

# TWO APPROACHES FOR EXAMINING LONGITUDINAL SOCIAL NETWORKS



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**Presented to Sunbelt Social Networks Conference  
Vancouver, B.C., April 2006**



# Two Approaches



- Changes in **Attributes** of Network
  - Density
  - Mean Link Strength
  - Mean Centrality
- Changes in the global network overall **patterns of relationships** among the nodes



# Example Data

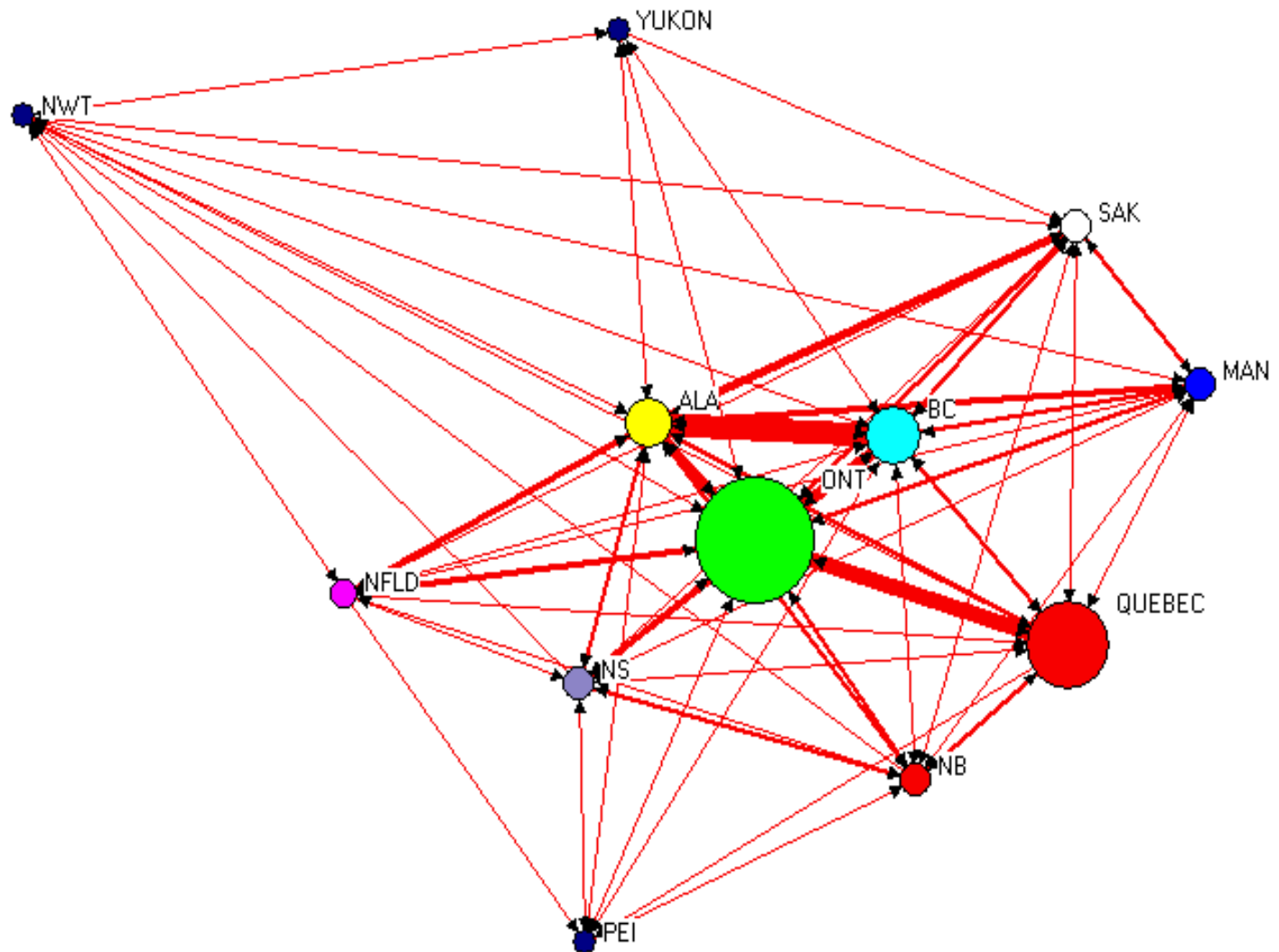


- **Migration among Canada's 13 provinces & territories**
- **Statistics Canada**
  - Report on the demographic situation in Canada: Current demographic analysis. (Catalogue no. 91-209-XPE), Ottawa.
- **Quarterly data**
- **N=73 (2nd quarter 1987 to 2nd quarter 2005)**
- **N = 38 pre-Nunavut; N = 35 post**





# Migration Network



# Migration Centralities

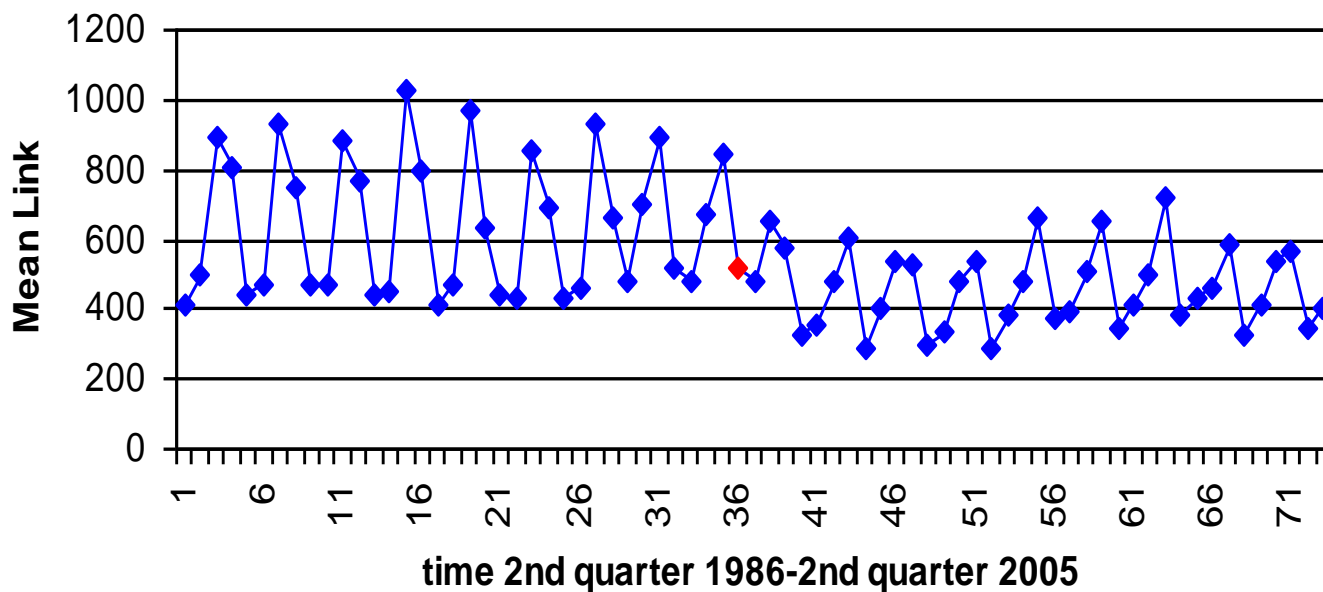
## Eigenvalue Centrality

● Newfoundland	15.003
● Prince Edward's Island	2.584
● Nova Scotia	18.730
● New Brunswick	12.339
● Quebec	39.630
● Ontario	<b>71.552</b>
● Manitoba	23.307
● Saskatchewan	27.895
● Alberta	<b>75.046</b>
● British Columbia	<b>74.843</b>
● Yukon	2.880
● Northwest Territories*	4.162
● Mean	28.207
● Std Dev	27.255
● *Nunavut Included	



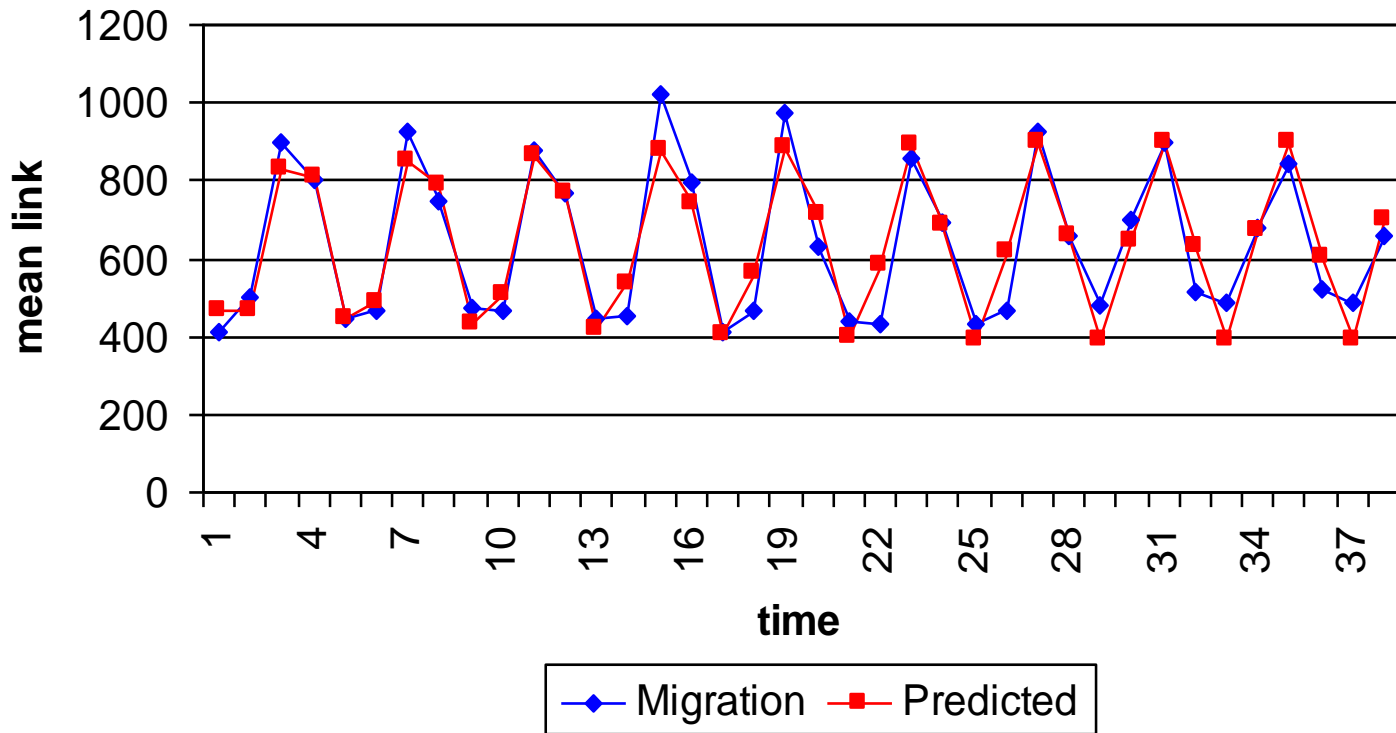
# Changes in Attributes of Network

Canadian Interprovincial Migration



# Changes in Attributes of Network

Canadian Migration 1987-1996 (quarterly)





# Changes in Attributes of Network – Curve Fit

$$Y = a + (\text{amp} * (\sin(\text{freq}(t - \text{phase}))))$$

	<u>coefficient</u>	<u>s.e.</u>	<u>t</u>
a	642.86	11.84	56.59
amp	255.34	16.83	15.17
freq	1.60	.01	266.50
phase	-1.44	.09	16.40
R <sup>2</sup>	.87		
N	38		



# Change in Network Attribute-Acoustics

- **Listen** to network changes
- **Mean Link Strength in Hz**
- **Beep in Norton Utilities**

**MIG**

**/F 414.03 /D2 /W1 (/F = frequency in Hz)**

**/F 500.81 /D2 /W1 (/D = duration in 55.56 msec. units)**

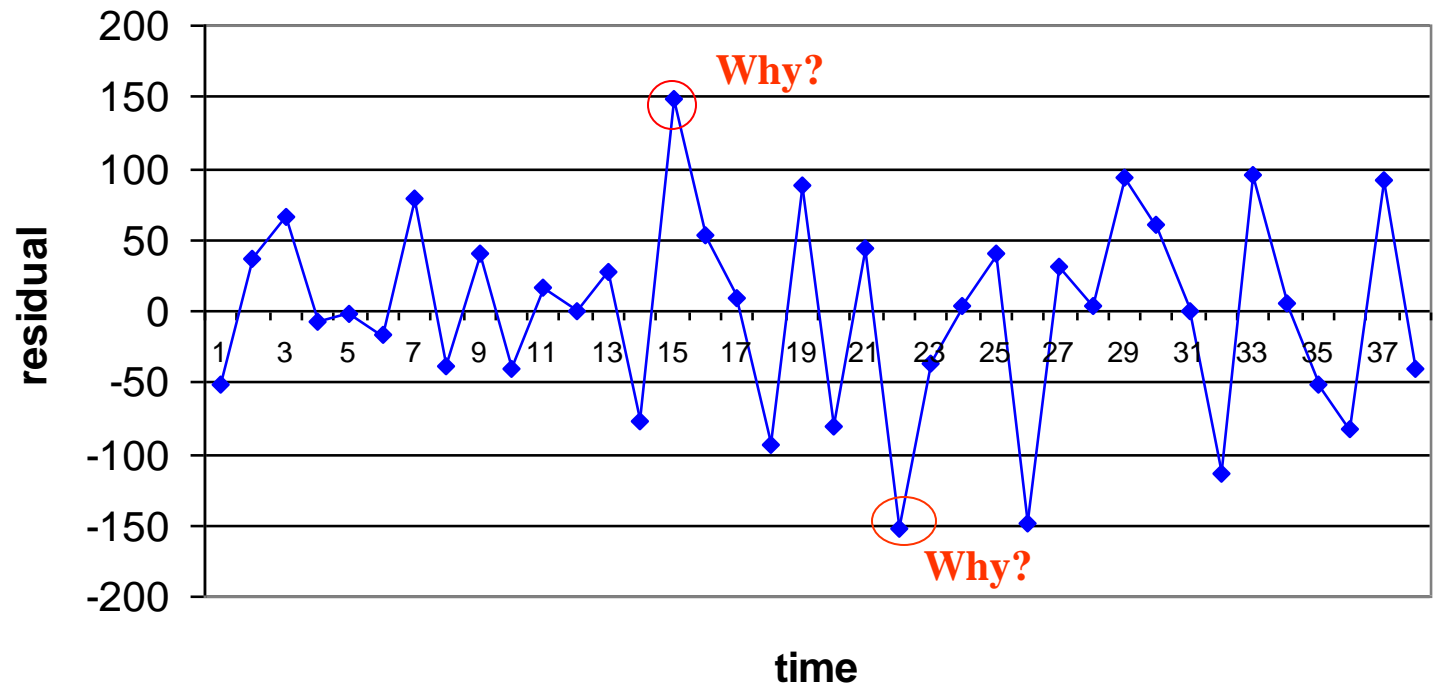
**/F 894.91 /D2 /W1 (/W = pause between tones)**

**C:\>beep mig.txt**

**Hear 4 tone cycle**

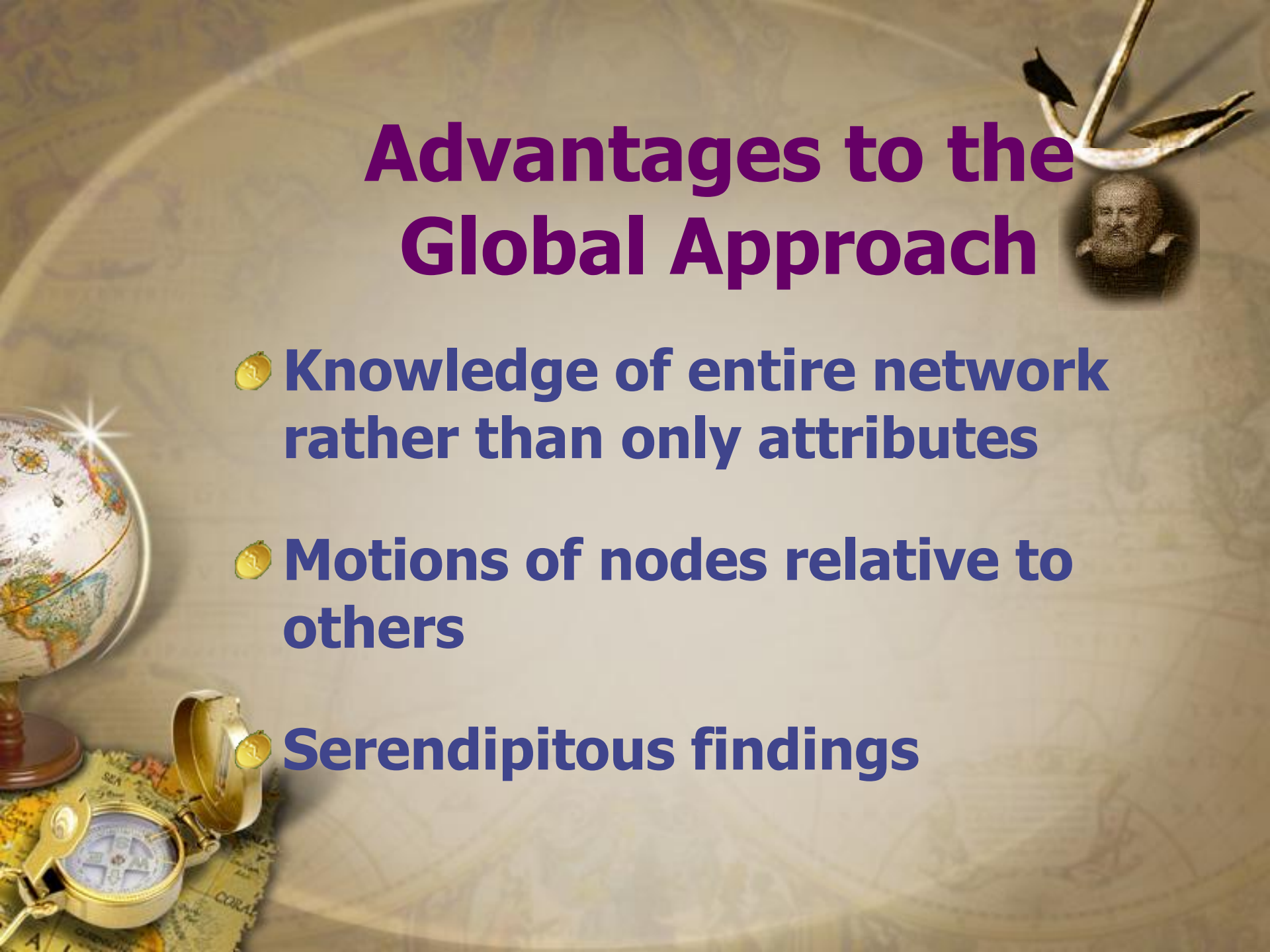
# Changes in Attributes of Network-Residuals

Canadian Migration 1987-1996



# Advantages to the Global Approach

- Knowledge of entire network rather than only attributes
- Motions of nodes relative to others
- Serendipitous findings





# Galileo & Social Networks

**Galileo** is a form non-Euclidean M.D.S. based on Riemann geometry

**Advantages for analysis of social networks:**

- 1. Orthogonal Dimensions—simpler mathematics**
- 2. Dynamics—Networks change over time**
- 3. Unlimited number of dimensions-- $n$  nodes requires  $n-1$  dimensions**





# Galileo & Social Networks



**Galileo** used in the literature

- Barnett & Rice (1985) USA Air Traffic Network (1968-1981)
- Rice & Barnett (1985) Computer Conference Network (24 months)
- Barnett (2001, 2002) International Telecommunication Network (1991-1999)
- Barnett & Sung (2003) Canadian Migration Network (20 quarters)
- Kwon & Barnett (2008) Semantic network of Universal Declaration of Human Rights (6 countries)



# Galileo Procedures

- Strength of tie (frequency) matrix symmetricized
$$s_{ij} = (s_{ij} + s_{ji})/2$$
- Reverse Scale – frequencies to social distance;
$$s_{ij} = 0$$
- Metric MDS
- Comparison of Coordinates to minimize departure from congruence (Woelfel, Holmes & Kincaid, 1988)
  - Common origin
  - Rotation - Determine new coordinates
  - **No** standardization — allow for dilation & contraction (strengthening & weakening ties)
  - Calculate differences between  $t_2 - t_1$ ,
  - Calculate correlations (angle) between dimensions & nodes

# Galileo Difference Scores



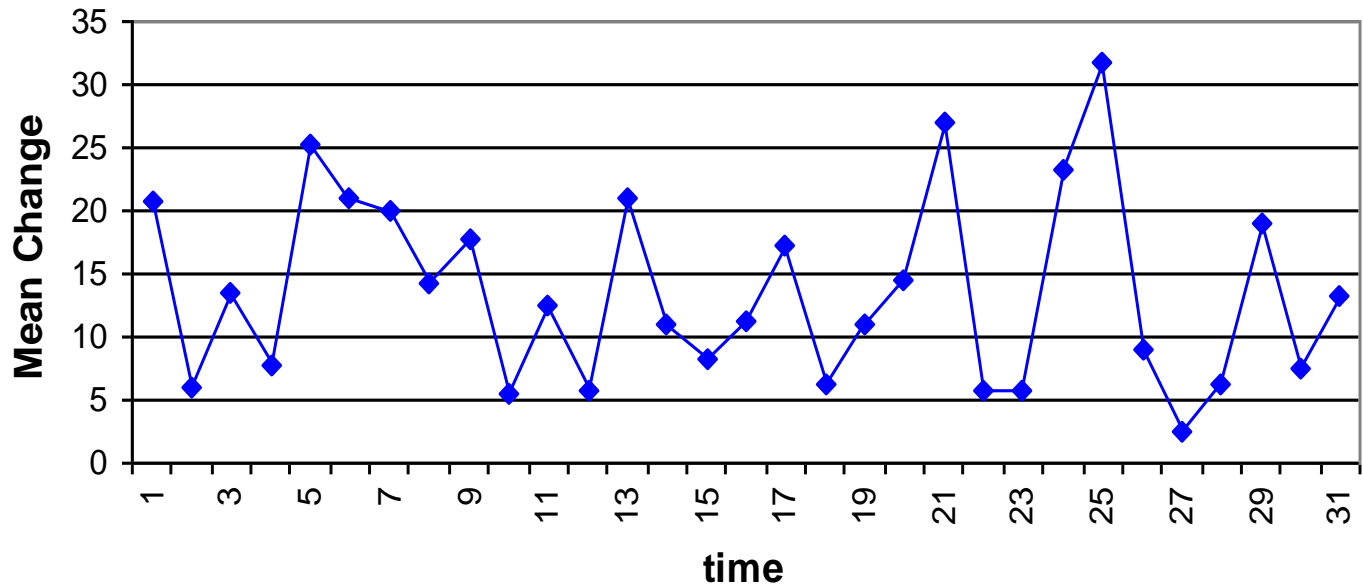
- **Difference Scores**
- **Correlations of Dimensions**
- **Correlations of Nodes-Angular motion**
  - **Change in relations among nodes**
  - **Can determine when change took place**





# Galileo Difference Scores-Mean

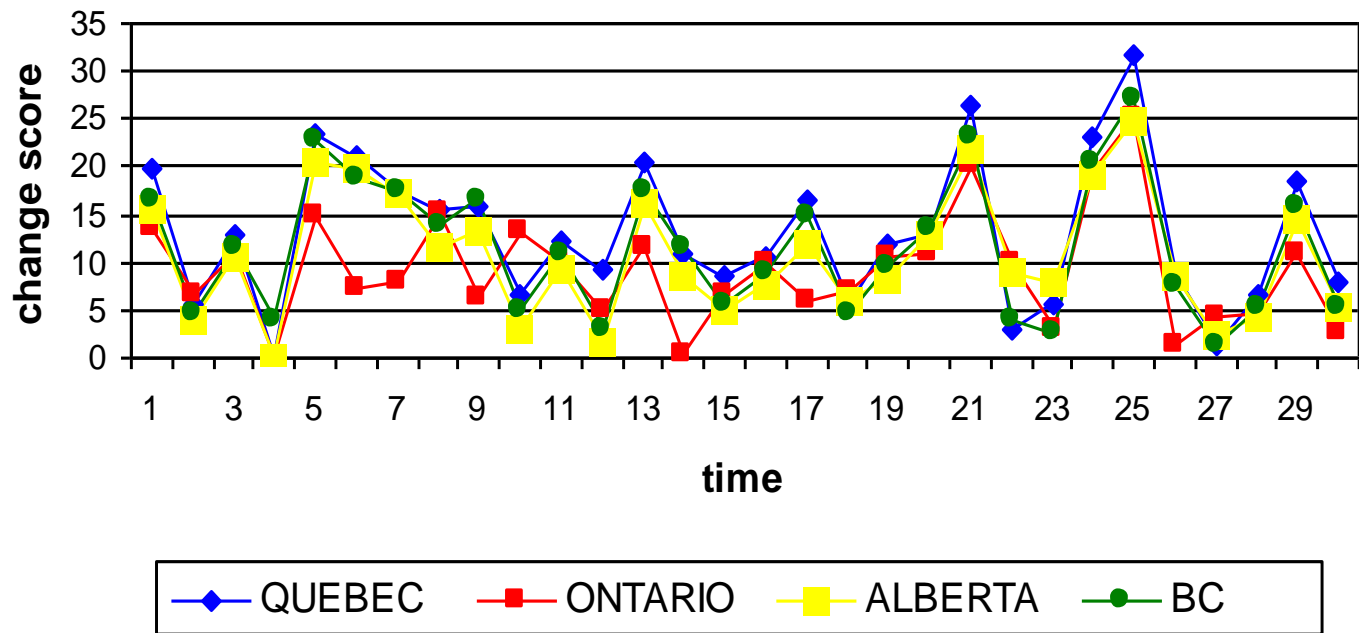
Galileo Mean Change in Canadian Migration  
by Quarter (1996[3rd]-2004 [2nd])



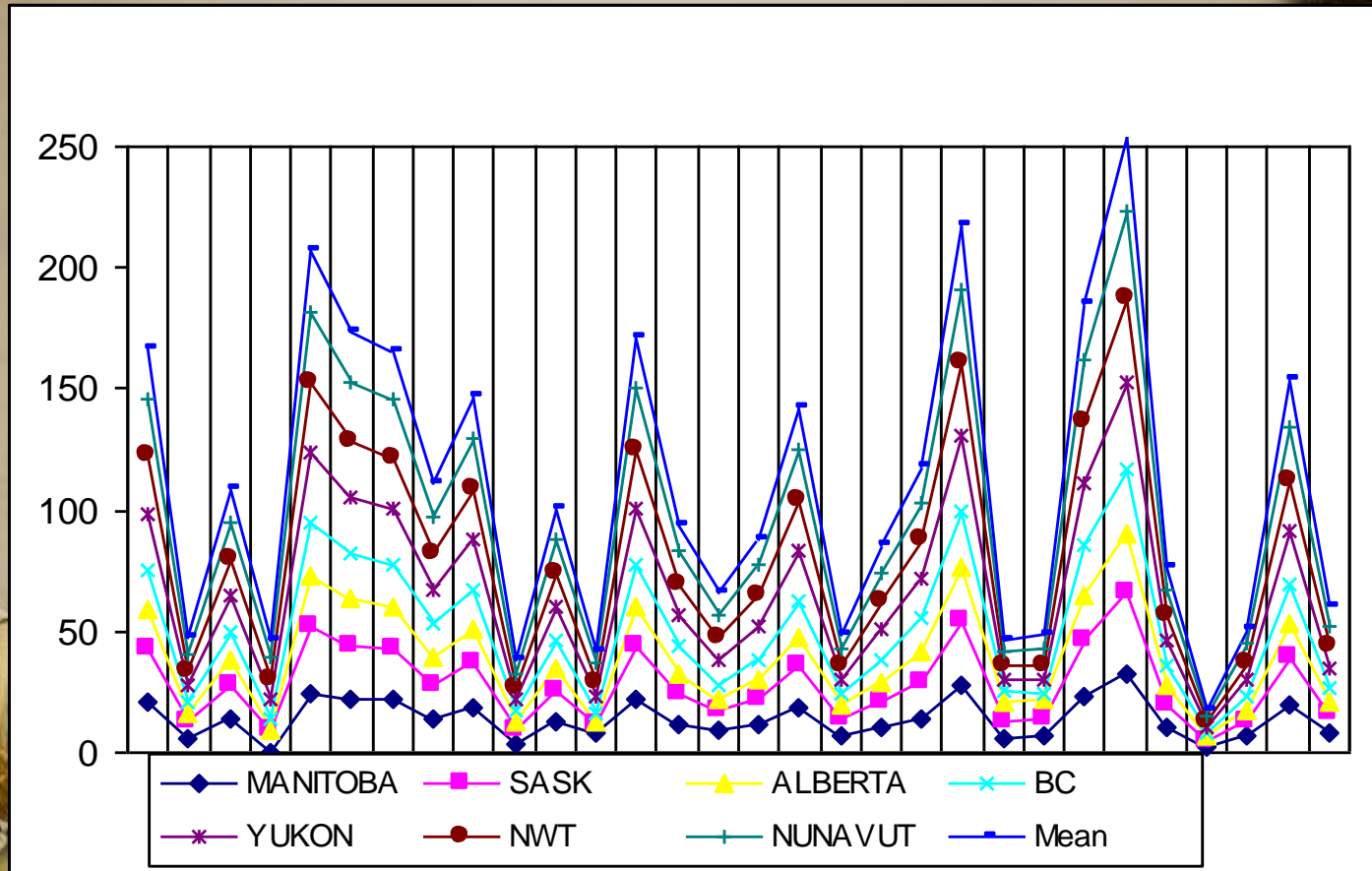


# Galileo Difference Scores Individual Nodes

Galileo Change in Migration  
Qubec, Ontario, Alberta & BC



# Galileo Difference Scores Individual Nodes



# Rotated Coordinates



## Correlations of Dimensions

Mean = .9669 (12 dimensions)

D1 = .9976 (3.9°)

D2 = .9971

D3 = .9962 (4.7°)

Motion is expansion & contraction  
not changes in relations





# Rotated Coordinates



## Correlations of Nodes Over Time

Mean = .9951 (5.7°)

Quebec = .9940 (6.1°)

Ontario = .9951 (5.7°)

Alberta = .9904 (7.9°)

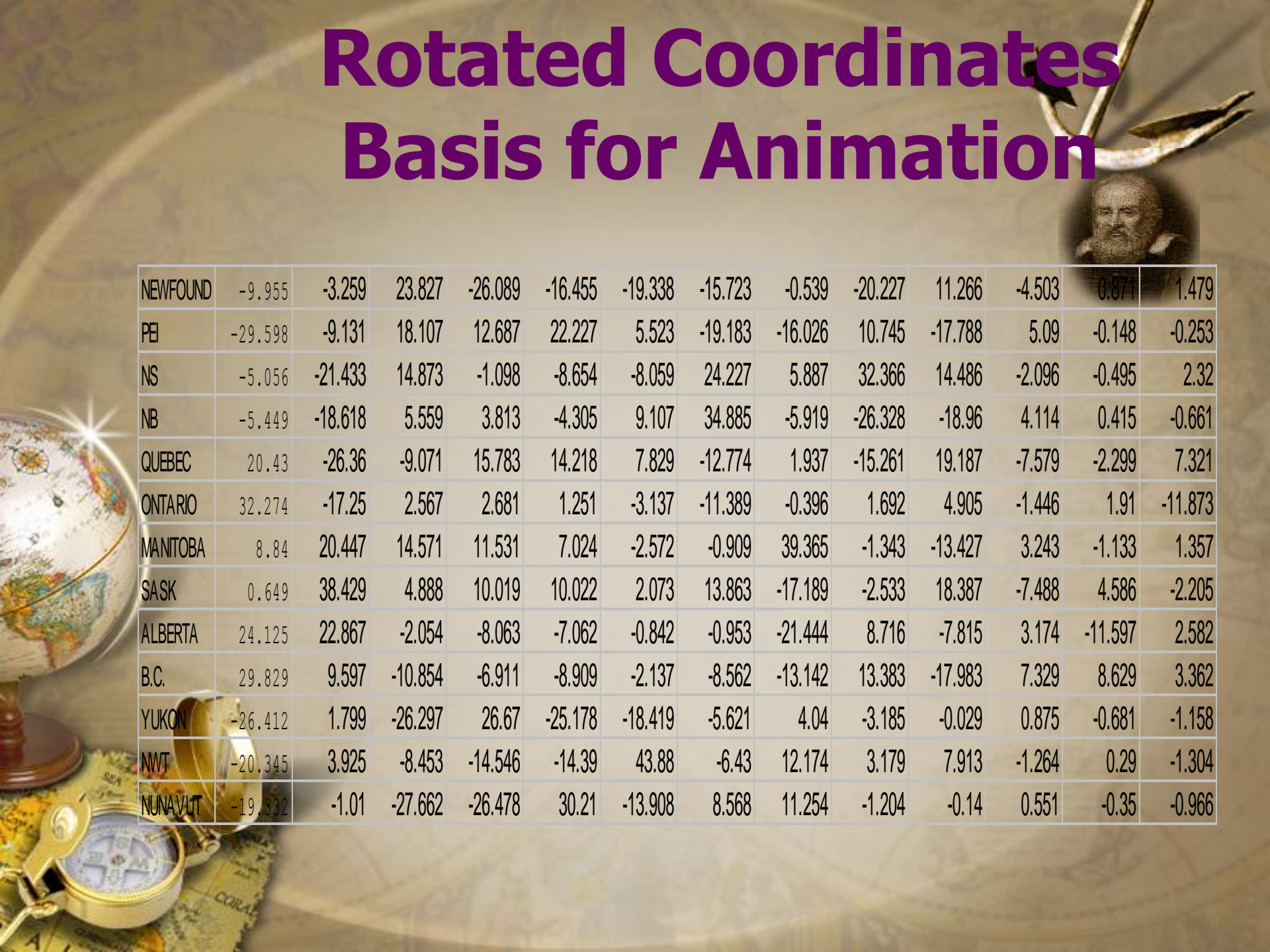
B.C. = .9950 (5.5°)

Alberta greatest change in relations with other nodes





# Rotated Coordinates Basis for Animation



NEWFOUND	-9.955	-3.259	23.827	-26.089	-16.455	-19.338	-15.723	-0.539	-20.227	11.266	-4.503	0.877	1.479
PEI	-29.598	-9.131	18.107	12.687	22.227	5.523	-19.183	-16.026	10.745	-17.788	5.09	-0.148	-0.253
NS	-5.056	-21.433	14.873	-1.098	-8.654	-8.059	24.227	5.887	32.366	14.486	-2.096	-0.495	2.32
NB	-5.449	-18.618	5.559	3.813	-4.305	9.107	34.885	-5.919	-26.328	-18.96	4.114	0.415	-0.661
QUEBEC	20.43	-26.36	-9.071	15.783	14.218	7.829	-12.774	1.937	-15.261	19.187	-7.579	-2.299	7.321
ONTARIO	32.274	-17.25	2.567	2.681	1.251	-3.137	-11.389	-0.396	1.692	4.905	-1.446	1.91	-11.873
MANITOBA	8.84	20.447	14.571	11.531	7.024	-2.572	-0.909	39.365	-1.343	-13.427	3.243	-1.133	1.357
SASK	0.649	38.429	4.888	10.019	10.022	2.073	13.863	-17.189	-2.533	18.387	-7.488	4.586	-2.205
ALBERTA	24.125	22.867	-2.054	-8.063	-7.062	-0.842	-0.953	-21.444	8.716	-7.815	3.174	-11.597	2.582
B.C.	29.829	9.597	-10.854	-6.911	-8.909	-2.137	-8.562	-13.142	13.383	-17.983	7.329	8.629	3.362
YUKON	-26.412	1.799	-26.297	26.67	-25.178	-18.419	-5.621	4.04	-3.185	-0.029	0.875	-0.681	-1.158
NWT	-20.345	3.925	-8.453	-14.546	-14.39	43.88	-6.43	12.174	3.179	7.913	-1.264	0.29	-1.304
NUNAVUT	-19.332	-1.01	-27.662	-26.478	30.21	-13.908	8.568	11.254	-1.204	-0.14	0.551	-0.35	-0.966

The background features a large, faded map of the world. In the bottom-left corner, there is a small globe on a wooden stand, a brass compass with its lid open, and a piece of an old map showing the word 'CORAL'. In the top-right corner, there is a wooden gaff with a black bird perched on it and a circular portrait of a bearded man, likely Jacob of Voragine.

# Animation of Canadian Migration Network

**Jacob's Ladder 12.0<sup>©</sup>**

# Jacob's Ladder



**Multidimensional Animation, Intonation &  
Clustering Displays in Open GL & Java**

**Benjamin Elbirt**

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# JL Clusters

## ● 3 Primary Clusters

- Ontario & Quebec
- Alberta, B.C., Manitoba & Saskatchewan
- Yukon, NWT, PEI, Nanavut, Newfoundland, NB & NS

## ● 2 Primary become 4 secondary

- Manitoba as a bridge from Saskatchewan to Alberta & B.C.
- NWT & Yukon bridged by PEI to Nanavut, Newfoundland, NB & NS

## ● Seasonal Cluster

● Relations among nodes relatively stable

## ● Proximal Similarities





# JL Animation & Intonation



- **Change primarily seasonal**
  - Relations among nodes relatively stable
- **B.C. & Ontario tie strength increases**
- **Newfoundland becomes more central**
- **Nanavut mid-stream intervention**
  - Intonation adjustment suggests massive shift of population
- **Stable Population Growth**

