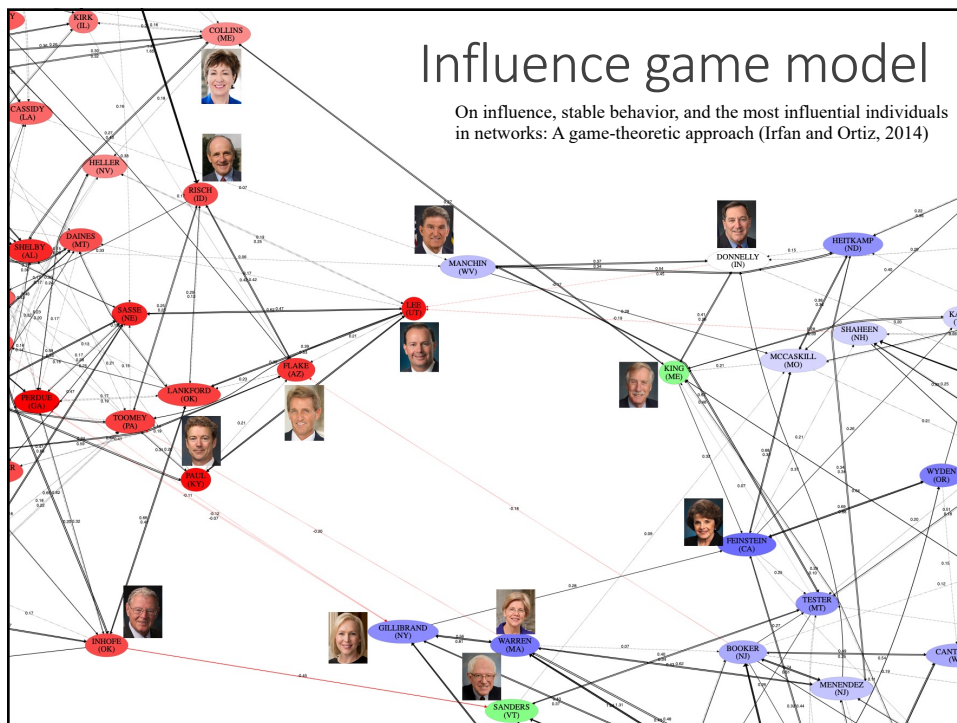


CSCI 3210
 Computational Game Theory

Influence Games

Mohammad T. Irfan
<https://mtirfan.com>

1



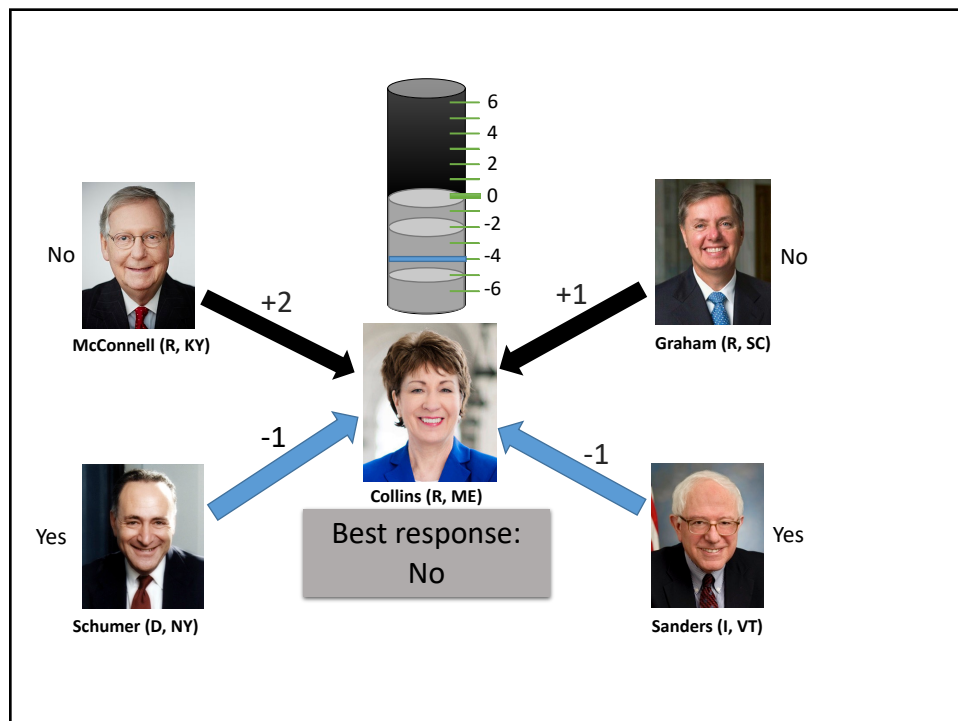
5

What will be the outcome of a bill?

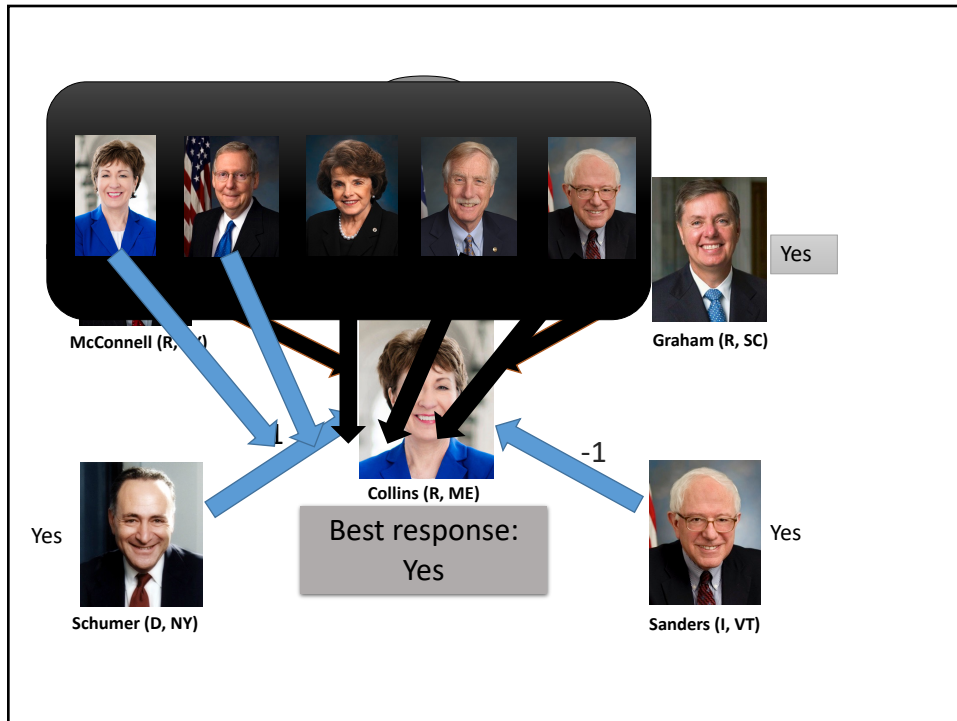
Who are the most influential senators?

Is the Senate as polarized as people say?

6




7



8

Nash equilibrium

Every player plays their best response to others simultaneously



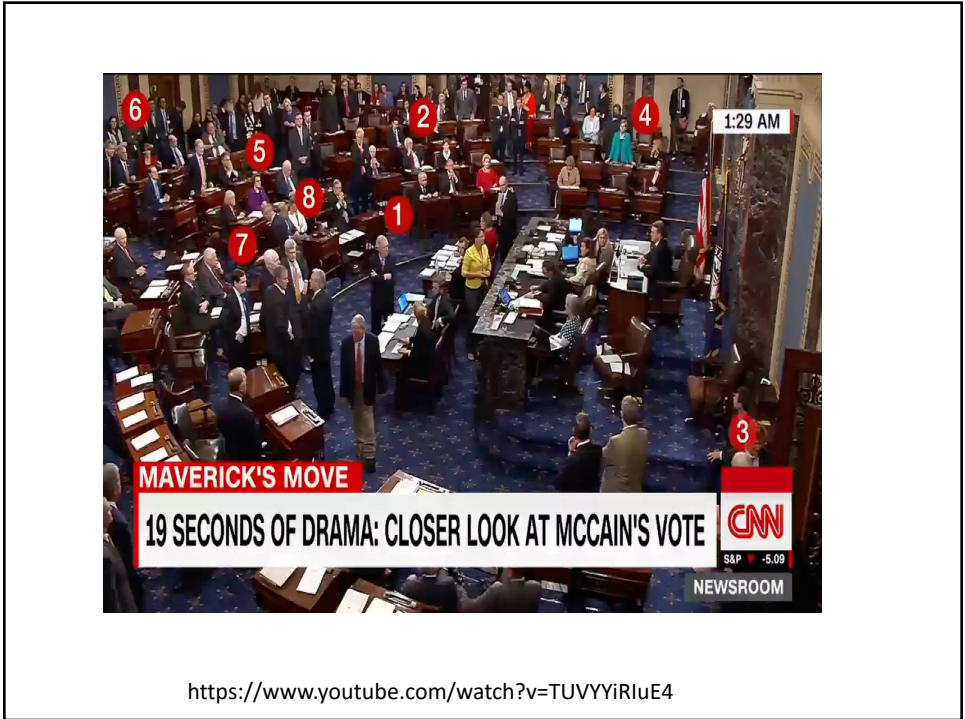
John Nash, Nobel Prize (1994)

The slide features a pink geometric pattern on the right side.

9


<div style="background-color: #4a7ebb; color: white; padding: 10px; border-radius: 10px; display: inline-block;"> Nash Equilibrium </div>	YEAs ---44		
	Baldwin (D-WI) Bennet (D-CO) Blumenthal (D-CT) Booker (D-NJ) Boxer (D-CA) Brown (D-OH) Cantwell (D-WA) Cardin (D-MD) Carper (D-DE) Casey (D-PA) Coons (D-DE) Donnelly (D-IN) Durbin (D-IL) Feinstein (D-CA) Franken (D-MN)	Gillibrand (D-NY) Heinrich (D-NM) Hirono (D-HI) Kaine (D-VA) King (I-ME) Kirk (R-IL) Klobuchar (D-MN) Leahy (D-VT) Markey (D-MA) McCaskill (D-MO) Menendez (D-NJ) Merkley (D-OR) Mikulski (D-MD) Murphy (D-CT) Murray (D-WA)	Nelson (D-FL) Peters (D-MI) Reed (D-RI) Reid (D-NV) Sanders (I-VT) Schatz (D-HI) Schumer (D-NY) Shaheen (D-NH) Stabenow (D-MI) Udall (D-NM) Warner (D-VA) Warren (D-MA) Whitehouse (D-RI) Wyden (D-OR)
	NAYs ---56		
	Alexander (R-TN) Ayotte (R-NH) Barrasso (R-WY) Blunt (R-MO) Boozman (R-AR) Burr (R-NC) Capito (R-WV) Cassidy (R-LA) Coats (R-IN) Cochran (R-MS) Collins (R-ME) Corker (R-TN) Cornyn (R-TX) Cotton (R-AR) Crapo (R-ID) Cruz (R-TX) Daines (R-MT) Enzi (R-WY) Ernst (R-IA)	Fischer (R-NE) Flake (R-AZ) Gardner (R-CO) Graham (R-SC) Grassley (R-IA) Hatch (R-UT) Heitkamp (D-ND) Heller (R-NV) Hoeven (R-ND) Inhofe (R-OK) Isakson (R-GA) Johnson (R-WI) Lankford (R-OK) Lee (R-UT) Manchin (D-WV) McCain (R-AZ) McConnell (R-KY) Moran (R-KS) Murkowski (R-AK)	Paul (R-KY) Perdue (R-GA) Portman (R-OH) Risch (R-ID) Roberts (R-KS) Rounds (R-SD) Rubio (R-FL) Sasse (R-NE) Scott (R-SC) Sessions (R-AL) Shelby (R-AL) Sullivan (R-AK) Tester (D-MT) Thune (R-SD) Tillis (R-NC) Toomey (R-PA) Vitter (R-LA) Wicker (R-MS)

10

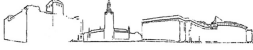


<https://www.youtube.com/watch?v=TUVYYiRluE4>

11



AAMAS 2018
STOCKHOLM



The Power of Context in Networks:
Ideal Point Models with Social
Interactions

With Tucker Gordon'17

“the most rewarding academic
experience of my time at Bowdoin”

12

Ideal Point Model w/ Social Interactions

115TH CONGRESS
1ST SESSION **S. 1804**

To establish a Medicare-for-all national health insurance program.

IN THE SENATE OF THE UNITED STATES

SEPTEMBER 13, 2017
Mr. SANDERS (for himself, Mr. BALDWIN, Mr. BLENKIN, Mr. BOOKER, Mr. FRANZOSI, Mrs. GELMAN, Mr. HARRIS, Mr. HEINRICH, Ms. HIRONO, Mr. LEAHY, Mr. MURKIN, Mr. MURKULEY, Mr. SCHUMER, Mrs. SHARPER, Mr. UDALL, Ms. WARREN, and Mr. WHITEHOUSE) introduced the following bill, which was read twice and referred to the Committee on Finance:

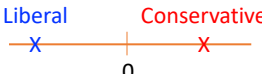
A BILL


To establish a Medicare-for-all national health insurance program.

1 *Be it enacted by the Senate and House of Representatives*

Topics or subjects

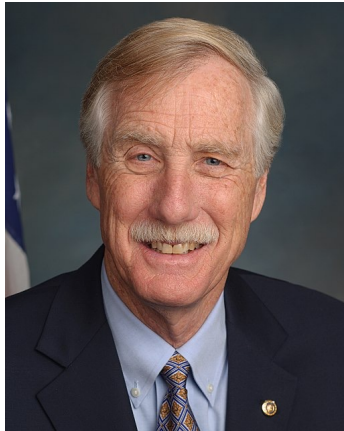
Polarity of the bill



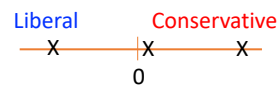


13

Ideal Point Model w/ Social Interactions



Ideal Point of Senator



14

Ideal Point Model w/ Social Interactions

- Influence function of Senator i for bill l

$$f_i(\mathbf{x}_{-i}, l) \equiv \sum_{j \in \mathcal{N}_i} \mathbf{w}_{ij} x_j - t_i + (p_i \cdot a_l)$$

Total incoming
influence

Threshold

Ideal point *
polarity

- Influence function $> 0 \rightarrow$ B.R. is to vote *yea*
- Influence function $< 0 \rightarrow$ B.R. is to vote *nay*
- Influence function $= 0 \rightarrow$ Indifferent

15

Bill & voting data

➔

115TH CONGRESS
1ST SESSION

S. 1804

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IN THE SENATE OF THE UNITED STATES

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Mr. SANDERS (for himself, Mr. BALDWIN, Mr. BLUMENTHAL, Mr. BOOKER, Mr. FRANZOSI, Mrs. GILLIBRAND, Mr. HARRIS, Mr. HEINRICH, Mr. HIRONO, Mr. LEAHY, Mr. MANNING, Mr. MENENDEZ, Mr. SCHUMER, Mrs. SHARHEEN, Mr. UDALL, Mr. WARREN, and Mr. WHITEHOUSE) introduced the following bill; which was read twice and referred to the Committee on Finance:

A BILL

To establish a Medicare-for-all national health insurance program.

1 Be it enacted by the Senate and House of Representa-

Vote:	Alexander	Ayotte	Baldwin	
1	-1	-1	-1	1
2	1	1	1	1
3	1	1	1	-1
4	1	1	1	-1
5	1	1	1	-1
6	1	1	1	1

16

Data
➔

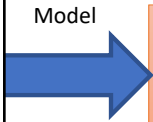
Machine Learning

➔

114th Senate: alpha-NOMINATE Ideal Point Estimates with 95% Credible Interval

17

Model



Compute equilibria

Baldwin (D-WI) Bennet (D-CO) Blumenthal (D-CT) Booker (D-NJ) Boxer (D-CA) Brown (D-OH) Cantwell (D-WA) Cardin (D-MD) Carper (D-DE) Casey (D-PA) Coons (D-DE) Donnelly (D-IN) Durbin (D-IL) Feinstein (D-CA) Franken (D-MN)	<p style="text-align: center;">YEAs ---44</p> Gillibrand (D-NY) Heinrich (D-NM) Hirono (D-HI) Kaine (D-VA) King (I-ME) Kirk (R-IL) Klobuchar (D-MN) Leahy (D-VT) Markey (D-MA) McCaskill (D-MO) Menendez (D-NJ) Merkley (D-OR) Mikulski (D-MD) Murphy (D-CT) Murray (D-WA)	Nelson (D-FL) Peters (D-MI) Reed (D-RI) Reid (D-NV) Sanders (I-VT) Schatz (D-HI) Schumer (D-NY) Shaheen (D-NH) Stabenow (D-MI) Udall (D-NM) Warner (D-VA) Warren (D-MA) Whitehouse (D-RI) Wyden (D-OR)
Alexander (R-TN) Ayotte (R-NH) Barrasso (R-WY) Blunt (R-MO) Boozman (R-AR) Burr (R-NC) Capito (R-WV) Cassidy (R-LA) Coats (R-IN) Cochran (R-MS) Collins (R-ME) Corker (R-TN) Cornyn (R-TX) Cotton (R-AR) Crapo (R-ID) Cruz (R-TX) Daines (R-MT) Enzi (R-WY) Ernst (R-IA)	<p style="text-align: center;">NAYs ---56</p> Fischer (R-NE) Flake (R-AZ) Gardner (R-CO) Graham (R-SC) Grassley (R-IA) Hatch (R-UT) Heitkamp (D-ND) Heller (R-NV) Hoeven (R-ND) Inhofe (R-OK) Isakson (R-GA) Johnson (R-WI) Lankford (R-OK) Lee (R-UT) Manchin (D-WV) McCain (R-AZ) McConnell (R-KY) Moran (R-KS) Murkowski (R-AK)	Paul (R-KY) Perdue (R-GA) Portman (R-OH) Risch (R-ID) Roberts (R-KS) Rounds (R-SD) Rubio (R-FL) Sasse (R-NE) Scott (R-SC) Sessions (R-AL) Shelby (R-AL) Sullivan (R-AK) Tester (D-MT) Thune (R-SD) Tillis (R-NC) Toomey (R-PA) Vitter (R-LA) Wicker (R-MS)

18

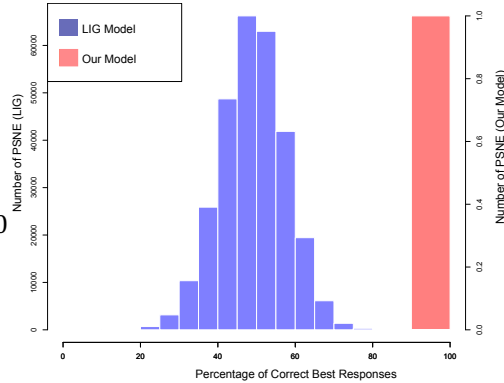
114th U.S. Senate

January 2015 – January 2017

19

Keystone XL Pipeline

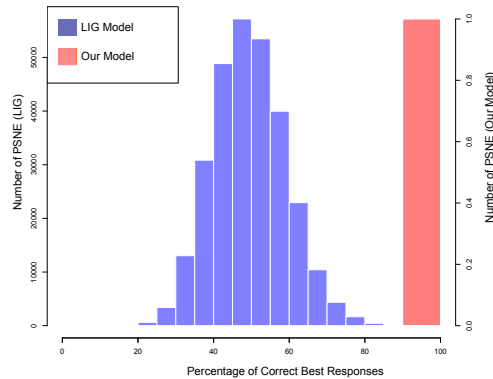
- Passed 62 - 36
- Polarity: 1.426
- Model without context:
 - 287,400 NE
 - Median correct votes: 50
 - 0.005% of eq. had at least 90
- Our model (with context):
 - Only one possible NE
 - 91 correct votes



22

Climate Change (Amdt. 777)

- Failed 49 - 50
- Polarity: -3.705
- Model without context:
 - 287,400 NE
 - Median correct votes: 50
 - 0.005% of eq. had at least 90
- Our model (with context):
 - Only one possible NE
 - 92 correct votes



23

Spheres Of Legislation: Polarization And Most Influential Nodes In Behavioral Context

Complex Networks (2019) and Computational Social Networks (2021)

With Andrew Phillips'19 & Luca Ostertag-hill'20



25

Different “spheres” of
legislation



Different networks

26

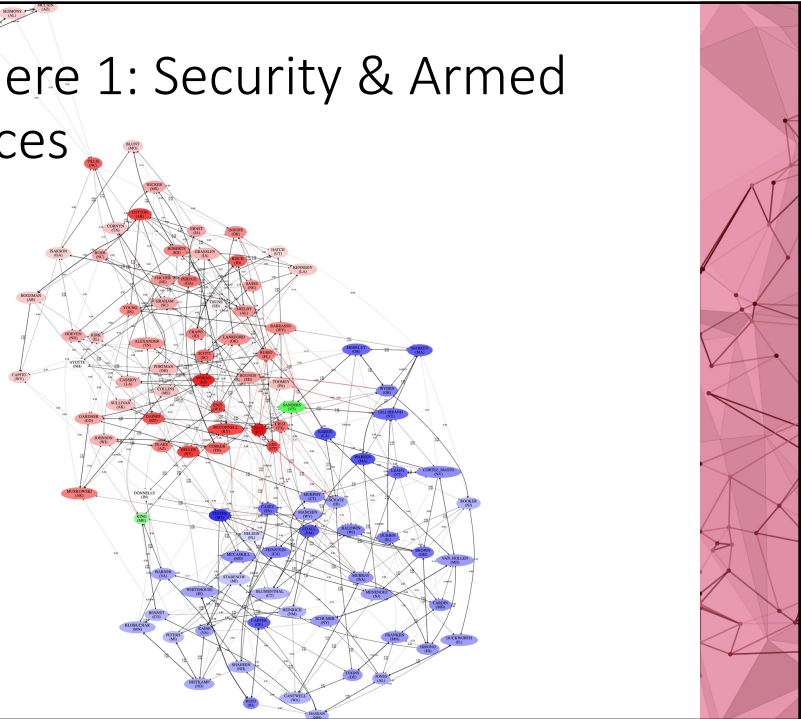
Spheres of Legislation

Sphere#	Size	Name of Sphere	Sampling of Bill Subjects
1	105	Security & Armed Forces	Armed forces and national security (77), Emergency management (11), Transportation and public works (10)
2	263	Economics & Finance	Economics and public finance (263)
3	284	Energy & Infrastructure	Energy (69), Education (31), Taxation (28), Transportation and public works (27)
4	313	Public Welfare	Health (52), Crime and law enforcement (43), Taxation (38), Education (31)

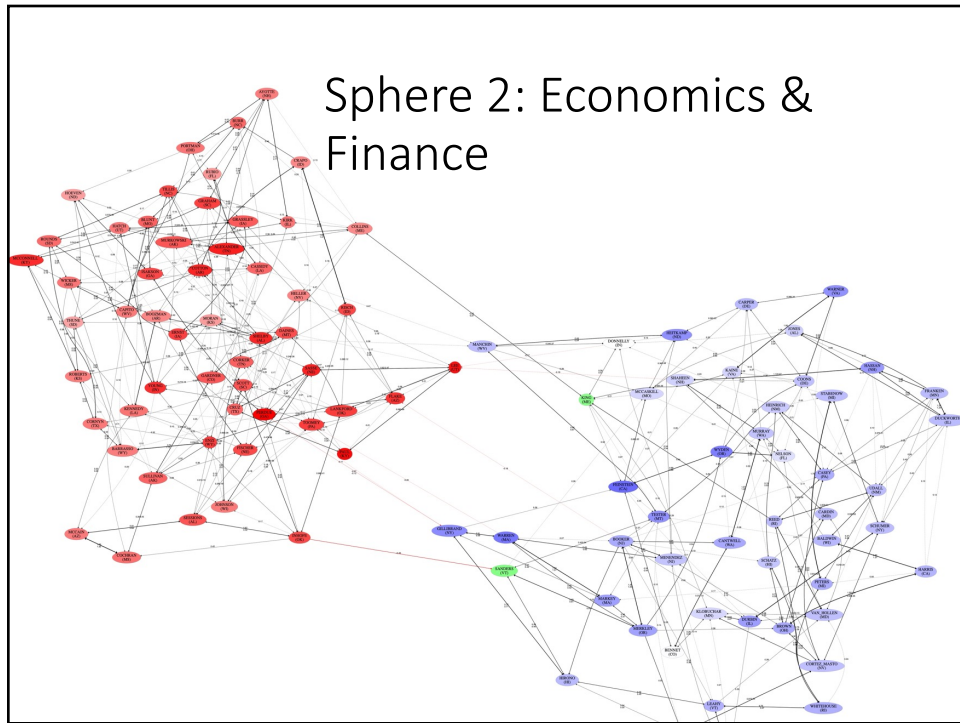
114th and 115th Senate
(Jan 2015 – Jan 2019)

27

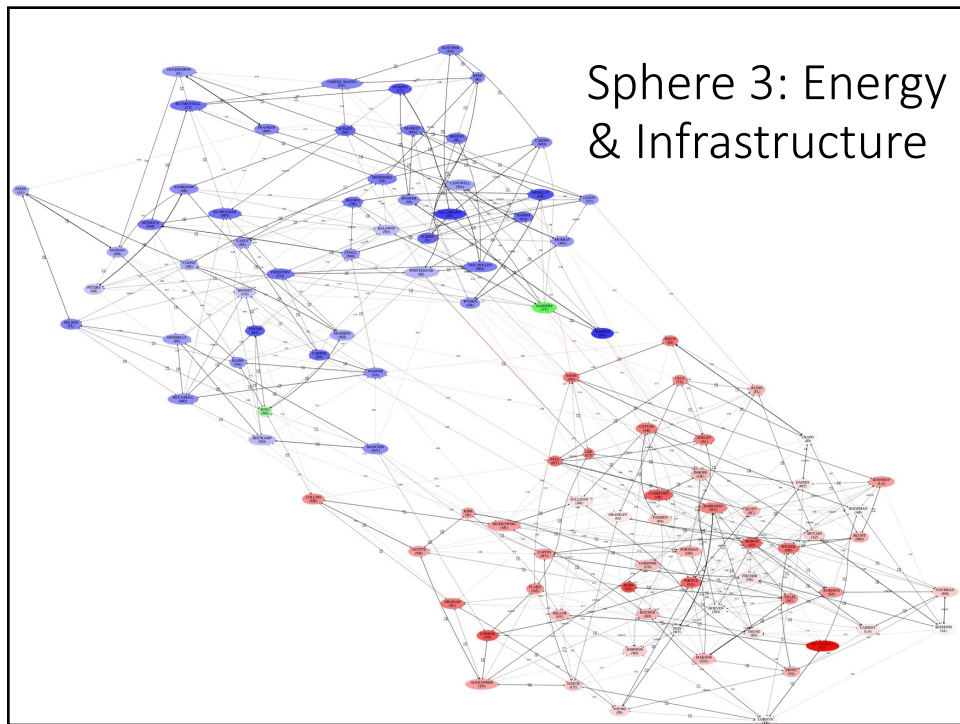
Sphere 1: Security & Armed Forces



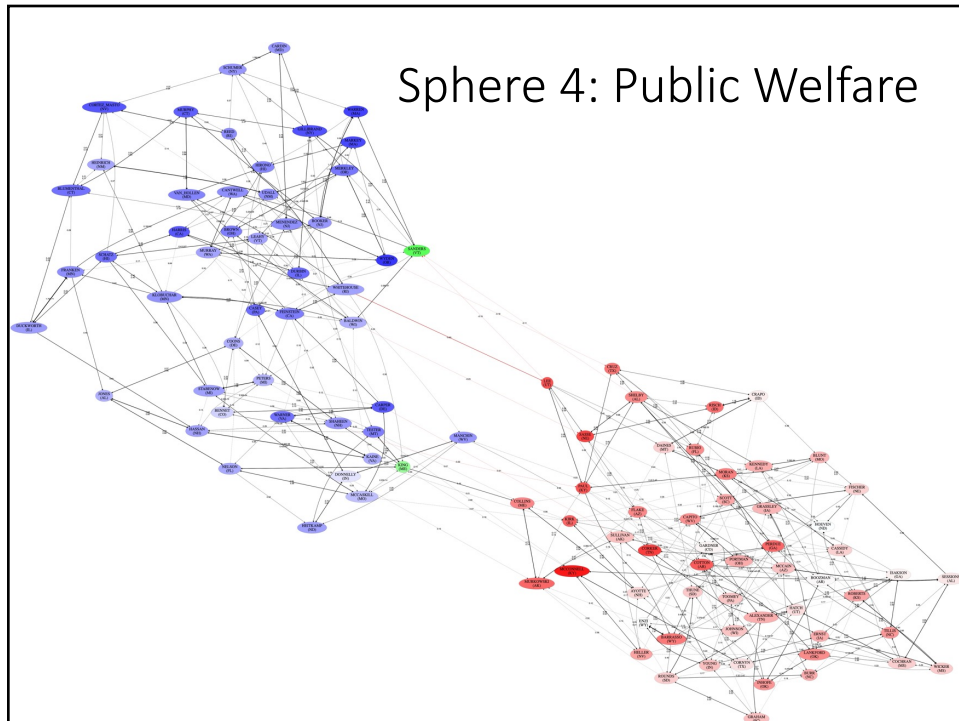
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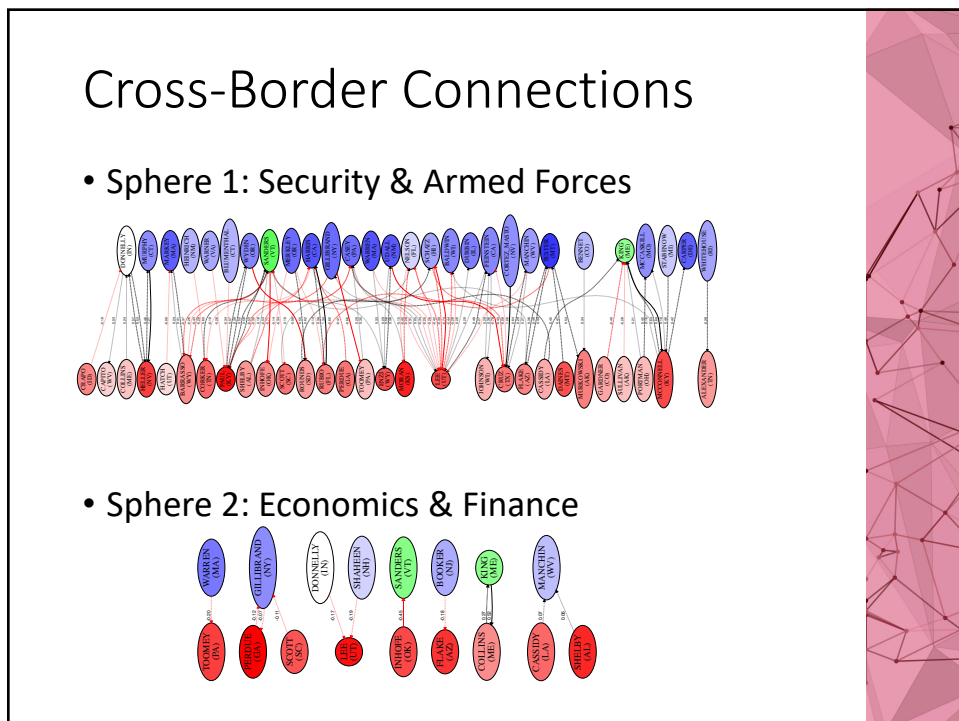
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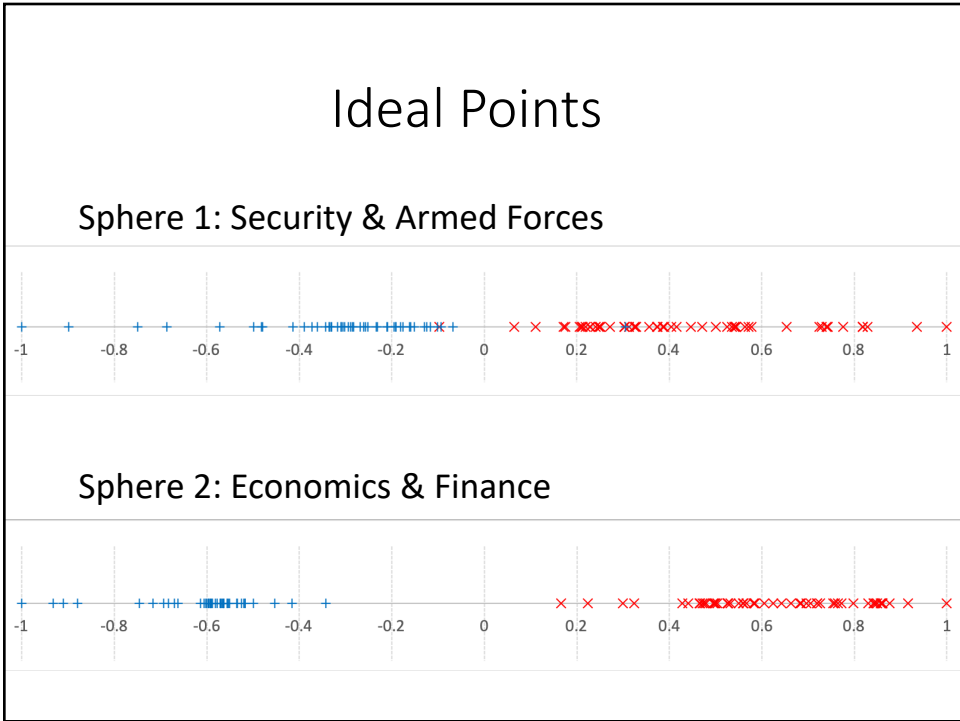
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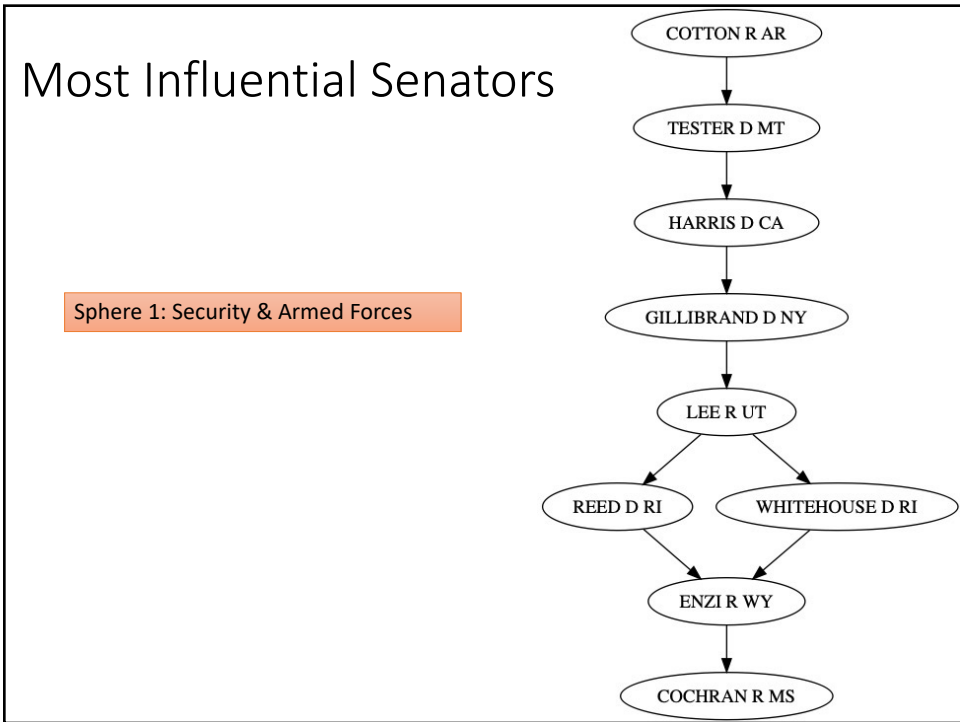
31



32



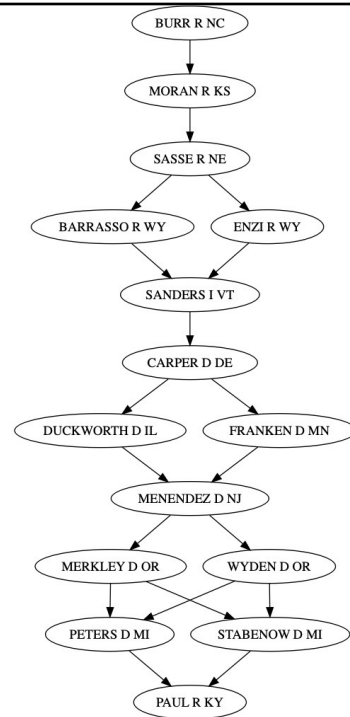
33



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Most Influential Senators

Sphere 3: Energy & Infrastructure



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Going Forward

1. The Challenge of Complexity
 - Toward Richer Models
2. The Reality of Dynamics
 - Toward Dynamic Influence Games
3. The Power of Context
 - Toward Context-Aware Influence Games



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