. The lowest government body in Papua New Guinea is the Local Level Government (LLG). Each province in PNG is divided into districts and
wards. Ward boundaries tend to be drawn along ethnic lines, although this is not always the case. Each ward has a Council (man) who is seated on the LLG. Villages within a ward may be represented as having links to the village where the Council lives. The Council’s village would then be linked to the LLG Office, which is likely to be in a town. These links represent the distribution of government funding.

5.2.7 Traditional enemies or allies

Language groups or villages that were traditionally enemies might be considered to have a negative link between them. Conversely, if long-term alliances were discovered, they could be modeled as positive links.

Some of the links I have just suggested studying will probably be unstable. In fact, people are always making new ties of various kinds and breaking old ones. It seems to me that it would be wise to plan long-term development programs based on analysis of what appear to be the most stable links discernable in a network.
CHAPTER 6
CASE STUDY: NAMBU LANGUAGE SUB-FAMILY, WESTERN PROVINCE

6.1 The East Morehead District

The languages of the Nambu Language Sub-Family are spoken in a portion of the East Morehead District of Western Province, which is located in the Trans-Fly region of Papua New Guinea (see fig. 14). The Trans-Fly is all of that area south of the lower Fly River over to the Indonesian border. The East Morehead District includes the area east of the Morehead River and west of the Mai Kussa River, from the coast of the Torres Strait in the south as far north as the watershed of the tributaries to the Fly River (Williams 1936:27). The area consists of sparsely populated, low-lying, flat, relatively open forest interspersed with patches of savannah. There were about 3120 people inhabiting this area of approximately 7000 square km (2750 sq. mi.) at the time of the 2000 Census (NSO 2002). Most of the area is flooded during the rainy season, from December through April, making travel difficult until the water recedes to the riverbeds during the dry season, except for in the lagoons near the coast. Another travel hazard is the abundance of snakes in the area, including the highly venomous death adder and black snake. Crocodiles also infest the Morehead River and are said to travel “considerable distances inland from the river-banks” (Williams 1936:2-8). Wild game, including cassowary and deer, are plentiful, as well as fish, and the people of the area are taller than most Papuans due, presumably, to their relatively high protein diet. Yams are the primary crop in the
Figure 14. Morehead River area, Papua New Guinea (Pyykkonen 2006)
Morehead region, supplemented with cassava, sago, and bananas (Allen et al. 2002).

The peoples of the Morehead District were headhunters until their pacification in the early 1900s. Williams (1936:25-26,262-87) describes the practice in detail as it had been carried out in 1928, but he also explains that the peoples of the East Morehead District were relatively peaceable and content, being more often the victims of such raids by the Tugeri (Marind) from across the Indonesian border and the Suki, inhabiting the south bank of the Fly River, than the perpetrators. I was told in Mari village in 2003 that the last instance of headhunting or cannibalism in the area occurred in the 1970s.

According to S. A. Wurm (1971:116), Sidney Ray, F. E. Williams (1936), and Arthur Capell all made some attempts at classifying the languages of the Trans-Fly area. In 1968, C. L. Voorhoeve (1968:9) tentatively claimed, on the basis of Riley and Rays’ (1930) wordlists from the coast of this area, that Peremka (spoken “west of the Morehead River” (Riley and Ray 1930:174)), Dorro (spoken in Mari), and Parb (spoken in Iaugoa, on Strachan Island, near the mouth of the Mai Kussa River), were three languages forming one language family, which he called the Morehead River Group.

Wurm (1971:116), in 1966, collected linguistic materials in the Wabuda, Southern Kiwai, Gidra, Bine, Gizrra, and Agöb languages, spoken from Wabuda Island, in the mouth of the Fly River, south to Daru, and west along the coast to the mouth of the Mai Kussa River. Then, in 1970, he collected more extensive materials in these languages and Aturu, Tirio, Idi, Nambu, and Tonda (i.e., from the mouth of the Fly River westwards to the Indonesian border). Wurm (1971:152) subsequently reclassified Nambu (spoken in Mibini, Garaita, Setavi, Mata, Saraina, Pangarakı, Gubam, Keru, Derideri, Arufi, and
Tais), Iauga, and Dorro as languages of the Nambu Sub-Family. This corresponds to Williams’s (1936:29) “Language Area II,” between the Mai Kussa and Morehead Rivers. Williams (1936:37) writes, “The people of Language Area II are fairly homogeneous in culture and may be regarded as one people, the Keraki.” The Nambu, Tonda (west of Nambu), Yey (north of Tonda), and Moraori (further west, in Indonesia) sub-families, constitute the Morehead and Upper Maro Rivers Family in Wurm’s classification, which is that displayed in the Language Atlas of the Pacific Area (Wurm and Hattori 1981).

John Clifton, Geoff Dyall, and Paul O’Rear resurveyed the same area in 1991, and their analysis verified many of Wurm’s findings, although they called into question the high degree of relatedness between languages he reported, and they identified additional languages and dialects. Concerning the Nambu Sub-Family, which is the focus of this case study, Clifton et al. (1991) reclassified the speech form of Bimadeben as belonging to the Nambu Sub-Family rather than the Pahoturi R. Family, as claimed by Wurm (1971:149), citing their calculated cognate percentages of 79 percent between Bimadeben and Gubam versus 12 percent between Bimadeben and Dimisisi. They found the Nambu Sub-Family to consist of a chain of six speech varieties, with the relationship between each link and the next being on the border between dialects and separate languages (i.e., around 80%). The separation of just the speech of Mari as a separate language appeared arbitrary to them. Furthermore, they found that the village of Iauga, previously occupied by about 25 people reported to speak the Parb language (Wurm 1971:152), no longer existed. It is not clear that any researcher had visited Iauga since Riley, prior to 1930.
In May, 2002, Marco and Alma Boevé coordinated an Alphabet Development Workshop (ADW) in Morehead Station in order to “develop trial orthographies for all languages/dialects of the Nambu Subfamily,” and to produce educational materials for the local elementary schools using these alphabets. Such workshops serve the national education policy of PNG, which aims to establish elementary schools throughout the country that will provide the first three years of instruction in the vernacular of the community’s choice (Patton 2000:12). ADW staffs encourage as many communities as possible to develop a common orthography and literature so that the materials produced will serve as wide an audience as possible. The Nambu Sub-Family peoples insisted on producing separate alphabets and literature for each of the speech varieties shown in table 3. However, the Nambo and Namna participants were willing to work together under one mentor, and the Nama and Namat groups worked together under another mentor. The language map drawn up during the ADW is presented as figure 15.

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<thead>
<tr>
<th>Language/Dialect</th>
<th>Villages</th>
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<td>Nama</td>
<td>Ngaraita, Mata, Daraia</td>
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<td>Namat</td>
<td>Mibini</td>
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<td>Nambo</td>
<td>Arufe, Gubam, Bebdeben</td>
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<td>Namna</td>
<td>Pongariki, Derideri</td>
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<td>Namo</td>
<td>Tais, Mari</td>
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<td>Neme</td>
<td>Keru, Mitere</td>
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<td>Nen</td>
<td>Bimadeben</td>
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Source: Boevé (2002a)
Figure 15. Language/dialect map from Morehead Alphabet Development Workshop II (Boevé 2002b)
6.2 Survey objectives

From the 4th to the 18th of June 2003, I led a language survey team in conducting a sociolinguistic survey of the languages in the Nambu Language Sub-Family, spoken in the East Morehead District under the auspices of SIL International. The purposes of the survey were to clarify the sociolinguistic situation, including verification of language identification and boundaries, to determine whether there was need for language development programs in the Nambu Sub-Family languages, and, if so, to suggest a strategy for meeting those needs, including identification of the best language(s) for allocation of SIL personnel, if appropriate. I demonstrate here that social network analysis helps to fulfill each of these purposes, but especially those of suggesting a language development strategy and the best location in the sociolinguistic landscape at which to initiate such a strategy.

6.3 Reported speech similarity

The most common means of collecting social network data is to ask a set of actors (whether by questionnaire or in interviews) which other actors they relate to in a particular way (Wasserman & Faust 1994:45). Since such interviews are a standard part of sociolinguistic surveys, the data gathered thereby can be submitted to social network analysis.

In each village we visited, during group interviews, we asked in which other villages the people spoke the same language, using a series of questions. The first question, “Which villages speak just like you?,” identified villages speaking the same dialect. The second question, “Which villages speak your language, but differently?,”
identified villages speaking other dialects of the same language. These were then
differentiated by ease of understanding with the third question, “Are some dialects hard
to understand?,” and similar follow-up questions. The data are presented as four levels of
reported dialect similarity in the adjacency matrix in table 4. Because the focus of the
survey was the Nambu Language Sub-Family, we collected data in at least one village of
every dialect (or possibly language) reported by Clifton et al. (1991) or Boevé (2002b).

Table 4. Adjacency matrix of speech similarities as reported by
Nambu Language Sub-Family villages

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Notes: 4 = speak the same; 3 = speak similarly; 2 = speak same
language differently, but understandably; 1 = speak same language,
but very difficult to understand; 0 = not mentioned; nd = no data
(questions not posed).

Figure 16 (in which the relative positions of some villages have been adjusted for
the sake of clarity) shows which villages claimed which other villages as speaking “the
same.” At this highest level of speech similarity, the Nambu Sub-Family consists of at
least three separate components and three isolates. However, note the asymmetry in the reporting. In the cases of Daraia, Bebdeben, and Tais, this is unavoidable, because we did not collect any data in those villages. (In Pongariki, we verified only that they claimed Derideri spoke the same as them.) However, note that Mata does not claim Ngaraita as speaking the same speech form, and, especially, that neither Ngaraita nor Tais reciprocate Mibini’s claim. If only reciprocated similarity claims are included (excepting the villages not visited), then Mibini and Tais also become isolates. So, there are between six and eight different speech forms within the Nambu Language Sub-Family.

Figure 16. Villages reported to speak “the same”
Figure 17 adds the links representing “similar” speech forms to those in figure 16. At this level of perceived similarity, all of the villages are joined into a single connected component if non-reciprocated links are included. If a mutual claim to speak similarly were required, however, Keru and Bimadeben would still be isolates at this level of reported similarity.

Figure 17. Villages reported to speak “similar” speech forms
The node sizes in figure 17 represent membership in $k$-cores of increasing connectivity. Keru and Bimadeben are claimed to speak similarly by only 2 other villages. Mari, Tais, and Mibini fall within a $3k$-core, indicating that they each have 3 similarity claims with a denser core of the network. Bebdeben and Daraia are located within the $4k$-core. At the heart of this sub-family, Ngaraita, Mata, Pongariki, Arufe, Derideri, and Gubam form the densest core of reported linguistic similarity.

In figure 18, one sees all claims to intelligibility of speech forms within the Nambu Language Sub-Family. The overall density of this network, not including the potential ties that we failed to ask about, is 64 percent, indicating a fairly high level of agreement that people from these villages all speak either dialects of a single language or languages which are similar enough to be intelligible at some level.
Figure 18. Villages reported to speak “understandably”

The $7k$-core (a clique, in this case) indicated by the largest nodes of figure 18, reveals those villages with the highest number of linguistic intelligibility claims, in either direction. Daraia, Keru, Pongariki, and Bimadeben join this core at the $5k$ level. I suspect that Daraia and Pongariki may have been part of the $7k$-core if we had collected data from them, but the inclusion of Tais (where we also did not collect data) in the denser core leaves some doubt about this. Likewise, Bebdeben received only 4 claims of similarity, but had no opportunity to make other claims. Nevertheless, it is clear that Keru and Bimadeben are less connected to this sub-family by speech similarity claims...
than any other villages in which we collected data. Each of them acts as a sink in this network rather than a facilitator. While each of them receives 5 claims, Keru reciprocates only 1 of them, and this is at the weakest possible level, reporting that it is “very difficult” to understand people from Gubam (Tucker et al. 2003:31). Bimadeben “could not name any villages that spoke anything similar to their language” (Tucker et al. 2003:31). From a language planning perspective, this indicates that, while the rest of the Nambu Language Sub-Family might be willing and able to use a common literature, it is unlikely that Keru and Bimadeben would be willing to use it.

6.4 Bride exchange network data

Marco Boevé, who has lived amongst the neighboring Arammba language group for several years and was a part of this survey team, informed us that the custom of exchanging brides between villages is a key to the social structure of this region. In many regions of Papua New Guinea, a groom must pay a “brideprice” to the family of the bride in exchange for his bride. In the Morehead River area, the traditional brideprice is that a young woman from the groom’s village must be given to a young man from the bride’s village in exchange. F. E. Williams (1936:166-8) verifies the importance of this practice, explaining it as follows.

Among the Keraki (and indeed throughout the Morehead district) exchange is the normal way of negotiating marriage, and . . . practically speaking there are no exceptions. The exchange may be effected simultaneously, or it may be deferred; but in the latter event the debt, girl for girl, is eventually squared. Not only do we see on the one side a demand that the contract be honoured, but on the other side a marked scrupulousness about honouring it. For a girl is expected and compelled to abide by it: in the event of desertion even her own group will disregard her sentiments and take no exception to the severest methods of discipline. It is plain
that the fulfilment of exchange is regarded as of great importance. . . . It is as if exchange were idealized, made an end in itself. . . .

There are many examples of such exchanges in primitive culture. In Papua we are familiar with the exchanges of large quantities of food between one group and another. They occur, without economic justification, in every culture of which I have any knowledge. We could cite the interchange of ornaments on the *Kula* trading route;\(^7\) or, as a striking example, the interchange of pigs in the *Soi* festival of the south coast, where men undertake long journeys in order to engage in what is, at least from the economic viewpoint, a senseless swapping of live animals.\(^8\)

Now I would submit that all these exchanges possess one important function in common. They serve to bring the groups concerned into closer connexion with one another; they establish relations and confirm them. The same function may be said to belong to exchanges between individuals, from those of primitive culture up to the veritable *potlach* of Christmas presents in our own. The gift, then, with the insistence on reciprocal return, is a means of cementing the relations between individuals or groups; it forestalls hostility and commits them to some sort of fellowship. The gift is a gesture of friendship; the return of the gift is a sign of acceptance. Exchanges in general help people to get on together.

Pursuing this argument I suggest that the exchange of girls in marriage falls into line with these other exchanges. The unmarried girl is, so to speak, the supreme gift. The insistence on reciprocity is the same, and the transaction serves the same purpose, that of binding the contracting groups together in a bond of mutual restraint and fellowship. We have seen that groups united by marriage acknowledge this bond; that they maintain it by reciprocal services, and that the norm of conduct between them is one of respect and goodwill.

This system was still in place in 1991, as witnessed by Paul O’Rear (1993:17).

Regarding marriage, there seems to be a very strong system of sister exchange in the whole Trans-Fly region and extending along the coast of the Gulf of Papua. In order for a man to marry, he must have a sister to offer in exchange for his bride. If he has no sisters either in his immediate or extended family, he cannot marry. We were told that this is the primary reason for the low population of the area. It is quite common for there to be old single men who have never married. It sometimes occurs that a man marries someone not according to the customs, but then he and his family have to pay heavy penalties for this to family of the bride. This can include surrendering their child (I am not sure if this means only the first

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\(^7\) B. Malinowski, *Argonauts of the Western Pacific.*

born female) to the bride’s family, and other forms of payment. As far as could be observed, there did not seem to be any penalty for marrying anyone from outside of the region. The problem with this type of marriage, of course, is that one has to go a long way to find a bride, and then has the possibility of having to pay some sort of bride price.

Since this was reportedly a “key” relationship to understanding the social structure of the region, in each village we visited, we asked which other villages they exchanged brides with. Since this bride exchange data is amenable to social network analysis, I now examine the East Morehead District social network consisting of villages as actors with the exchange of brides as valued, directed ties between them.

The exchange of brides between villages anywhere near the local scene is depicted in the sociogram in figure 19. The sociogram is laid out with villages as the nodes in approximately their relative geographical positions, moved slightly for the sake of legibility. The villages in which we gathered bride exchange data are represented by circles, while other villages that they reported exchanging brides with are represented by squares. The thickness of the lines is proportional to the greater of the number of brides sent in either direction between two villages, from 1 to “10 or more.” The same data is presented as an adjacency matrix in table 5.

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9 The few brides from far away towns, such as Port Moresby, Popondetta, Rabaul, and Buka Island, are not included in this analysis as they reveal nothing about local patterns of social interaction. Their presence indicates, rather, that a few young men find jobs in far away towns, for a time, and then return home.
It seems that villagers often list more outsiders, in general, living with them than the converse. Perhaps this is because we generally ask about immigrants first, or perhaps it is because it is easier to recall people that one sees on a daily basis. In any case, I am more confident in the accuracy of the in-ties reported than the out-ties. For example, it is extremely unlikely that Bebdeben receives no brides from any other villages. So, villages that were not visited likely have a higher in-degree than indicated, as well as ties to other villages that we did not learn about.
Table 5. Nambu Language Sub-Family bride exchange adjacency matrix

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</tbody>
</table>


Notes: Rows indicate number of brides given. Columns indicate number of brides received. Box encloses exchanges within Nambu Language Sub-Family.
6.4.1 Rational for analysis

Since a great deal of social network analysis can be performed on binary (i.e., does or does not exist), undirected ties, the information contained in the value (i.e., how many brides moved from one village to another) and the directionality of bride exchange ties is superfluous to many social network analysis algorithms. There are, however, a variety of ways to use the “extra” information supplied by the value and directionality of the ties. It is important to choose substantive, significant ways, rather than ways that are mathematically possible but substantively meaningless. For instance, I can calculate the degree of any village as the total number of brides it has sent out plus the total number of brides it has received by summing that village’s row and column in the adjacency matrix. If I interpret each instance of a bride being exchanged as an equal opportunity for communication, this sum allows me to compare the total communicative potential of any village with all other villages. However, it does not reveal much about the “shape” of this potential. Is each village’s communication potential focused on just a few other villages or is it spread broadly about the network? Which links are broader than others? Such facets of the network are hidden by a simple summation of the values of the ties.

In order to profit from the “valued” nature of this data, I interpret the number of brides as the breadth of the potential communication channel between two villages or, in other words, the strength of the social link between them. I then “dichotomize” the data by selecting a tie strength threshold and setting the value of the links at or above this threshold to 1 and the value of the links below this threshold to 0. By starting with a high threshold, I take just the strongest (or most robust) ties in the network—those the most
likely to maintain their effectiveness or the least likely to be interrupted by difficulties in any particular relationship—into account in the first analysis. Then, I lower the threshold and reanalyze the network. This process is continued until all ties have been taken into account. The results can be thought of as layers of social potential or social topography. An alternate analogy would be of a bowl being built up out of coils of clay, with each new, lower strength threshold representing a new coil increasing the communicative capacity of the network.

Some readers may find it curious that I have not suggested explicitly that the population sizes of the villages be included as a factor in determining which village is the most central to the network. I have not done so because a village’s population is one of its attributes and I am not performing attribute or variable analysis but, rather, relational analysis. However, it is in the strength, or robustness, of its relations to other villages that the effect of a village’s population size will be seen, if it actually matters. A village with a large population has more potential to establish intermarriage links with other villages than one with a small population. However, if it does not actually establish many intermarriage links, (and I assume that intermarriage links are indicative of all other links as well) then it will not actually have much ability to spread an innovation throughout the network. So, while a large population is a necessary condition for establishing multiple, strong social links, it is not a sufficient indicator that such links have actually been formed. Since it is the links that allow the flow of innovations throughout the network, I contend that it is more profitable to study the links than the
potential for links (i.e., population or other attributes) when establishing a strategy to spread an innovation (such as language development) throughout a network.

6.4.2 Analysis at tie-strength 10

I start the analysis of the Nambu Language Sub-Family bride exchange network by examining the social structure indicated by the strongest links in this network, those representing 10 or more brides. Figure 20 reveals three separate components in this “strongest ties” network: Ngaraita-Mata, Keru-Gubam-Derideri, and Dimisisi-Bimadeben. Note that only Keru-Gubam-Derideri is a strong component (having reciprocal ties). If bridal exchange is truly the best indicator of the social structure of this region, this would appear to be the most significant social structure in the region. Note, too, that Gubam is at its component’s center in terms of degrees (2 in-ties plus 2 out-ties equals 4 degrees). Gubam is also central to its component in terms of closeness because its total distance to the rest of the component is only 2 (1 to each neighbor) while its two neighbors each have a total distance to the rest of the component of 3 (1 to Gubam plus 2 to the other alter). Finally, Gubam is central to its component in terms of betweenness because Keru and Derideri are only connected via Gubam.
While these findings highlight the strongest elements of this network, they do not indicate much about how to organize a language development program that would include the entire Nambu Language Sub-Family. So, let us observe this network at a lower the tie strength threshold.

6.4.3 Analysis at tie-strength 7

Decreasing the tie strength threshold to 7 brides exchanged yields the sociogram in figure 21. The Bimadeben-Dimisisi component is now attached to the Gubam component, leaving 2 components in the network. Arufe and Bebdeben have also joined.
the Gubam component, as well as Mukfideben. While most of these ties are within the Nambu Language Sub-Family, there are also strong social ties to Mukfideben, in the Tonda Language Sub-Family, and Dimisisi, in the Pahoturi River Language Family.

![Figure 21. Nambu Sub-Family 7+ brides exchange network](image)

Summing the rows and columns of the adjacency matrix at a threshold of 7 brides (see table 6) reveals that Gubam still has the highest degree centrality in this network. Each “1” in Gubam’s column represents a tie coming in, for a sum total of 3 in-ties, shown at the bottom of the table, beneath the matrix. Each “1” in Gubam’s row
represents a tie going out, for a sum total of 4 out-ties, shown in the first column to the right of the matrix. Adding Gubam’s in-degree (3) to its out-degree (4) yields a total degree of 7, which is more than double that of any other actor.

Table 6. Nambu Sub-Family bride exchange adjacency matrix dichotomized at 7

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<th>Ke</th>
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<th>Ng</th>
<th>Mi</th>
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</tr>
</tbody>
</table>

*Note:* Central box encloses exchanges within Nambu Language Sub-Family.

At this point, let us consider the substantive nature of in-degrees and out-degrees in this network and ask whether it is meaningful to add them together. Each in-tie to a village represents brides moving into the village. When a bride moves into a village, it gives her family members (her parents, her siblings and parallel cousins, and any nieces and nephews) a socially acceptable reason to visit her new village and, normally, the
guarantee of her hospitality while they are there. In terms of the flow of innovations (including language development) throughout the network, each in-tie represents opportunity for outsiders to visit a village and learn what new things are happening there. If they like the innovation, they are likely to try taking it back home to their own village. Likewise, each out-tie represents opportunity for people to visit other villages and export the innovations occurring in their own village.

So, are in-ties or out-ties more effective in spreading innovations throughout the Nambu Language Sub-Family bride exchange network? I suspect that in-ties are more effective in promoting an innovation to others, because it gives visitors a chance to see what difference the innovation has made in a community. However, when it comes to implementing an innovation in a new community, I suspect that at least some outside assistance is required from those who are familiar with the innovation. Out-ties may be thought of as opportunities to go and render this assistance, or to pass along the innovation. Thus, I conclude that, in this network, in-ties and out-ties represent different and important opportunities for the spread of innovations, and, therefore, when calculating the degree of each actor in the network, it makes sense to maintain the distinction between in-degrees and out-degrees and to add them together to arrive at an indication of an actor’s total potential for spreading an innovation.

When it comes to closeness centrality, however, the presence of one-way ties in this network makes it impossible to calculate the closeness, in the strictest sense, of any actor in the main component to the rest of the component. Since Bebdeben, Dimisisi, and Mukfideben act only as sources (with no links directed towards them), they are not
reachable (infinitely far) from the rest of the component. However, because it makes sense to think of communication and the spread of innovations occurring in both directions along an intermarriage link between villages, I will ignore the directionality of the ties when calculating closeness centrality in this network, thus, taking semi-paths into account.

Table 7 shows the geodesic distances for the main component of the sociogram shown in figure 21. Including semi-paths effectively makes this matrix symmetric since the shortest path between any two actors is the same distance in either direction. So, the “global” farness of any actor from all of the other actors in the component may be obtained by adding together his distance from each of them. Each actor’s farness is the sum of his row in the symmetrized geodesic distances matrix. At tie-strength 7, Gubam has the lowest farness, or the highest closeness centrality, within the main component.

Table 7. Geodesic distances within the main component at tie-strength 7

<table>
<thead>
<tr>
<th></th>
<th>Mukfideben</th>
<th>Keru</th>
<th>Derideri</th>
<th>Gubam</th>
<th>Arufe</th>
<th>Bebbeben</th>
<th>Bimadeben</th>
<th>Dimisisi</th>
<th>Farness</th>
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</thead>
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<td></td>
<td></td>
<td></td>
</tr>
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<tr>
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<tr>
<td>Arufe</td>
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<tr>
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</table>

Gubam also has the highest betweenness centrality in its component because removing Gubam would turn the rest of the component into three separate components
and an isolate. The most significant effect of removing any other actor would be to leave two components or a component and one isolate.

6.4.4 Analysis at tie-strength 6

Decreasing the tie strength threshold to 6 brides yields the sociogram in figure 22. All of the connected nodes are now members of a single component. Tais, in the Nambu Sub-Family, and Weam, in the Tonda Sub-Family, are now connected to the component. However, not all of the Nambu Sub-Family villages are members of the component yet. Mari, Mibini, Daraia, and Pongariki are still isolates. The only sub-grouping evident is Gubam-Arufe-Derideri, which is a semi-clique. This suggests that Gubam-Arufe-Derideri is an important social unit in this region.
In terms of degree centrality, Gubam is still the most central village of this component, with a total of 7 degrees (see table 8). Keru is the next most central village with 5 total degrees.
Table 8. Nambu Sub-Family bride exchange adjacency matrix dichotomized at 6

<table>
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<tr>
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Note: Central box encloses exchanges within the Nambu Language Sub-Family

Closeness centrality gives us the same answers since Gubam has a total distance of 21 steps to the rest of the component and Keru has a total distance of 23 steps (see table 9). This suggests that Gubam is the best place to introduce innovations if one wants them to spread throughout the component and Keru is the next best choice.
### Table 9. Geodesic distances within the component at tie-strength 6

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*Note:* Central box encloses exchanges within the Nambu Language Sub-Family.

#### 6.4.5 Analysis at tie-strength 4

Lowering the tie-strength threshold to 4 brings Mibini, Pongariki, and Mari into the component, but does not otherwise change the sub-groupings (see fig. 23). This is the first component that includes villages from each language of the Nambu Sub-Family.
At a tie-strength threshold of 4, however, Gubam is no longer so obviously the central actor in the component. Table 10 shows that both Gubam and Arufe have a degree of 8.
Table 10. Nambu Sub-Family bride exchange adjacency matrix dichotomized at 4

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Note: Central box encloses exchanges within the Nambu Language Sub-Family

At this point, closeness centrality becomes more revealing than degree centrality.

Gubam is still the closest node to the rest of the component, with a total distance to it of 30 steps (see table 11). However, it is now Keru, rather than Arufe that is the second closest (33 steps) to the rest of the component, although Arufe is only a single step further than Keru from the whole component.
Table 11. Geodesic distances within the component at tie-strength 4

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Note: Central box encloses exchanges within the Nambu Language Sub-Family

In terms of betweenness, Gubam is still the most central actor in the tie-strength 4 component because removing it would leave the largest number of actors with no remaining path between them. Keru and Arufe also have high betweenness, but removing either of them does not break the only path between as many pairs of actors as removing Gubam does. Removing either Keru or Arufe leaves one large component and a small component. Removing Gubam leaves two mid-sized components and a third small component.

6.4.6 Analysis at tie-strength 2

6.4.6.1 Subgroupings

Lowering the tie strength threshold to 2 brings all actors into a single component, as shown in figure 24. This would have happened by definition at tie-strength 1, since
actors outside the boundary of the Nambu Language Sub-Family were brought into this network only because they were connected to actors in the Nambu Sub-Family. That it happens at tie-strength 2 shows that no village near the sub-family is connected to a village in the sub-family by a thin tie of just one instance of intermarriage.

Figure 24. Nambu Sub-Family 2+ brides exchange network

Including all ties of 2 or more brides makes the Nambu Sub-Family bride exchange network dense enough to contain more types of sub-groups. The $k$-core is usually a broad sub-grouping. $K$-cores are also easily located by counting links in a
sociogram to find sets of nodes which all have at least \( k \) links with one another.

Alternatively, an adjacency matrix may be entered into the NetDraw computer program (Borgatti 2002), and the program will highlight all of the \( k \)-cores in the network, as shown in figure 24. In figure 24, we can see that, at tie-strength 2, there is a \( 3k \)-core in the interior of this network that corresponds almost perfectly to the boundary of the Nambu Language Sub-Family. Every village within this sub-family, except for Daraia, has marriage ties to at least 3 other villages in the sub-family, but no village outside the sub-family has ties to 3 villages in the sub-family. So, the linguistic boundary corresponds to another social boundary, namely that of intermarriage density.

I am not sure why Daraia displays such a low intermarriage density with the rest of the sub-family, but several explanations are possible. It may be that Daraia actually has more ties than the single one of medium strength to Ngaraita that we learned about and we would have discovered more if we had collected data in Daraia. In effect, Daraia’s exclusion from this \( 3k \)-core may be an artifact of our failure to gather data there. While it is impossible to rule out this possibility, the fact that Bebdeben and Tais, which we also did not collect data from, are included in the \( 3k \)-core shows that this is not necessarily the reason for Daraia’s exclusion.

Another plausible explanation might be that Daraia has a low population, and therefore, a limited capacity to establish intermarriage ties. However, a glance at the village populations gathered during the survey (see table 12), reveals that, in fact, Daraia has one of the larger populations within the language sub-family. Its population is about four times as large as that of Bebdeben and about three times as large as that of Derideri,
both of which are included in the 3k-core. According to the 2000 census, Daraia is even larger than Gubam and Arufe, which, as we have already seen, play central roles in this network. This illustrates nicely how misleading it can be to base decisions on actors’ attributes when it is their relationships that are more important from a strategic point of view.

Table 12. East Morehead District village populations

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Source: Tucker et al. (2003:6-7).

Tucker et al. (2003:6) hint at another plausible explanation by referring to Daraia as a “settlement,” or offshoot, of Mata. If Daraia was considered to be a subset of Mata by either the surveyor who collected the intermarriage data or the people who provided it, then they may have included the brides exchanged with Daraia in their count of those
exchanged with Mata. This could explain the lack of a tie between Daraia and Mata, for instance.

At the $2k$ level, this core expands to include Jarai and Indonesia. Since Indonesia is not a single village, it is not really comparable to the rest of the nodes in this network, so I will not consider it further in this discussion. At a tie-strength of 2, Jarai is the most connected non-member village to those villages in the Nambu Language Sub-Family.

Let us now look within this well connected $3k$-core for denser sub-groupings, such as $k$-plexes. Starting with a $k$ of 3, we find two 6-member 3-plexes: Keru-Mata-Ngaraita-Mibini-Pongariki-Gubam, and Pongariki-Gubam-Derideri-Arufe-Bebdeben-Bimadeben. Figure 25 shows that these are the western and eastern sets of the inland Nambu Sub-Family villages, with Gubam and Pongariki playing a bridging role between them.
The $k$-plex routine in UCINET (Borgatti et al. 2002) reveals that there are also 48 5-member 3-plexes at tie-strength 2. Aside from being an overwhelming number to investigate, they don’t seem like a very substantial grouping since each member of a 5-member 3-plex need only be connected to 2 of the 4 other members. Such actors do not seem very immersed in groupings that are supposed to indicate immersion, so I do not explore them here.
There are no 2-plexes with 5 or more members at tie-strength 2. There are, however, 24 4-member 2-plexes at this tie-strength. Their members are all of the members of the $2k$-core in figures 24 and 25.

Rather than explore the cliques (in which all members have links to each other) in this network at tie-strength 2, I reserve that discussion for the next level of analysis.

6.4.6.2 Centrality

Since the focus of this survey was on the Nambu Language Sub-Family, and the $3k$-core found at this tie-strength confirms that this is a cohesive social group, I now include only nodes within the Nambu Sub-Family in my analysis of network centrality.

Table 13 shows that within the Nambu Sub-Family, it is Arufe that has the highest degree (13) at tie-strength 2 and, therefore, the highest degree centrality. Gubam is second with a degree of 12.

<table>
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<th>Mib</th>
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Table 13. Nambu Sub-Family exchanges of 2 brides or more
In terms of closeness centrality, table 14 shows that Arufe is also the least far from, or the closest to, the rest of the villages in the Nambu Sub-Family, at a total distance of 16 steps. Gubam is a close second, once again, at a global distance of 17 steps.

Table 14. Geodesic distances within the Nambu Sub-Family at tie-strength 2

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The 3k-core is dense enough that no one actor is essential to the flow between any two other actors, so betweenness centrality becomes a less critical factor in enabling an innovation to spread throughout k-cores of 3k or higher. However, removing both Gubam and Arufe from this network would break off the Bebedebebe-Bimadebebe dyad as a separate component, which demonstrates that Gubam and Arufe play an important betweenness role in this 3k-core along the east-west axis. Likewise, removing Arufe and
Mibini would isolate the Mari-Tais dyad from the rest of the 3k-core. So Arufe and Mibini play an important betweenness role along the north-south axis of this 3k-core.

6.4.7 Analysis with all known brides exchange ties

6.4.7.1 Subgrouping

Considering all of the bride exchange links that we know of between villages in or near the East Morehead District, the adjacency matrix density is 0.13, which means that just 13 percent of all possible ties are realized.\(^\text{10}\) Since I am including semi-paths in parts of the analysis, it is also reasonable to symmetrize the adjacency matrix, which raises its density to 17 percent. This is low, but it is greatly affected by the inclusion of several outlying villages.

There is, however, a 4k-core comprised of the inland villages of the Nambu Language Sub-Family (see fig. 26), except for Daraia (see discussion in section 6.4.6.1). The overall density of this 4k-core is 0.52, or 0.62 if we symmetrize the adjacency matrix. This is a high density, and, according to Hanneman (2001:35,52), this means that this subgroup is likely to be not only robust, but also egalitarian and able to respond quickly and effectively to new stimuli. This is the kind of grouping that should be a good target for the introduction of an innovation, such as language development.

\(^10\) This is calculated by dividing the number of non-zero entries in the adjacency matrix (table 3) by the total number of entries (excluding the non-numeric entries on the diagonal). With a computer spreadsheet, one can replace all values greater than 0 with a “1” and then calculate the average of the whole matrix.
Figure 26. Nambu Sub-Family bride exchange network

At this density, there are so many $k$-plexes, $n$-cliques, and weak cliques that it is not reasonable to think of any one of them as a subgroup to target for the introduction of an innovation. The ways in which these denser subgroups overlap and the union of the sets of actors that make them up, however, reveal some pertinent insights.

Up to this point, all of the analysis I have presented may be performed with a standard computer spreadsheet program. To make the analysis of subgroup overlaps practical, however, requires the use of more specialized software. I have employed the
UCINET program (Borgatti et al. 2002) for this purpose and have found it straightforward to use.

I now present the results of searching the Nambu Language Sub-Family bride exchange network, including all known ties between villages (see table 5), for successively tighter (denser) subgroups and suggest some implications of my findings.

Since $n$-cliques seem to indicate subgroups within which insiders might search for innovations, and my interest is in introducing innovations from the outside, I will not investigate the $n$-cliques in this network.

First, I used UCINET to find all 3-plexes of 6 or more members. There are 23 of them in this bride exchange data set. Not surprisingly, since each member of a 6-member 3-plex must have $6 - 3 = 3$ links to the other members of the 3-plex, the union of these 23 3-plexes includes all members of the $3k$-core shown in figure 26.

UCINET also presents a hierarchical clustering analysis of the results of this search, based on the way in which these subgroups overlap. In this hierarchical clustering analysis, those actors who are co-members of the most subgroups are clustered together as a unit first. This indicates that these actors are those that most frequently interact with the rest of the network in a similar way, from the point of view of this method of subgrouping. Next, the actor who is a co-member of the most subgroups along with the first cluster is joined to the cluster. Next, the actor who is a co-member of the most subgroups along with the existing cluster is joined to the cluster, and so on, until all of the members of all of these subgroups are included in a single cluster.
UCINET’s hierarchical clustering routine offers three criteria for judging when to agglomerate a new member to a cluster: the “single-link,” “complete-link,” and “average-link” methods. If one conceives of various levels of subgroup co-membership as various “distances” between actors, then the three criteria describe how the distance from any given actor to a cluster is measured. In the “single-link” method, this distance is defined as the shortest distance between the potential new member and any member of the cluster. So, as soon as any non-member actor is closer to just one member actor than any other non-member actor is, he is joined to the cluster. An analogy to help picture this is of separate drops of vegetable oil floating in a pot of water. In the single-link method, as soon as a small drop touches a larger drop, the surface tension between the two breaks, and the smaller drop becomes a part of the larger drop.

In the “complete-link” method, the distance between actors and clusters is defined as the longest distance between a potential new member (which might be a cluster already), and all members of the cluster. With this method a non-member cannot be joined to the cluster until he is the closest actor to all members of the cluster. In the oil drop analogy, a smaller drop must completely enter into a larger drop before the surface tension breaks and the two drops merge into one.

In the “average-link” method, the distance between actors and clusters is defined as the average distance between the potential new member and all members of the cluster. Here, an actor joins a cluster when he is the closest potential new member, on the average, to all members of the cluster. In the oil drop analogy, the surface tension breaks between two drops when the distance between their centers is the smallest.
I reject the single-link criteria for hierarchical clustering analysis of subgroup overlaps because I think that the similarity between all members of the cluster should come into consideration. However, the complete-link criteria seems unduly stringent to me, in this case. So, I will utilize the average-link criteria for hierarchical clustering analysis of subgroup overlaps. This is also preset as UCINET’s default criteria.

We can observe in figure 27 that hierarchical clustering by the average-link criteria based on the overlaps of the 3-plexes of at least 6 members results in two main clusters of villages. The northern villages of the Nambu Language Sub-Family, except for Daraia, form the strongest cluster. Arufe and Mata are co-members of 15 3-plexes, and the rest of the northern villages, except for Keru, Bebdeben, and Bimadeben, are co-members of nearly 10 3-plexes, on the average, with Arufe and Mata. A second cluster is formed by Mibini and Mari at the level of co-membership in 7 3-plexes. This cluster grows to include Tais at the level of 5 co-memberships, and eventually, Rouku, at just under 2 co-memberships, on the average. The northern cluster picks up Bebdeben and Bimadeben at just under 7 and 5 co-memberships, on the average, respectively. Finally, Keru joins the northern cluster at an average of more than 1 co-memberships before the northern and southern clusters combine at less than 1 co-membership, on the average. So, at this level of immersion, all members of the $3k$-core are included, and there is a rift between the northern members and the southern members, with Mibini and Rouku on the southern side of the rift.
A subgroup showing slightly tighter immersion is the 7-member 3-plex. There are 3 of them in my data. While it would be possible for them to include all members of the 4k-core shown in figure 26, they do not. Bebdeen and Bimadeben are excluded, which shows that they are not as immersed in the 4k-core as the rest of its members. The subgroup overlaps are relatively simple in this case. Keru, Arufe, and Mibini are each co-members with the Gubam-Derideri-Pongariki-Mata-Ngaraita core in 2 of the 3-plexes.

Lowering $k$ to 2 increases the amount of immersion required for $k$-plex membership. There are 9 2-plexes with 5 or more members in this data. Although it is possible for all members of a 3k-core to be members of a 5-member 2-plex, this does not eventuate in this case. Rather, these 2-plexes consist of various sub-sets of the 4k-core,
which shows that Mari, Tais, and Rouku are not as immersed in relations with the 4k-core villages as they might be. Increasing the minimum 2-plex size to 6 results in 5 2-plexes, which also include all members of the 4k-core, although Keru is only a member of one of them, and Bebdeen and Bimadeben are members of just one, also.

Finally, searching for all weak cliques of villages in the Nambu Sub-Family bride exchange data reveals that there are 21 of them, and they include all members of the 2k-core. Figure 28 shows how these villages cluster together by the average-link criteria based on clique co-membership. Note the rift in the clique overlaps between the eastern villages (in the lower portion of figure 28) and the western villages (in the upper portion). Note, too, that Mari and Tais form a third cluster which joins the western cluster only at a level of less than one average overlap with it. The first village of the Tonda Sub-Family to join this western cluster, Rouku, has already done so before Mari and Tais do.
6.4.7.2 Centrality

Once again, I confine my analysis of centrality to the members of the 3k-core plus Daraia (since Daraia is within the original boundary of the study). Table 15 reveals that Gubam, once again, has the highest degree (15) within the 3k-core. Thus Gubam has the most neighbors to which an innovation could be passed directly. Nonetheless, Arufe is nearly as central as Gubam in terms of degree centrality with a degree of 14. Note, too, that Bebdeben, Bimadeben, and Keru join the actors outside the 4k-core as the most peripheral members of this group, in terms of degree centrality.
Table 15. Nambu Sub-Family bride exchange adjacency matrix dichotomized at 1

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Table 16 reveals that Arufe has the least global distance to the rest of the $3k$-core (17) and, therefore, the greatest closeness centrality. Thus, Arufe should have the capability to spread an innovation throughout this entire group more efficiently than any other village. Gubam is only a single step further from Arufe to the whole of this group.
Table 16. Geodesic distances within the 3k-core

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</table>

6.5 Lexical similarity of speech varieties

From the “acts of identity” perspective of language, shared items of vocabulary may be viewed as links between any two people who share them. Since we collected 170-item wordlists throughout the Nambu Language Sub-Family, we now have relational data for as many as 170 more layers of this network. Rather than analyze each of these individually, I utilize the concept of multiplexity and visualize this data set as a single network layer with the potential for a 170-plex tie between every pair of actors. One could argue that not all vocabulary items are equally important in establishing a common identity with one’s interlocutor, but since determining an appropriate weighting for each item is far beyond the scope of this thesis, I follow the standard lexicostatistical practice of assuming that all items on a list of basic vocabulary items are equally important in establishing a relationship. This assumption justifies the use of the m-core in searching for nested subgroups in the lexical similarity network.
Table 17 shows the multiplexity of the shared vocabulary links, normalized by the number of items not excluded from consideration,\textsuperscript{11} between each pair of villages in which we collected wordlists. In this study, words were counted as shared if their corresponding phonetic segments were similar, as determined by inspection (Tucker et al. 2003:31). However, the present analysis would be performed the same if all words determined to be cognates by the historical-comparative method were counted as shared. The method of determining which words to count as shared is incidental to my analysis.

\begin{center}
\textbf{Table 17. Lexical similarity percentages between East Morehead District villages}
\end{center}

\begin{tabular}{|c|c|c|c|c|c|}
\hline
Keru & 50 & & & & \\
\hline
51 & Bimadeben & 51 & & & \\
\hline
55 & 61 & Arufe & 62 & & \\
54 & 63 & & 84 & Gubam & 63 \\
54 & 59 & 75 & 80 & Pongariki & 64 \\
55 & 58 & 80 & 80 & 86 & Derideri 66 \\
\hline
54 & 49 & 62 & 62 & 64 & 67 & Mata 61 \\
50 & 43 & 57 & 57 & 61 & 64 & 82 & Ngaraita 58 \\
46 & 43 & 52 & 54 & 58 & 62 & 68 & 63 & Mibini 56 \\
30 & 31 & 36 & 37 & 41 & 41 & 45 & 41 & 54 & Mari 40 \\
9 & 8 & 9 & 11 & 11 & 11 & 13 & 13 & 13 & 15 & Jarai \\
\hline
\end{tabular}


\textit{Note:} Percentages following village names are averages with rest of matrix except Jarai.

Wurm and McElhanon (1975:152) adopted the following guidelines for lexicostatistical classification of Papuan languages, based on a version of the Swadesh

\textsuperscript{11}“Twenty-two of the 170 [items] were excluded, as they were synonyms with other [items] already compared in the lists, or because the wrong word had been elicited for the [item], or because the words were loan words from Hiri Motu or English” (Tucker et al. 2003:31).
200-item list of basic vocabulary items as modified by Wurm. Dialects of a single language are mostly above 81 percent similar. Varieties mostly below 78 percent similar are separate languages. Members of a sub-family are mostly above 55 percent similar and rarely below 45 percent similar. Members of a family are mostly above 28 percent similar and rarely below 20 percent similar. Members of a stock are infrequently below 12 percent similar. Members of a phylum are not less than 5 percent similar. The following analysis is based on these guidelines.

The sociogram in figure 27 shows the 0.78m-cores of villages, which may be considered languages by these criteria. Since items shared are, by definition, common to both actors, there can be no sense of direction to these links, and so they are shown as undirected links. We can see that Gubam, Arufe, Derideri and Pongariki form two overlapping cliques and can be considered, by these criteria, to speak the same language. Likewise, Ngaraita and Mata are linked into a single language. Keru, Bimadeben, Mibini, Mari, and Jarai are all isolates at this level, indicating that they each speak separate languages from the rest of the network. So, this analysis suggests that seven different languages are represented in the sociogram in figure 29.
The 0.54$m$-cores shown in figure 30 correspond to the higher threshold for members of a common linguistic sub-family. At this point, it becomes pertinent to ask how connected an actor must be in order to be considered a member of this sub-family. The eight villages in the center of the network display a relatively high level of connection by forming a 5$k$-core. This makes them an 8-member 3-plex, indicating that each member village is well immersed in this core. Bimadeben is slightly less connected as a member of the 4$k$-core. Mari has a single link to this subgroup, via Mibini. Thus, in this data, the language used in Mari does not meet the criteria for inclusion in the same
sub-family with the large majority the languages used in the rest of the East Morehead District villages.

Figure 30. Nambu Language Sub-Family lexical similarity 0.54m-core

Sliding down to the bottom of the acceptable range for sub-families, the 0.45m-core looks substantially the same as that shown in figure 30. The differences are that the 5k-core has become a 7k-core (a complete clique in this case), Bimadeben has picked up 2 more ties to this clique (making it effectively a 9-member 3-plex, which indicates a
high level of immersion), and Mari has gained 1 more tie to the rest of the sub-family, meaning that it would join only at the $2k$-core level of connectivity.

In contrast to our lexical similarity figures (table 17), Wurm (1975:330) found, based on historical-comparative studies, that Dorro (spoken in Mari) and Nambu (spoken in the densest core of villages shown in fig. 30 plus Saraina [Daraia] and Tais (Wurm 1971:152)) were 62% cognate, although he does not specify which villages this comparison was between. This figure may have been the similarity between the speech of Mari and Tais, which he considered to speak a transitional dialect between Nambu and Dorro, or between either Mari or Tais and another Nambu-speaking village. He also gives a cognate percentage of 54 between Dorro and Keraki (later identified as Nambu), which he credits to Voorhoeve’s analysis (Wurm 1971:121). If Keraki was the speech variety of Mibini, then Tucker et al. are in agreement with Voorhoeve, in one instance. However, as shown in figure 30, this appears to be a rather weak link for the inclusion of Mari’s language in the Nambu Sub-Family. It must be acknowledged, however, that the 2003 survey did not include Tais, and so lacks what Wurm explained to be a transitional link in the linguistic chaining relationship that he considered sufficient to group speech varieties together (Wurm 1971:121,129,152; 1975:330). Wurm (1971:131) also points out that many earlier lexicostatistical percentage figures, based, as ours are, on the inspection method, were found to be significantly higher when more data was collected and the historical-comparative method was employed.

Clifton et al. (1991) collected wordlists throughout the East Morehead District, including at Tais. Although they offer no explanation for their method of cognate
determination, their lexicostatistical percentages (see table 18) are all significantly higher than those calculated by Boevé (see table 17). If the figures of Clifton et al. are more accurate than those of Tucker et al., then Bimadeben, Gubam, Mata, Daraia, Mibini, Tais, and Mari would form a complete clique at the 0.45\(_m\)-core level of the East Morehead District lexicostatistical network. Boevé’s figures bring the component in figure 30 into a complete clique only at a multiplexity of 0.28, which is the criterion for members of a linguistic family, rather than a sub-family.

Table 18. Lexicostatistical similarity percentages within Nambu Language Sub-Family

<table>
<thead>
<tr>
<th>Bimadeben</th>
<th>Gubam</th>
<th>Daraia</th>
<th>Mibini</th>
<th>Tais</th>
<th>Mari</th>
</tr>
</thead>
<tbody>
<tr>
<td>79</td>
<td>53</td>
<td>49</td>
<td>46</td>
<td>46</td>
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</tbody>
</table>

*Source:* Clifton et al. (1991), table 3.

Identifying members of a stock corresponds to locating 0.12\(_m\)-cores in lexicostatistical data, like that shown in figure 31. Jarai attaches to the Nambu clique with 4 links at this level of multiplexity. As this brings it into a 4\(_k\)-core, I propose that this is sufficient connectivity to consider it a member of the same stock as the Nambu languages. Clifton et al., however, find cognate percentages between Nambu and Lower Morehead [Kunja] to range from 13 to 34 percent. This would most likely alter the sociogram such that Jarai joined a 4\(_k\)-core with the Nambu villages at the family level.
6.6 Results of social network analyses

I synthesize here the results of social network analysis of three kinds of data from the Nambu Language Sub-Family villages: reported similarity of speech, bride exchanges, and lexicostatistics. The discussion is organized according to the goals of the 2003 sociolinguistic survey.
6.6.1 Verification of language identification and boundaries

6.6.1.1 Reported speech similarity

At the highest level of reported similarity, figure 16 shows that Arufe, Gubam, and Bebdeben speak “the same” speech variety, which they call Nambo, or, in Gubam, Kerake (Tucker et al. 2003:31). Pongariki and Derideri also claimed to speak a common variety, called Namna. Mata, Daraia, and Ngaraita may also be considered to speak the same variety, called Nama, although the lack of reciprocity in the Ngaraita-Mata link leaves room for doubt. Likewise, there is a difference in opinion between Ngaraita and Mibini as to whether they share the same speech form. Unfortunately, as this illustrates, incomplete data always leaves some room for doubt about the results of social network analysis (Wasserman & Faust 1994:8), which Laumann et al. (1983:19) judge to be “probably a more serious issue for network analysis than for much survey analysis.” Thankfully, I am not left to rely on this part of the data alone. Furthermore, the issue at stake at this level of similarity is whether these are separate dialects rather than whether people can communicate effectively, and Papua New Guineans can be very exacting in emphasizing the slightest differences in their forms of speech (Sankoff 1980:10). In addition to the varieties mentioned above, Mari, Keru, and Bimadeben each claim to speak a unique variety, which they call Namo, Neme, and Nen, respectively.

Figure 17 shows the links that corresponded to villages which speak “my language, but differently.” Here, every member of Wurm’s sub-family is potentially

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12 Williams (1936:29,32), who did fieldwork in “Bebedeben,” subsumes all Nambu Sub-Family varieties under the label “Keraki.”
drawn into a single language, and social network analysis reveals a pattern in the claims. In particular, Keru and Bimadeben speak the most peripheral dialects in this potential language, each being claimed as the same language by only two of the seven other villages asked. Furthermore, neither of them reciprocates these claims. If this grouping does speak more than one language, then this data indicates that the dialects of Keru and Bimadeben should be the first to be named separate languages. This part of the data also indicates that the next layer of dialects to be differentiated from this language should be the 3k-core, consisting of Mari, Tais, and Mibini. If my primary proposal is justified, this part of the data (whether it actually indicates intelligibility or acceptability) provides no justification for separating the remaining villages into more than one language, since they share enough similarity claims to form a 4k-core. Note that even a complete lack of data from three villages did not preclude their membership in this 4k-core.

At the lowest level of reported speech similarity, people named villages whose speech was difficult, but still possible, to understand. Figure 18 shows that all members of the 3k-core in figure 17, except Daraia, Pongariki, and Bebdeben, which we collected no data from, form a clique at this level. This indicates that, in at least one direction, they all claimed to speak a language that was intelligible to each other. I believe this provides a reasonable basis for hope that eventually, a common body of literature could serve all of these villages (i.e., all Nambu Language Sub-Family villages except Keru and Bimadeben).

Although these villages formed three separate working groups at the second Morehead ADW and produced five separate sets of elementary school materials (see sect.
6.1), we must bear in mind that they were pursuing the goal of facilitating their children’s acquisition of literacy by producing materials that could be read in exactly the same way as their children spoke each day. The concept, familiar to people with a long history of literature in their own language, that people who speak noticeably (even humorously) different dialects can share a standardized literature is a learned idea rather than an intuitive one, and these people have not yet had the opportunity to learn it.

Although Daraia and Pongariki are not a part of this largest clique, each of them is a member of a clique with the five members of the 4k-core in figure 17 that we visited, which means that only the members of the 3k-core in figure 17 did not choose them as speaking an understandable language. It is plausible that Daraia and Pongariki are, for some reason, less significant than the other five villages they clique with, in the eyes of people from Mibini and Mari, and that they would have mentioned them as speaking an understandable language if they had come to mind. Perhaps Daraia is seen as a part of Mata, and so, did not bear separate mention. Perhaps the same is true of Pongariki and Derideri and of Bebdeben and Gubam. Perhaps they reasoned that they had already named enough villages that spoke a particular dialect and so, did not need to give an exhaustive listing. Whatever their reason, their failure to mention them at this level serves to underline the significance of the distinction between the k-cores at the previous level. This distinction is further highlighted by the fact that it is the same five villages that named Daraia and Pongariki as understandable that also bring Keru and Bimadeben into the 5k-core. The tree diagram of the average-link hierarchical clustering of these clique overlaps (see fig. 32) also illustrates this distinction nicely. Mata, Derideri, Arufe,
Ngaraita, and Gubam cluster at 5 overlaps. Keru, Daraia, Bimadeben, and Pongariki join them in the vicinity of 1 overlap. Mari, Mibini, and Tais cluster separately at 1 overlap and then join the main cluster at less than ½ of an overlap. Finally, Bebdeben is brought into the cluster at about 1/10th of an overlap. If Mata had named Bebdeben, or vice versa, then the five most highly clustered villages would join at 6 overlaps and Bebdeben would also join them in the vicinity of 1 overlap.

Figure 32. Average-link hierarchical clustering of weak clique overlaps amongst all reportedly understandable villages of the Nambu Language Sub-Family

The persistent lack of reciprocity in the reported similarity ties between Keru and Bimadeben and the 7k-core, even at this lowest level of acknowledged intelligibility, makes it unlikely that they could be persuaded to accept a standard literature that the rest
of the component might accept. Their status as peripheral sinks of understandability claims may indicate that they are marginalized minorities with respect to the rest of the group, who, in turn, are unaware of the difficulties those on the periphery have in understanding them.

6.6.1.2 Bride exchange

The 7 or more brides exchange network (see fig. 21) reveals that at the stronger levels of this social grouping, there is a cleavage between the eastern and western villages. In the east, there is a string of strong relationships from Mukfideben to Keru to Gubam to Bimadeben to Dimisisi, and which also connects Bebdeben, Arufe, and Derideri to Gubam. In the west, only Ngaraita and Mata exhibit this strength of relationship. This division between the eastern and western villages is consistent with the highest level of reported speech similarity. The western Ngaraita-Mata link occurs in both places. The eastern Gubam-Arufe-Bebdeben connection occurs in both places, and the additional link to Derideri is not surprising given their geographical proximity. The strong bride exchange links from Gubam east to Dimisisi, in the Pahoturi River Language Family, via Bimadeben and from Gubam up to Mukfideben, in the Tonda Language Sub-Family, via Keru are not anticipated in the reported speech similarity data. However, these strong social links into neighboring language families show us likely routes for the flow of communication and innovations.

One more point of comparison between the reported speech similarity data and the bride exchange data bears mention here. Remembering that from the point of view of the rest of the villages, those villages that cluster together tend to relate to the rest of the
network as a unit (see sect. 6.4.7.1), note in figure 33 the striking correspondence between the hierarchical clustering of clique overlaps in the bride exchange data and the dialect boundaries as reported by the speakers of these languages (circled in fig. 33).

Figure 33. Correspondence between reported language boundaries and average-link hierarchical clustering of villages based on clique co-membership in the Nambu Language Sub-Family bride exchange network

There are two main differences between this hierarchical clustering and the components of reportedly identical speech shown in figure 16. The first is that Daraia, reportedly a Nama-speaking village, is missing altogether from this intermarriage clustering (see section 6.4.6.1 for discussion). The second is the late joining of Bebdeben to the Gubam-Arufe cluster despite its reportedly identical dialect. This is due, in part, to Bimadeben’s co-membership with Gubam and Indonesia in an intermarriage clique of size 3. If both Gubam and Bimadeben have received brides from the same village in
Indonesia, then these links must remain in the data set as they are. If, however, the Indonesian brides in Gubam and Bimadeben are from different villages, then this clique does not actually exist. If that is the case, then Bebdeben and Bimadeben switch places in this hierarchical clustering, which means that only the Namna villages join the Nambo cluster before Bebdeben.

A final note of interest regarding this correspondence is that the bride exchange data supports Mibini’s claim to a close speech similarity relationship with Ngaraita more strongly than its claim to a strong relationship with Tais (as shown in fig. 16). This is in contrast to Mibini clustering with Mari and Tais in the clique overlaps of the reported speech similarity data (see fig. 32). I contend that, when planning for a project that will require sustained cooperation between different parties over a long period of time, such as language development, the social relationships are more important than the linguistic ones, and, therefore, it is the relationship between Mibini and Ngaraita-Mata that is more important than the Mibini-Tais-Mari relationship.

Thus, the reported linguistic boundaries correspond very closely to another social reality—that of intermarriage ties between villages. While this correspondence is striking, it should not be surprising if one recalls that language is, in fact, simply another form of social behavior.

The hierarchical clustering shown in figure 33 also suggests that, given their close social integration, the two sets of dialects most likely to be willing to be grouped into a single language are Namna with Nambo and Namat with Nama. This conclusion is supported by the willingness of precisely these groups to work together under a single
mentor during the second Morehead ADW (Boevé 2002a). Furthermore, during our visit to Mibini, people alternated between the names Namat and Nama when referring to their language (Tucker et al. 2003:38).

The union of Namna and Nambo into one language is also suggested by the 0.78$m$-cores in the lexicostatistical data (see fig. 29).

Taken together, social network analysis of reported speech similarity, lexical similarity, and bride exchanges between Nambu Language Sub-Family villages verify the existence of six separate languages as shown in Table 19. It also gives some cause for hope that eventually, speakers of Nama, Namat, Nambo, and Namo might be willing to use one standard body of literature, so that no more than three sets of literature would be required to serve this language sub-family.

<table>
<thead>
<tr>
<th>Table 19. Nambu Sub-Family languages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language</td>
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<tr>
<td>-----------</td>
</tr>
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<td>Nambo</td>
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<td>Neme</td>
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<tr>
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</table>

### 6.6.2 Suggested language development strategy

At the level of 4 or more brides exchanged (see fig. 23), all of the Nambu Sub-Family villages except Daraia are connected via intermarriage ties of medium strength, which corresponds well to the medium strength, reported speech similarity ties. The east-west divide has been bridged, but, surprisingly, it is via Keru. Keru is a peripheral village
with regard to reported language similarity (which Carla Radloff (1993) has shown to be an indicator of language attitudes), but it is the sole bride exchange link of this strength between Mata to the “west” (just a bit west of due south) and Gubam to the east.

Apparently, then, while Keru’s dialect is likely to have peripheral status within the Nambu Sub-Family, Keru is not likely to be peripheral to the sub-family when it comes to the spread of innovations, such as language development, throughout it. At this tie-strength level, Keru has the second-highest closeness centrality in the network, behind Gubam (see table 11). Closeness centrality suggests that Gubam and Keru, followed by Arufe, would be the three best places in which to initiate a development project if one wanted the development to spread throughout the whole connected network as efficiently as possible.

Also, note that the only bride exchange link of strength 4 or more to Mari is not to the western side of the sub-family, but to the eastern side at Arufe, via Tais. So, Tais’s social ties to the rest of the sub-family appear to be more significant than Mari’s, and the strongest of them are with Arufe, on the east. Mibini’s only intermarriage tie of this strength is to Ngaraita. Although Mibini claimed strong linguistic similarity to Tais, this does not correspond to relatively strong social links. Likewise, although linguistic similarity should facilitate joint language development projects, when it comes to actually working together, or relying on the work of another, robust, established relationships of social solidarity are probably a better indication of the probability of successful project completion than relationships that could be strong, in theory. Thus, at this point in the analysis, I would expect that Mari and Tais are more likely to participate in effective
language development with Arufe than with Mibini, while Mibini is likely to partner effectively with Ngaraita.

Ngaraita also has a link to Weam, in the Tonda Language Sub-Family, near the Indonesian border, at this medium strength of bride exchange ties. This indicates another potential source of innovations for the Nambu Language Sub-Family.

In figure 26, showing all of the bride exchanges involving the Nambu Language Sub-Family, the $3k$-core corresponds closely to the entire component of reportedly understandable villages in figure 18. This shows that, in addition to being a group who can reportedly understand one another, these villages form a cohesive social unit. There are two points of difference between these groupings in these two data sets. The first is that while Daraia is part of the $5k$-core of reportedly understandable villages, it joins the bride exchange core at only the $1k$ level (see sect. 6.4.6.1 for discussion). The second is that Rouku, which was not reported as speaking understandably, is a part of this cohesive bride exchange group. Rouku is part of the Tonda Language Sub-Family, as are most members of the bride exchange $2k$-core. In fact, if we had collected bride exchange data from the Tonda Sub-Family, too, we would certainly have learned about links between them that, in all likelihood, would have brought them into the $3k$-, if not the $4k$-, core. This suggests that we have not yet found the true size of the cohesive social sub-group in this region, and that innovations are likely to spread between the Nambu and the Tonda sub-families. Perhaps, if complete bride exchange data were collected for the Tonda Sub-Family, we would discover that the $3k$-, or the $4k$-, core corresponded to both sub-families. I maintain that this would suggest that innovations are likely to flow efficiently
throughout both sub-families, and, therefore, that both of them should be included in a joint language development plan.

Thus, social network analysis primarily of bride exchange data and reported speech similarity from the Nambu Language Sub-Family suggests that the languages of the Tonda Sub-Family should also be targeted along with the Nambu languages in a cooperative language development plan. The known bride exchange ties within the two sub-families indicate that Ngaraita and Mibini are the two most central villages within the network, as we know it thus far (see table 20). Given that Ngaraita’s bride exchange ties are stronger than Mibini’s (see figures 22, 23, and 24), Ngaraita appears to be the best village in which to initiate a language development project that would serve both sub-families.
Table 20. Known geodesics within the Nambu and Tonda Sub-Families’ bride exchange network

<table>
<thead>
<tr>
<th></th>
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<th>Jar</th>
<th>Rou</th>
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However, since the 2003 survey was designed to address particularly the language development needs within the Nambu Language Sub-Family, I submit the following conclusions regarding a strategy for meeting the language development needs of just the Nambu Language Sub-Family. The villages that make up the 4k-core of the complete Nambu Sub-Family bride exchange matrix (see fig. 26)—namely, Keru, Ngaraita, Mata, Mibini, Pongariki, Derideri, Gubam, Arufe, Bebdeben, and Bimadeben—are those amongst whom a cooperative language development program has the best chance of success. The next most likely villages to participate in such a program are the members of the 3k-core—Tais, Mari, and Rouku—however, extra effort will probably be required to ensure that these more peripheral villages stay involved with the program.

Assuming that the language developers desire to invest enough extra effort for the program to serve all of the villages included in the 3k-core (Mari, Tais, and Rouku), then Arufe, which can reach all of the rest of the villages in the 3k-core via the least number of bride exchange links (see table 16), is probably the most efficient place in which to establish the base of such a program. Gubam would be the close second best choice. This result is consistent with those of the degree centrality analysis of the language understandability claims shown in table 21. However, table 21 also shows that Ngaraita has as high a total degree as Gubam.
Table 21. Degree centrality of villages reported to speak “understandably” by Nambu Language Sub-Family villages

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The lexical similarities of the wordlists collected, by contrast, would have suggested that Derideri, with the highest average similarity to the rest of the sub-family (see table 17), was the best place to base a language development program; Arufe and Gubam would have been indicated as the third and fourth best choices, respectively, instead of first and second as the bride exchanges and reported similarity indicate.

If it is not realistic to expect enough supplemental effort to be made to ensure that Mari, Tais, and Rouku are fully included in the program, and the goals are thereby restricted to serving the more cohesive 4k-core, then Gubam becomes the most efficient base for a language development program, with Arufe as a close second best choice.

Table 22 shows that Gubam has the highest closeness centrality within the 4k-core of Nambu Sub-Family bride exchanges.
Table 22. Geodesics within the 4k-core of bride exchanges between Nambu Language Sub-Family villages

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<tr>
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<td>2</td>
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</table>

This result is also consistent with that of a degree centrality analysis of the language understandability claims within the 4k-core (see table 23). Average lexical similarities calculations, by contrast, would still have suggested that Derideri was the best place to base a language development program within the 4k-core.

Table 23. Degree centrality of reportedly understandable Nambu Sub-Family villages within the bride-exchange 4k-core

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<th>Ker</th>
<th>Mat</th>
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CHAPTER 7
SUMMARY AND CONCLUSION

Graham (2001) has shown that submitting linguistic data to social network analysis reveals other current and historical social relationships. Indeed, the tracing of the history of peoples’ interactions with others peoples through the comparative analysis of their languages has been a common goal of linguists since the dawn of the science of linguistics.

I have pursued the proposition that the future development of peoples’ languages is likely to flow along the same lines as their established patterns of social interaction. I suggest that when planning for future language development, it is more profitable to examine peoples’ current social networks than the linguistic evidence of their past history.

Social network analysis is consistent with LePage & Tabouret-Keller’s (1985) “acts of identity” view of language, which recognizes “a language” as a set of shared decisions by a group of people who wish to identify with one another about how they will speak. In this view, the primary determinant of the nature of one’s language is the nature of one’s social contacts. Adopting this viewpoint, I propose that if one wishes to discern the lines along which a language, or a group of languages, is likely to develop, analyzing the social networks of the people who speak and, therefore, develop these languages on a
continual basis, should yield the most accurate insights about how they are likely to develop.

If this is true, and if a language development agency wishes to engage speakers of minority languages in a participatory process of the development of several of those languages in concert, then that agency would be wise to plan language development programs along the same lines as existing social networks in which the speakers of those languages are already engaged. In other words, coordinated multi-language development programs that rely on the cooperation of speakers of those languages are most likely to succeed if they are organized in the same way that the peoples’ significant social networks are organized. Therefore, those language communities that are already engaged with one another in dense, cohesive social groupings should be those that are the most likely to work well together in the development of their languages.

Social network analysis offers various means for identifying a variety of kinds of cohesive social groupings. I have investigated some of those that require a data set indicating the existence, or lack thereof, of any particular link between all pairs of actors within some boundary. I suggest that in Papua New Guinea, at least, links that may be appropriate to submit to such analysis include intermarriage, trading partnerships, common traditions, ecclesiastical hierarchy, the educational system, the Local Level Government system, and reported and measured linguistic similarities.

I have introduced a number of social network analysis concepts. While the analyst must always ensure that a particular analytical routine has an interpretable social meaning and significance, which will depend on the nature of the data being analyzed, I
have proposed that $k$-cores with a $k$ value of 4 or higher will be sufficiently cohesive groupings to successfully implement cooperative language development programs. In addition to having, in my opinion, an optimally cohesive quality for joint language development, $k$-cores may be quickly identified with the use of NetDraw graph visualization software (Borgatti 2002).

I have proposed, furthermore, that closeness centrality, which may be calculated using any computer spreadsheet program, is the best indicator of the most efficient “place” within a social network (or subgroup) to introduce any innovation (such as language development) that one hopes to see spread throughout the entire network (or subgroup). For small, dense networks, degree centrality, which is more straightforward to calculate than closeness centrality, gives approximately the same answer (Hanneman 2001:66).13

As a case study, I have applied social network analysis to three data sets collected during a sociolinguistic survey of the Nambu Language Sub-Family, located in the Eastern Morehead District of Western Province, Papua New Guinea (see fig. 14): reported speech similarity between villages, exchanges of brides between villages, and similarity of basic vocabulary lists between villages. On nearly all of the 13 sociolinguistic surveys in which I have participated in PNG, we have collected these types of data. I estimate that with reference to the usual amount of time required for data

13 Generally, degree centrality is a measure of local centrality, while closeness centrality is a measure of global centrality (Scott 2000:85).
collection, ensuring as complete a tally of intermarriage ties between villages as possible required about 20 minutes extra per village.

NetDraw graph visualization software (Borgatti 2002)\textsuperscript{14} has been used to create sociograms and to locate cohesive $k$-cores of actors in three kinds of social network data from the Nambu Language Sub-Family of the Eastern Morehead District, Western Province, Papua New Guinea. I have demonstrated that helpful calculations of network centrality may be made with the aid of a standard computer spreadsheet program. The UCINET computer program for social network analysis (Borgatti et al. 2002)\textsuperscript{15} has been used to identify dense subgroups, such as $k$-plexes and cliques, within social network data and to perform hierarchical clustering of actors based on their membership in overlapping cliques.

The boundaries of the Nambu Language Sub-Family were found to correspond to a single, connected component of villages whose forms of speech they reported to be similar (see fig. 17). $K$-core analysis of these speech similarity claims revealed a central core of villages receiving the most speech similarity nominations with three peripheral groups on the south, the north, and the eastern edges of the area.

The language sub-family boundaries were also found to correspond closely to a $3k$-core in the bride exchange data (see fig. 26). The exclusion of the Nambu village of Daraia from this $3k$-core merits further investigation as it was one of the three Nambu villages where no bride exchange data was collected. The fact that the other two were

\textsuperscript{14} NetDraw may be freely downloaded from its author at: \url{http://www.analytictech.com/downloadnd.htm}.

\textsuperscript{15} UCINET may be downloaded from \url{http://www.analytictech.com/ucinet.htm} for a free 30-day trial.
included in the 3k-core anyway may suggest that Daraia is not socially integrated with the rest of the language sub-family. If this is true, then Daraia is probably a poor choice for a place in which to attempt to introduce innovations to this sub-family. On the other hand, it may be that Daraia is so closely integrated with Mata village that most other villages did not even distinguish the two in their reporting of bride exchange ties.

I propose that the 4k-core in the bride exchange network, consisting of the villages of Gubam, Arufe, Bebdeben, Derideri, Pongariki, Mata, Ngaraita, Mibini, Keru, and Bimadeben, is that portion of the Nambu Language Sub-Family in which it is most likely that a language development project could successfully be carried out that would meet the needs of all of its member villages. My analysis suggests that the next most likely villages to join in such a program would be the coastal Nambu villages of Mari and Tais and the Tonda Sub-Family village of Rouku. However, as these villages are less socially integrated with the rest, extra efforts will probably be required to ensure their continued participation.

The measure of closeness centrality within the 4k-core (see table 22) indicates that Gubam is the most central village in this subgroup, and that it is, therefore, probably the base from which language development (or any other social innovation) would spread the most quickly throughout this subgroup. Within the larger 3k-core, however, it is Arufe that is the most central village both in terms of degrees (see table 15) and in terms of closeness (see table 16). So, Arufe is probably a better choice of a base for a development program that would attempt to reach the entire Nambu Language Sub-Family.
Hierarchical clustering analysis of the Nambu Sub-Family bride exchange clique overlaps revealed that those villages that clustered most closely together (see fig. 33) were also those who claimed to have the same form of speech (see fig.16), who formed components at the “language” level of lexical similarity (see fig. 29), and who worked together at the 2002 Morehead Alphabet Development Workshop II (see sect. 6.1). This correspondence is striking. It demonstrates that, in this case, social network analysis of intermarriage data is a very good indicator of reported and measured linguistic similarity and a very good predictor of willingness to cooperate in language development activities. This is the best support I can offer, presently, of the validity of the use of social network analysis of social data in addition to linguistic data in order to plan for cooperative multi-language development programs.

The presence of bride exchange links to several villages in the neighboring Tonda Language Sub-Family, which bring three such villages into a 2k-core (see fig. 26) and into the hierarchical clustering tree in the midst of the Nambu Sub-Family villages (see fig. 33), suggest that the 2003 Nambu Sub-Family survey may not have discovered the true extent the 4k-core, and that investigation of bride exchange links within the villages of the Tonda Sub-Family is merited. Addition of bride exchange data from the Tonda Sub-Family villages to this data set may reveal that the 4k-core actually includes much of both sub-families. If so, it seems that all of the villages so indicated should be included in a joint language development program. If, on the other hand, there is a rift between the two sub-families with 4k-cores on either side, then it is probably wiser to plan for two separate language development programs.
Social network analysis of the villages of the Nambu Language Sub-Family is consistent with, and therefore, serves to confirm some of the conclusions previously drawn from lexicostatistical and interview data. It reveals that, in a social sense as well as in a lexicostatistical sense, Gubam and Arufe are more central to the cluster than Ngaraita and Mata. The finding that Mari and Tais are significantly removed from the rest of the sub-family also supports the lexicostatistical findings but conflicts with Mibini villagers’ claims that the language spoken in Tais is the same as theirs.

While social network analysis of intermarriage patterns has added something to our understanding of the Nambu Sub-Family survey data, other considerations, such as the airstrip and other facilities at Morehead Station, next to Ngaraita, and the potential that a language development center there might be able to serve the Tonda Sub-Family as well as the Nambu Sub-Family, are likely to dictate that a language development center be established at Morehead Station to serve the entire sub-family.

I conclude that adopting a social network perspective while performing sociolinguistic surveys is a profitable thing to do. Discovering what socially significant links exist between villages and language groups is undoubtedly a very important finding when planning for any kind of development work. Social network analysis of data that sociolinguistic survey teams typically gather may also provide enough additional insight in cases which are not already clear to make recommendations about which language groups to join together in multi-language development programs and about which villages are the most central to each language and the multi-language cluster.
GLOSSARY

Actors – Those units in a social network that are capable of relating to one another. Also referred to as “nodes” in a sociogram.

Adjacency matrix – A matrix with actors listed as both the row and column headings and the relations between them indicated as the matrix elements. A “1” in the adjacency matrix indicates a link going from the actor in that row to the actor in that column, making them socially adjacent. A “0” in the adjacency matrix indicates the absence of such a link.

Alter – All actors other than ego.

Betweenness centrality – In which an actor on a geodesic path between more pairs of other actors is more central. Actors with high betweenness can serve as gatekeepers within the network.

Centrality – The extent to which an actor is in the center of a network, either globally (relative to the entire network) or locally (relative to a subgroup). Of the various ways to conceive of network centrality, degree centrality, closeness centrality, and betweenness centrality are touched upon in this thesis.

Clique – A maximally complete sub-graph. A sub-group (of at least three actors) consisting of all actors who are adjacent to one another. Every pair of actors in a clique has a direct connection between them.

Closeness centrality – In which an actor with a smaller sum of geodesic distances to all other actors is more central. Closeness centrality is usually an indicator of global centrality.

Component – A maximally connected sub-graph. A sub-group consisting of all actors that are connected to each other. In a strong component, there is at least one path from every member of the component to every other member of the component. In a weak component, there is at least one semi-path from every member of the component to every other member.

Degree – The number of ties that an actor has. If the ties are directed, then each actor will have both an in-degree (the number of ties directed towards him) and an out-degree (the number of ties directed from him towards others).

Degree centrality – In which an actor with a higher degree is more central. Degree is usually an indicator of local centrality.

Density – The extent to which links between all pairs of actors in a network are present, ranging from 0 to 100 percent.
Ego – Any particular actor that the social network analyst wishes to focus on.

Farness – The sum of the geodesic distances from an actor to all other actors in the network.

Geodesic distance – The number of links in the shortest path(s) between two actors.

Graph – See sociogram.

Hierarchical clustering – Builds sub-groups starting with the two actors who are the most similar or closest and then adding the next most similar or closest actor or group of actors, and so on.

In-degree – The number of directed ties received by an actor.

Isolate – An actor that has no relations with any other actors.

K-core – A maximal sub-graph in which each point is adjacent to at least $k$ other points. A sub-group consisting of all actors that have a degree of at least $k$ with respect to the sub-group. The defining characteristic of a $k$-core is the members’ connection to the sub-group.

K-plex – A sub-group consisting of all actors who are have links to all but $k$ members of the sub-group. In a $k$-plex of size $N$, each member is connected to $N-k$ other members. The defining characteristic of a $k$-plex is the members’ immersion in the sub-group.

Language group – All of those villages that claim to speak the same language and can understand a common form of that language.

Link – See relation.

$M$-core – A maximal sub-graph in which each line has a multiplexity greater than or equal to $m$. A sub-group consisting of all actors joined by links of multiplexity $m$ or greater.

Mode – The level or tier of a network being examined. For example, one could analyze the “individual” mode or the “village” mode of a social network.

Multiplexity – The number of different relationships between any two actors (e.g., friends, neighbors, colleagues, kin).

N-clique – A sub-group consisting of all actors who are joined by paths of length $n$ or less. The defining characteristic of an $n$-clique is the members’ attachment to the sub-group.

Neighborhood – All of the actors who are adjacent to a particular actor.

Nodes – See actors.

Out-degree – The number of directed ties sent by an actor.

Path – Any series of links and nodes between two actors that uses each link and node only once.
Relation – Any specific relationship between two actors. May be directed (e.g., “likes”) or undirected (e.g., “is a sibling of”), valued or binary. Also referred to as “links” or “ties.”

Semi-path – A path that ignores the directionality of directed links.

Sink – An actor with a high in-degree.

Snowball sampling – A method of discovering a social network by starting with some actor, ego, and determining who all of the actors that he relates to are. Next, all of the relations of each of these actors are investigated, adding a new layer of actors to the network, and so on.

Sociogram – A diagram of a social network in which the actors are usually represented as points and the relations are represented as lines between the points. Also referred to as “graphs.”

Source – An actor with a high out-degree.

Star network – The theoretical maximally centralized network, in which the “star” actor has links to all alters and all alters have a link only with the “star” actor.

Tie – See relation.

Weak clique – A clique in which some of the links are not reciprocal. Also known as “semi-cliques” since they contain semi-paths.
REFERENCES


VITA

Michael J. Rueck earned a Bachelor of Science degree, magna cum laude, in aeronautical engineering from The Wichita State University in 1990. As an undergraduate student, through participation in the cooperative education program, he worked as an engineer at the LTV Aircraft Products Group in Dallas, Texas for three semesters. He then worked at the National Aeronautics and Space Administration’s Johnson Space Center, in Houston, Texas for two semesters. He was responsible for the design of an electrical connector wrench that went into orbit aboard the Space Shuttle Columbia on the 33rd Shuttle mission, designated STS-32 in January 1990. After graduating, Rueck worked for two years as a project engineer at Johnson Space Center where he was responsible for the design and implementation of mock-ups of space equipment used in astronaut training exercises.

In 1993, Rueck earned a Certificate of Biblical Studies from Columbia International University. He then commenced the study of linguistics at the Summer Institute of Linguistics in Dallas, Texas. From 1996 to 1999, he worked as a sociolinguistic survey specialist for the Niger Branch of the Summer Institute of Linguistics, participating in surveys of the Zarma, Kanuri, Northern Songhay, and Fulfulde languages. He presented reports from these surveys at the 21st West African Linguistics Society Congress in Abidjan and the 7th Nilo-Saharan Linguistics Conference in Vienna in 1998. He then served as a teaching assistant for the sociolinguistic survey methods course at the Oregon Summer Institute of Linguistics in 1999.

In 2000, Rueck took up the post of Language Survey Team Leader in the Papua New Guinea Branch of the Summer Institute of Linguistics. Over the course of the next five years, he was responsible for the mentoring of 10 language survey interns and oversaw 22 sociolinguistic surveys investigating 51 languages in 10 different provinces of Papua New Guinea. He participated in 13 of these surveys himself, investigating 29 languages in 9 different provinces. In 2005, he coordinated one day, devoted to social network analysis, of SIL International’s 5th International Language Assessment Conference in Chiang Mai. He is a member of SIL International and the International Network for Social Network Analysis. His publications include three papers in SIL International’s Electronic Survey Reports series.