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Hubs as Catalysts for Geospatial Communication in Kinship Networks

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***Abstract*—**Earlier studies in kinship networks have primarily focused on observing the social relationships existing between family relatives. In this study, we pre-identified hubs in the network to investigate if they could play a catalyst role in the transfer of physical information. We conducted a case study of a ceremony performed in one of the families of a small Hindu community – the *Uttar Rarhi Kayasthas*. Individuals (n = 168) who resided in 11 geographically dispersed regions were contacted through our hub-based representation. We found that using this representation, over 98% of the individuals were successfully contacted within the stipulated period. The network also demonstrated a small-world property, with an average geodesic distance of 3.56.

***Keywords*—**Social Networks, Kinship Networks, Social Network Analysis, Geospatial Communication, Hubs

I. Introduction

A social network is a set of individuals who have some kind of relationship existing among them. Relationships between individuals could be anything – from friendship, business relations, and kinship to animosity. In graph theory, individuals are referred to as nodes (or vertices) and relationships between them as edges. Social network analysis (SNA), a well established analysis method in Information Sciences, uses mathematical algorithms to analyze social networks [1]. Kinship networks have been extensively studied. Such studies have involved family rituals [2], family preservation [3], family functioning [4], and managing kinship over long distances [5], among others. Researchers who have quantitatively measured kinship networks using SNA have observed the interplay of nodes and edges, analyzed the pattern, and reported their findings. However, in this study, we took a different approach. Our aim was to pre-identify well-connected individuals and investigate whether they could play a catalyst role in faster dissemination of information in geographically dispersed regions. We carried out a case study of one of the ceremonies in an *Uttar Rarhi Kayastha* family. *Uttar Rarhi Kayastha* is a small Hindu community settled primarily in the states of Jharkhand and Bihar. Ancestors of this community belonged to the princely *Ghosh* dynasty. As for definition of kinship, due to the nature of this close-knit community, we included not only relatives but also close friends of the family.

II. Material and Methods

Since the primary purpose of our study was to understand whether hubs (popular individuals) could play a role in faster dissemination of physical information (i.e., invitation cards), we carried out an exploratory study.

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In this Hindu community, the last rites ceremony is a 12-day event, culminating in a grand feast (*Brahma Bhoj*). It is required for the family that is organizing the function (organizers) to invite relatives and close family friends to partake in the ceremony. The final three days of this ceremony are particularly important. Physical invitation cards are of ceremonial significance in this Hindu ritual. The card provides all the details about the last rites, vedic invocations, and contact details. Unlike other functions, such as the marriage ceremony, where the organizer has sufficient time to plan for the event and send out invitation cards, the last rite ceremony is abruptly organized. Invitation cards must reach the recipients in a week's time as the relatives who live in distant places need to organize their travel schedules to attend at least the last day of the ceremony. Organizers of this function have traditionally used the postal medium to send out these invitations, which has been not only cumbersome, resource intensive, and time-consuming, but also ineffective as, due to poor postal service in this region, many invitations arrive after the function is over. Moreover, due to organizers having out-of-date recipient addresses, several invitations always remain undelivered.

For this study, instead of following the traditional path (i.e., postal), we chose individuals we thought would know most of the people in a town. Eleven towns were identified: Patna, Bhagalpur, Bihpur, Marwa, Deoghar, Jamshedpur, Ranchi, Bokaro, Dumka, Delhi (the only town outside of Jharkhand and Bihar), and Naugachia. Ten individuals were identified as coordinators (hubs). In total, 168 individuals were identified (this includes the organizer as the main contact point) as recipients and coordinators, and a code sheet was prepared to with the names of the coordinator, recipients, and the medium through which the coordinator received the invitation card pack for onward delivery to the designated recipients. Some of the coordinators were also recipients.

Social network analysis using NodeXL was used to map the distribution pattern of invitation cards and calculate the graph metrics [6, 7]. Geospatial coding and visualization was done using gpsvisualizer.com

For analysis, we calculated one global topology - geodesic distance - and two local metrics - degree and betweenness centralities. Calculation of geodesic distance determines the level of randomness of a network. Degree of a node is the number of nodes directly connected to the network. Degree of centrality, k_i of node *i* is defined as

$$k_i = \sum_{j=1}^{n} g_{ij} \quad (1)$$

where g_{ij} = 1, if there is link between vertices *i* and *j* and g_{ij} = 0, if there is no such connection. Betweenness centrality of node *i* was the fraction of geodesic paths that pass through *i*. Mathematically, betweenness centrality, *b* of node *i*, is expressed as

$$b(i) = \sum_{j,k} \frac{m_{jik}}{m_{jk}} \quad (2)$$

where m_{jk} is the number of geodesic paths from vertex *j* to vertex *k*(*j*, *k* ≠ i) and m_{jik} is the number of geodesic paths from vertex *j* to vertex *k*, passing through vertex i (see [1, 8]).

III. Result and Discussion

Two coordinators came to Patna to receive the invitation card pack. Six coordinators were sent invitation cards through speed courier service. One coordinator was the organizer himself and the other coordinator, who was available in Patna, used e-mail service with a scanned copy of the invitation letter. JA1, the main coordinator for Jamshedpur town, was responsible for onward distribution of the invitation card pack to two sub-coordinators, whereas MA4 served as the coordinator of two regions, Naugachia and Marwa.

The cards were sent to all coordinators on January 2, 2012, with instructions that recipients must receive the invitation by January 6, 2012, at the latest.

As the study progressed, constant telephone contact was maintained with the coordinators to keep tabs on the current position of card delivery. An update of January 5, 2012, revealed that 121 recipients had already received the invitation cards. However, contact could not be established with coordinator MA4 and there was no clue about whether he was able to deliver his set of cards. A second contact was made with all coordinators (including MA4) on January 6, 2012, and we confirmed that all but three recipients (JA7, JA11, BI3) had received the cards (see Fig. 1). The three recipients who did not receive the card were either unavailable or had shifted their residences, information about which was not available to the coordinators.

28 December, 2011	→ Commencement of Ceremony
29	
30	
31	
1	
2	→ Cards despatched to co-ordinators
3	
4	
5	→ Total of 121 individuals receive the cards
6	→ Total of 164 individuals receive the cards
7	
8 January, 2012	→ Last and most important day of the Ceremony

Fig. 1 Progress of Cards distribution

The use of identified hubs for dissemination of physical information had a success rate of 98%. It ensured that all recipients received the cards well in time. This representation of using region-wise coordinators also ensured personal delivery to individuals, which means a lot emotionally in this community. Moreover, such gatherings reconnect people's ties, which otherwise may decay over time [9].

Figure 2 shows the communication network. The network has 168 nodes with 176 unique edges (see Table I). As we designated the hubs, it was obvious that these nodes would have high betweenness centralities (see Table II). The presence of hubs made this network scale-free. We found that the average geodesic distance of the network was just 3.56, which also confirmed that the network is a small-world network (see Table I).

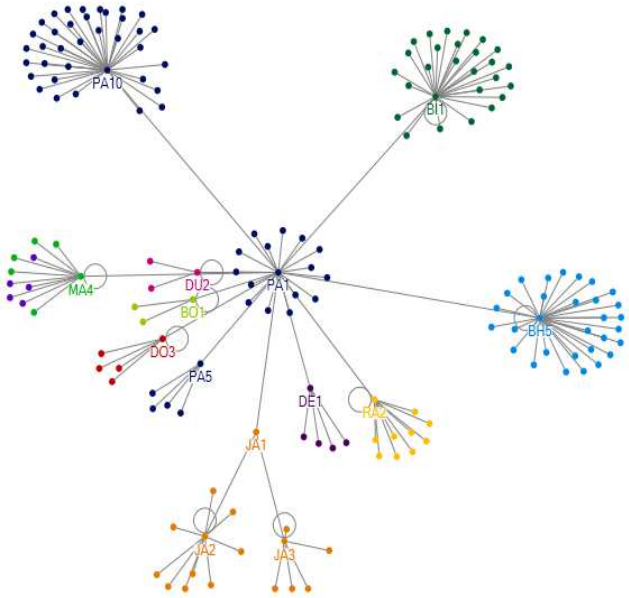

Fig. 2 Network diagram of kinship network. Hubs in communication network are delineated

TABLE I
Global Measures of the Network

Vertices	168
Unique Edges	176
Edges With Duplicates	0
Total Edges	176
Self-Loops	9
Connected Components	1
Single-Vertex Connected Components	0
Maximum Vertices in a Connected Component	168
Maximum Edges in a Connected Component	176
Maximum Geodesic Distance (Diameter)	5
Average Geodesic Distance	3.562783

TABLE II
Degree and Betweenness Centrality of Hubs in the Network

Node	Degree	Betweenness Centrality
PA1	26	12173
BH5	32	4408
BI1	29	3991
MA4	13	1615
DO3	7	658
JA1	3	2476
RA2	12	1458
BO1	5	331
DU2	5	331
DE1	5	658
PA10	36	5215
PA5	5	658
JA2	12	1458
JA3	8	820

A. Geospatiality

Since the ceremony was held in Patna, it was obvious that being local, larger number of cards would be distributed to the recipients of this place (see Table 3). Geospatiality of the network showed that majority of the family relations stayed in 4 regions - viz, Patna, Bhagalpur, Bihpur and Jamshedpur (see Fig. 3).

TABLE III
NUMBER OF VERTICES AND UNIQUE EDGES OF EACH LOCATION WHERE KINS RESIDE

Group	Vertices	Unique Edges
Patna	57	56
Bhagalpur	30	30
Bihpur	27	27
Marwa	6	6
Deoghar	5	5
Jamshedpur	17	18
Ranchi	10	10
Bokaro	3	3
Dumka	3	3
Delhi	5	4
Naugachia	5	0

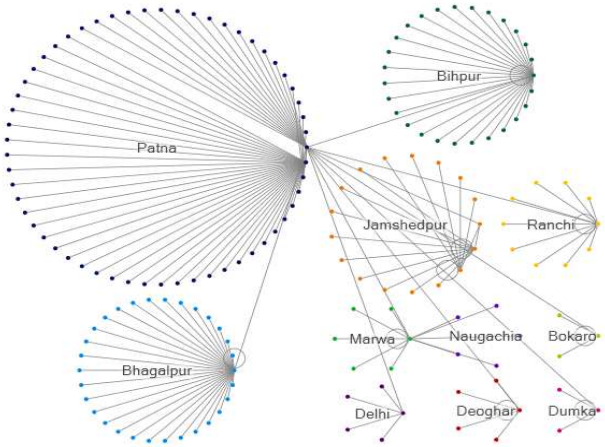

Fig. 3 Network diagram of kinship network based on locations the kins reside

Latitude, Longitude of each city and the frequency of the nodes were input in gpsvizualizer.com to draw geographic maps. When the nodes are overlayed on the actual map, geospatial dynamics become more evident (see fig. 4).

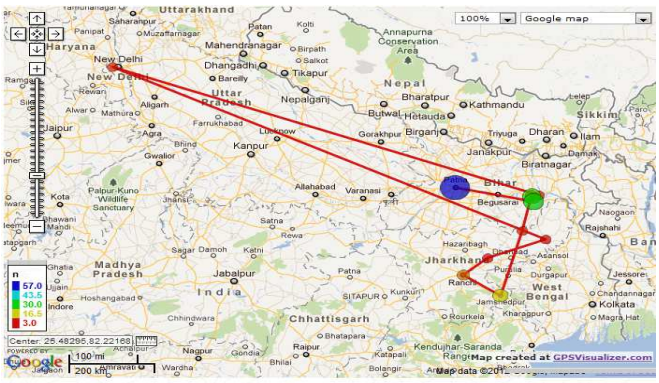

Fig. 4 Geospatial map. Size of nodes depict the number of people present in the area. Edges are unweighted

IV. CONCLUSION

In this study we investigated the importance of hubs for delivery of physical information in geographically dispersed regions. Last rites ceremony of an established family of *Uttar Rarhi kayastha* clan was used as a case study. We found that by pre-identifying hubs and using them as bridges could be instrumental in faster and reliable dissemination of information. Provided a social structure already exists, this representation may have practical implications in circumstances where information in physical form needs to be spread in geographically dispersed regions and there is paucity of time.

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