

Systems Governance

An Overview on a New Trend Applied to Societal Systems

Mo Mansouri



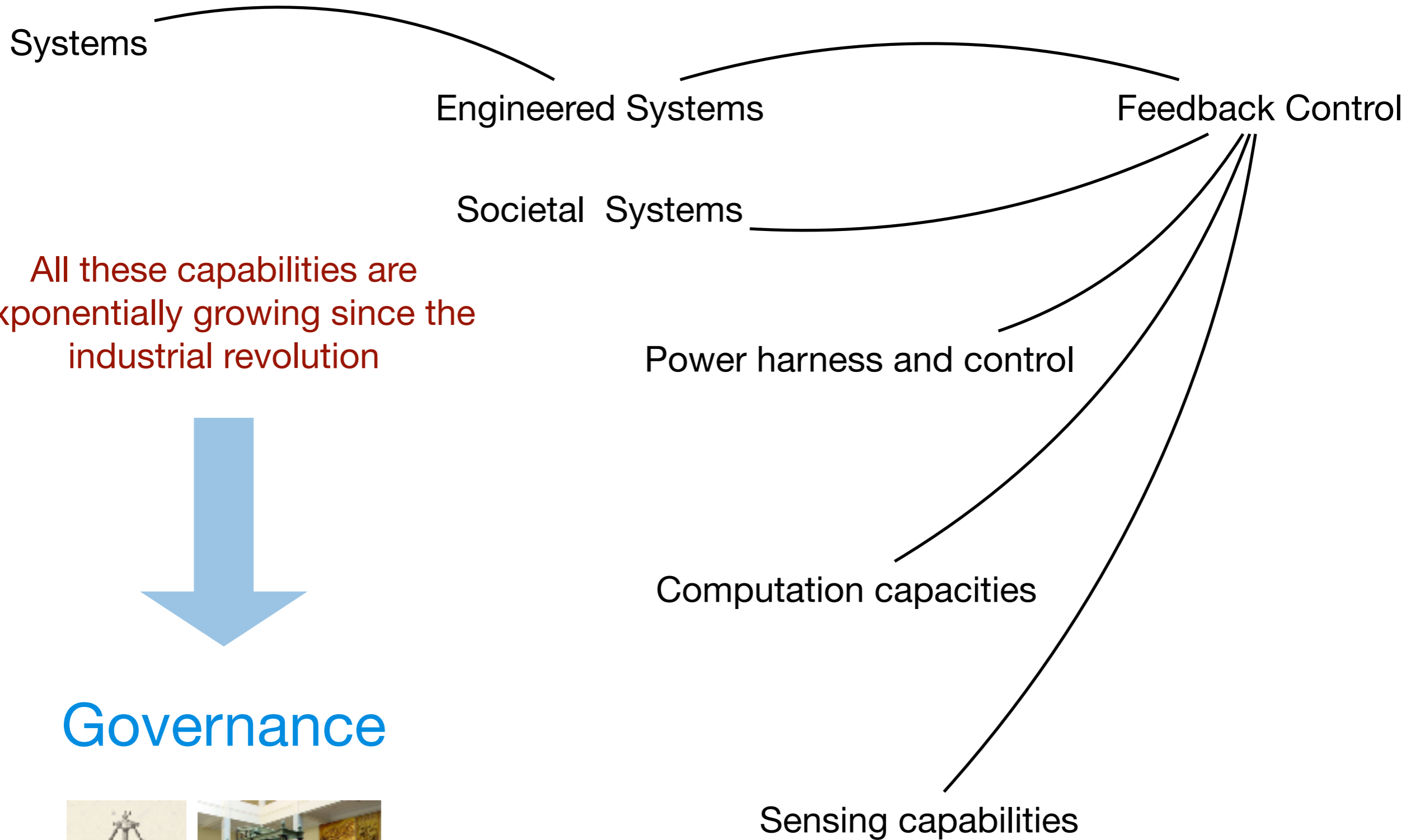
ISN University of
South-Eastern Norway

Stevens Institute of Technology
University of South-Eastern Norway

February 2020



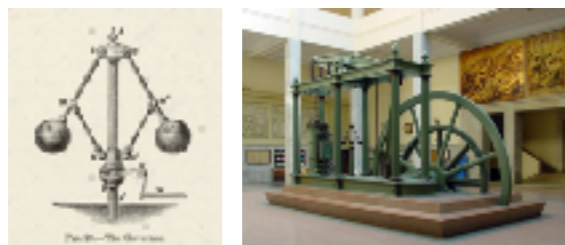
Systems Governance: An Overview on a New Trend Applied to Societal Systems



All these capabilities are exponentially growing since the industrial revolution



Governance

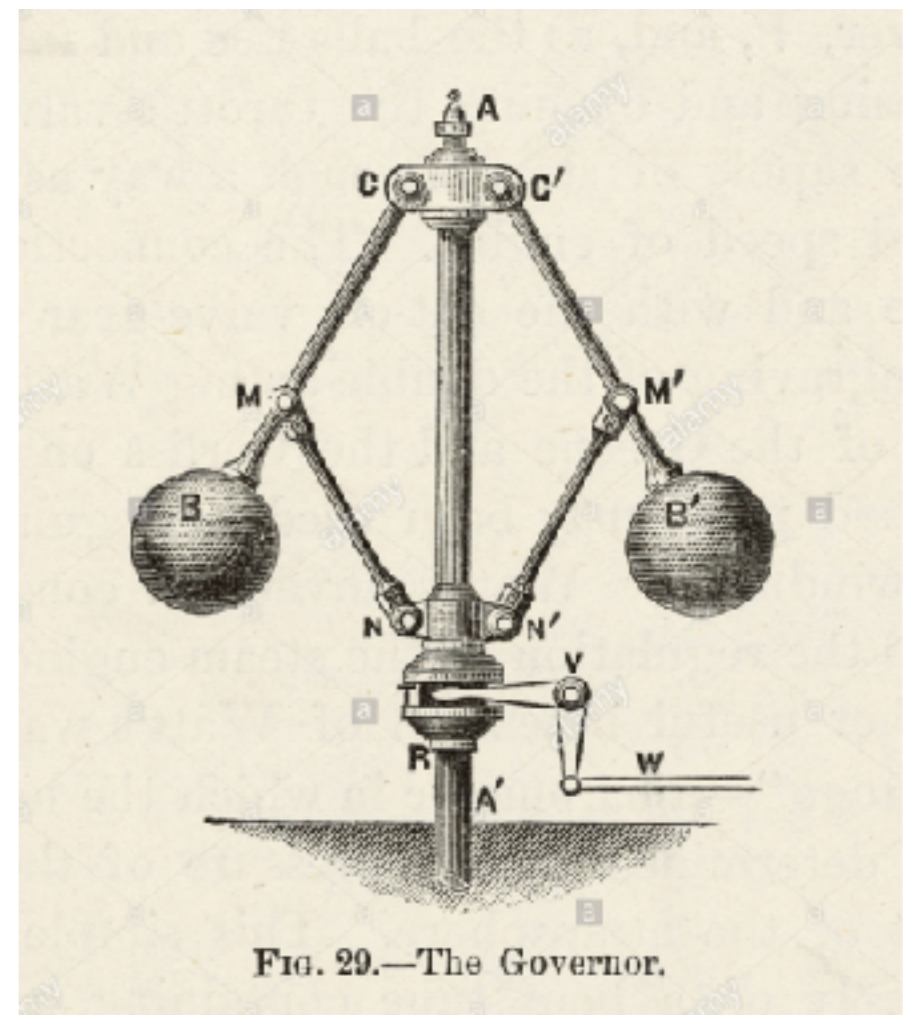
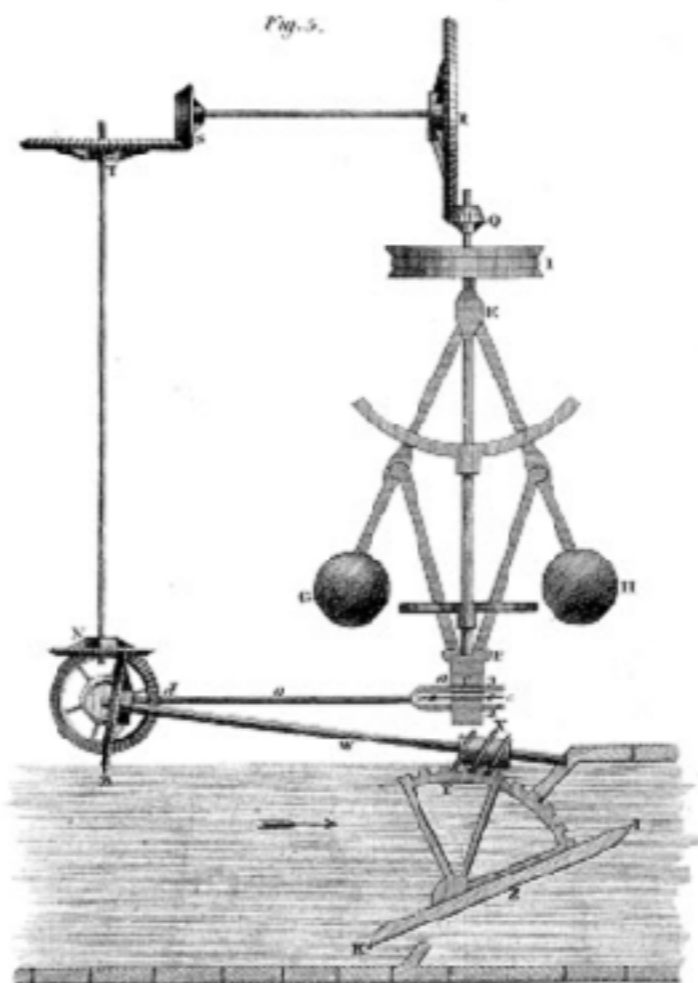
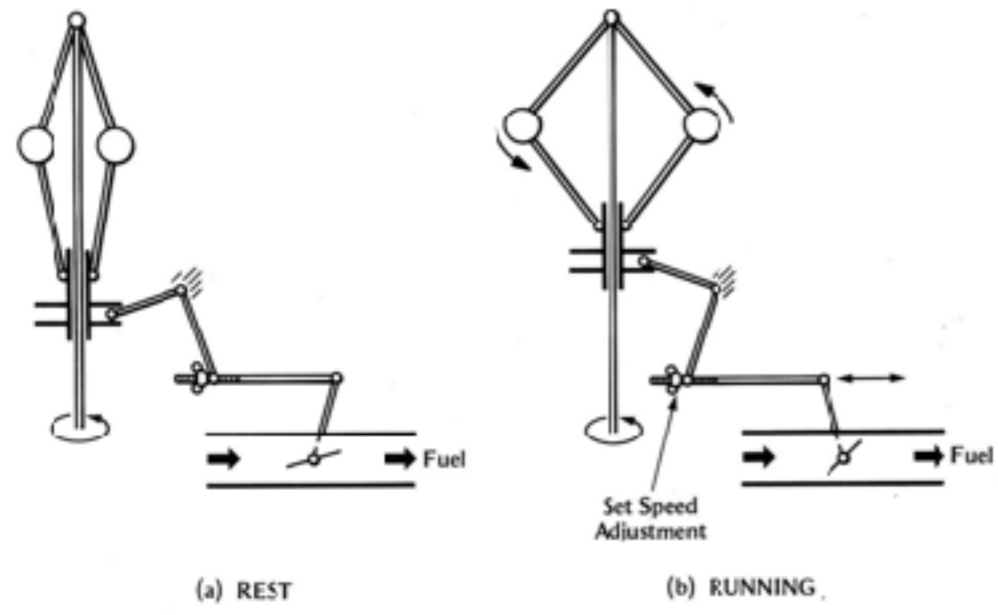


Governance

Boutlon and Watt
Steam Engine



Flyball Governor: runs at a constant speed regardless of any changes in systems environment!



A genius Solution with lots of shortcomings in responding effectively in face of sudden **fluctuations** and **oscillations**.

Why not bringing the same concept to a new context?

The case of Governing Fake News
(Ehsanfar and Mansouri, 2017)

On formulating pay off and mathematical modeling of fake news dissemination.

$$p_v(M) = \begin{cases} 1-c & \text{if } M \geq k \\ 1-a-c & \text{if } M < k \end{cases} \quad p_d(M) = \begin{cases} 1 & \text{if } M \geq k \\ 1-a & \text{if } M < k \end{cases}$$

$$p_v(k) = \begin{cases} 1-cf & \text{if } k \geq M \\ 1-a-cf & \text{if } k < M \end{cases} \quad p_d(k) = \begin{cases} 1 & \text{if } k \geq M \\ 1-a & \text{if } k < M \end{cases}$$

Regular agents: $\overline{P}_v(k) \quad \overline{P}_d(k)$

Fake news agents: $\overline{P}_v(M) \quad \overline{P}_d(M)$

April 5, 1868.

JOHN PETER GASSIOT, Esq., V.P., in the Chair.

It accords with the Statute, the names of the Candidates for election into the Society were read as follows:—

- | | |
|------------------------------------|---------------------------------------|
| Alexander Armstrong, M.D. | George Matthey, Esq. |
| John Baily, Esq., Q.D. | St. George Mirart, Esq. |
| John Ball, Esq., M.A. | Edward Chambers Nicholson, Esq. |
| Henry Clifton Bastien, M.D. | Thomas Namatky, Esq. |
| Samuel Brown, Esq. | Rev.-Admiral Erasmus Ommaney, |
| Lieut.-Colonel John Cameron, R.E. | C.B. |
| Charles Chambers, Esq. | Captain Sherard Osborn, R.N., C.E. |
| Frederic Le Gros Clark, Esq. | Rev. Stephen Parkinson, B.D. |
| Robert Bellamy Clifton, Esq., M.A. | James Bell Pettigrew, M.D. |
| George Crockett, Esq. | Charles Bland Radcliffe, M.D. |
| Morgan William Croton, Esq., B.A. | John Russell Reynolds, M.D. |
| Bernett Davis, M.D. | Vice-Admiral Robert Spencer Robinson. |
| Joseph Bernard Davis, M.D. | Edward Henry Sleveking, M.D. |
| Henry Dixon, Esq. | Edward James Stone, Esq., M.A. |
| P. Martin Dimeson, M.D. | Colonel Henry Edward Leader |
| William Eason, Esq., M.A. | Threllet, B.A. |
| Alexander Fleming, M.D. | Rev. Henry Baker Tristram, M.A. |
| George Garry Foster, Esq., B.A. | Edward Burnett Tylor, Esq. |
| Peter Le Neve Foster, Esq., M.A. | William Satcha Wright Vaux, Esq., |
| Sir Charles Fox. | M.A. |
| Edward Hamilton Greenhow, M.D. | Augustus Voelcker, Esq., Ph.D. |
| Peter Gieson, Esq. | Edward Walker, Esq., M.A. |
| Augustus George Vernon Hancock, | George Charles Wallen, M.D. |
| Esq. | J. Alfred Wandlyn, Esq. |
| Edmund Thomas Higgins, Esq. | Edward John Vining, M.D. |
| William Charles Hood, M.D. | Henry Wilde, Esq. |
| George Johnson, M.D. | Samuel Wilks, M.D. |
| Rev.-Admiral Ashley Cooper Key, | Henry Worms, Esq. |
| C.E. | |
| David Nindouglis, M.I. | |

The following communications were read:—

I. "On Governors." By J. Clerk Maxwell, M.A., F.R.S.E., & R. Received Feb. 20, 1868.

A Governor is a part of a machine by means of which the velocity of the machine is kept nearly uniform, notwithstanding variations in the driving-power or the resistance.

James Clerk Maxwell

On stability of governors using mathematical models, which lead to a the new field of **Control Theory**.

Now, let A be a function of another variable ϕ (the divergence of the centrifugal piece), and let the kinetic energy of the whole be

$$\frac{1}{2} A \frac{d\phi}{dt}^2 + \frac{1}{2} B \frac{d\psi}{dt}^2,$$

where B may also be a function of ϕ , if the centrifugal piece is complex.

If we also assume that P, the potential energy of the apparatus, is a function of ϕ , then the force tending to diminish ϕ , arising from the action of gravity, springs, &c., will be $\frac{dP}{d\phi}$.

The whole energy, kinetic and potential, is

$$E = \frac{1}{2} A \frac{d\phi}{dt}^2 + \frac{1}{2} B \frac{d\psi}{dt}^2 + P = f(\phi). \quad (2)$$

Differentiating with respect to t , we find

$$\left. \begin{aligned} \frac{d\phi}{dt} \left\{ \frac{dA}{dt} \frac{d\phi}{dt} + \frac{1}{2} \frac{dB}{dt} \frac{d\psi}{dt} + \frac{dP}{d\phi} \right\} + A \frac{d\phi}{dt} \frac{d^2\phi}{dt^2} - B \frac{d\psi}{dt} \frac{d^2\psi}{dt^2} \\ = \frac{dP}{d\phi} \end{aligned} \right\} \quad (3)$$

whence we have, by eliminating $\frac{dP}{d\phi}$,

$$\frac{d}{dt} \left(B \frac{d\psi}{dt} \right) = \frac{1}{2} \frac{dA}{d\phi} \frac{d\phi}{dt}^2 + \frac{1}{2} \frac{dB}{d\psi} \frac{d\psi}{dt}^2 - \frac{dP}{d\psi}. \quad (4)$$

The first two terms on the right-hand side indicate a force tending to increase ϕ , depending on the squares of the velocities of the main shaft and of the centrifugal piece. The force indicated by these terms may be called the centrifugal force.

If the apparatus is so arranged that

$$P = \frac{1}{2} A \omega^2 + \text{const.} \quad (5)$$

where ω is a constant velocity, the equation becomes

$$\frac{d}{dt} \left(B \frac{d\psi}{dt} \right) = \frac{1}{2} \frac{dA}{d\phi} \left(\frac{d\phi}{dt}^2 - \omega^2 \right) + \frac{1}{2} \frac{dB}{d\psi} \frac{d\psi}{dt}^2. \quad (6)$$

In this case the value of ϕ cannot remain constant unless the angular velocity is equal to ω .

A shaft with a centrifugal piece arranged on this principle has only one velocity of rotation without disturbance. If there be a small disturbance, the equations for the disturbances θ and ψ may be written

$$A \frac{d^2\theta}{dt^2} + \frac{dA}{d\phi} \omega \frac{d\theta}{dt} = L, \quad (7)$$

$$B \frac{d^2\psi}{dt^2} - \frac{dA}{d\phi} \omega \frac{d\psi}{dt} = 0. \quad (8)$$

The period of such small disturbances is $\frac{2\pi}{\omega} (AB)^{-\frac{1}{2}}$ revolutions of the

shaft. They will neither increase nor diminish if there are no other terms in the equation.

To convert this apparatus into a governor, let us assume viscosities X and Y in the motions of the main shaft and the centrifugal piece, and a resistance G ϕ applied to the main shaft. Putting $\frac{dA}{d\phi} = X$, the equations become

$$A \frac{d^2\theta}{dt^2} + X \frac{d\theta}{dt} + K \frac{d\psi}{dt} + G\phi = L, \quad (9)$$

$$B \frac{d^2\psi}{dt^2} + Y \frac{d\psi}{dt} - K \frac{d\theta}{dt} = 0. \quad (10)$$

The condition of stability of the motion indicated by these equations is that all the possible roots, or parts of roots, of the cubic equation

$$ABx^3 + (AY + BX)x^2 + (XY + K^2)x + GK = 0 \quad (11)$$

shall be negative, and this condition is

$$\left(\frac{X}{A} + \frac{Y}{B} \right) (XY + K^2) > GK. \quad (12)$$

Combination of Governors.—If the break of Thomson's governor is applied to a moveable wheel, as in Jenkin's governor, and if this wheel works a steam-valve, or a more powerful break, we have to consider the motion of three pieces. Without entering into the calculation of the general equations of motion of these pieces, we may confine ourselves to the case of small disturbances, and write the equations

$$\left. \begin{aligned} A \frac{d^2\theta}{dt^2} + X \frac{d\theta}{dt} + K \frac{d\psi}{dt} + T\phi + J\dot{\psi} = P - H, \\ B \frac{d^2\psi}{dt^2} + Y \frac{d\psi}{dt} - K \frac{d\theta}{dt} = 0, \\ C \frac{d^2\phi}{dt^2} + Z \frac{d\phi}{dt} - T\phi = 0, \end{aligned} \right\} \quad (13)$$

where θ , ψ , ϕ are the angles of disturbance of the main shaft, the centrifugal arm, and the moveable wheel respectively, A, B, C their moments of inertia, X, Y, Z the viscosity of their connections, K is what was formerly denoted by $\frac{dA}{d\phi}$, and T and J are the powers of Thomson's and Jenkin's breaks respectively.

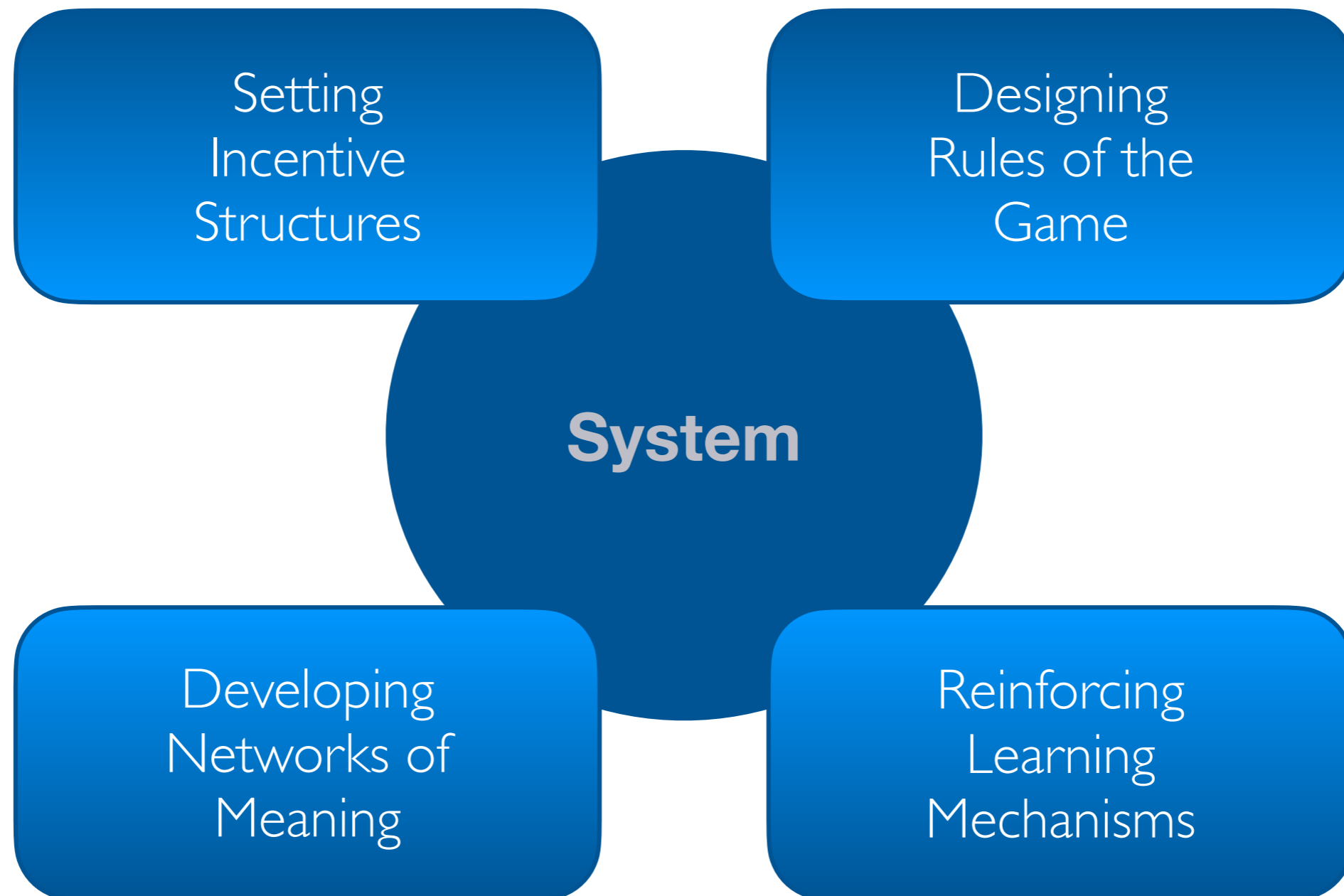
The resulting equation in n is of the form

$$\begin{vmatrix} An^2 + Xn & Kn + T & J \\ -K & Bn + Y & 0 \\ 0 & -T & Cn^2 + Zn \end{vmatrix} = 0, \quad (14)$$

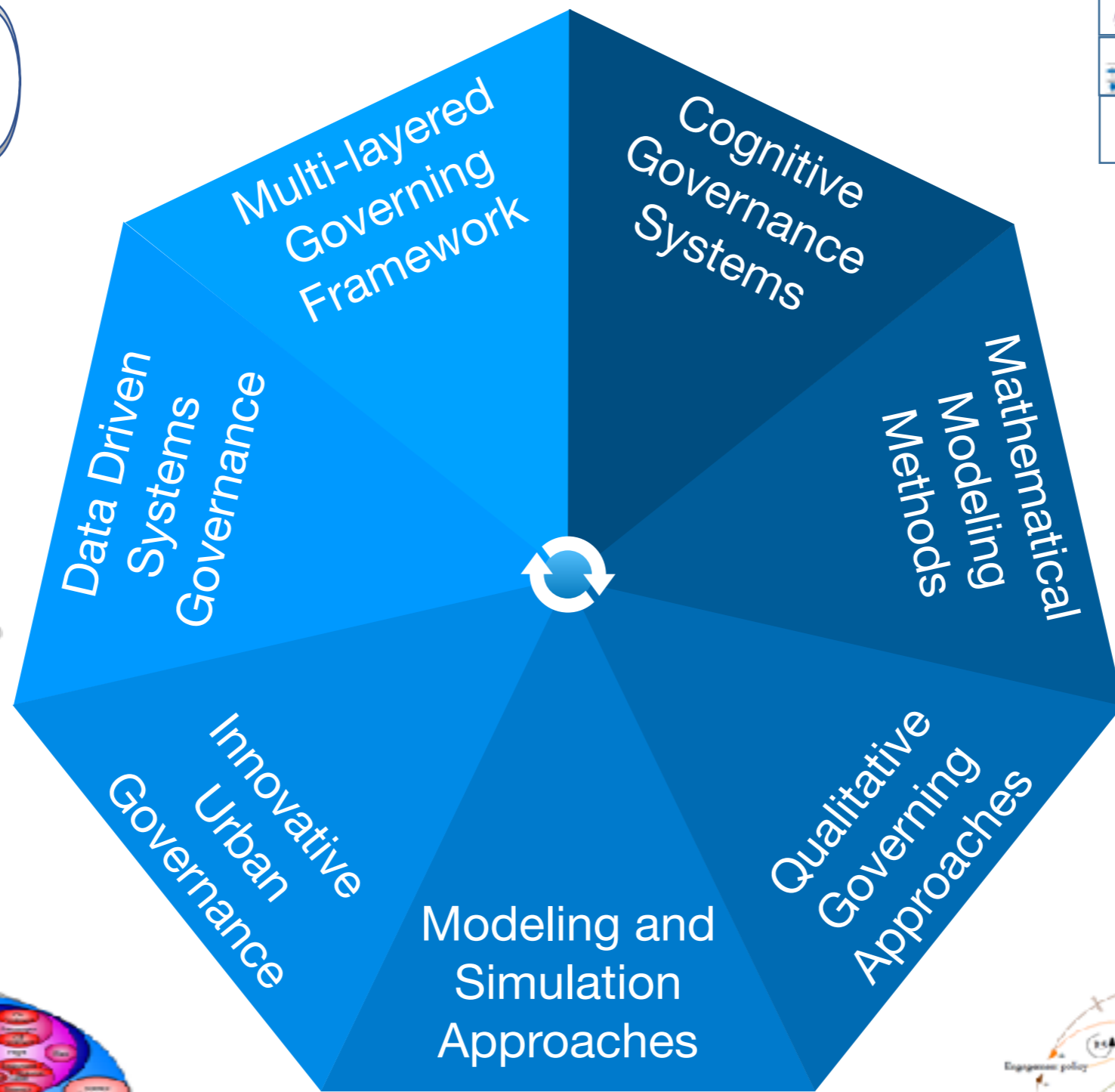
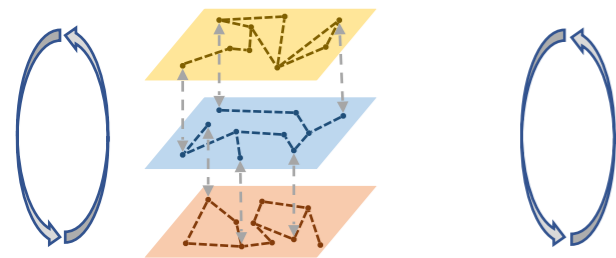
$$\text{or } n^3 + n^2 \left(\frac{X}{A} + \frac{Y}{B} + \frac{Z}{C} \right) + n \left[\frac{XYZ}{ABC} \left(\frac{A}{X} + \frac{B}{Y} + \frac{C}{Z} \right) + \frac{K^2}{AB} \right] + \frac{K}{ABC} \left(\frac{XYZ}{ABC} + \frac{KTZ}{ABC} + \frac{KTZ}{ABC} \right) = 0. \quad (15)$$

Governance of Societal Systems

Implementation of governing policies through:



Understanding the Nature of the Beast



$$p_v(M) = \begin{cases} 1-c & \\ 1-a-c & \end{cases} \quad p_d(M) = \begin{cases} 1 & \text{if } M \geq k \\ 1-a & \text{if } M < k \end{cases}$$

$$p_v(k) = \begin{cases} 1-cf & \\ 1-a-cf & \end{cases} \quad p_d(k) = \begin{cases} 1 & \text{if } k \geq M \\ 1-a & \text{if } k < M \end{cases}$$

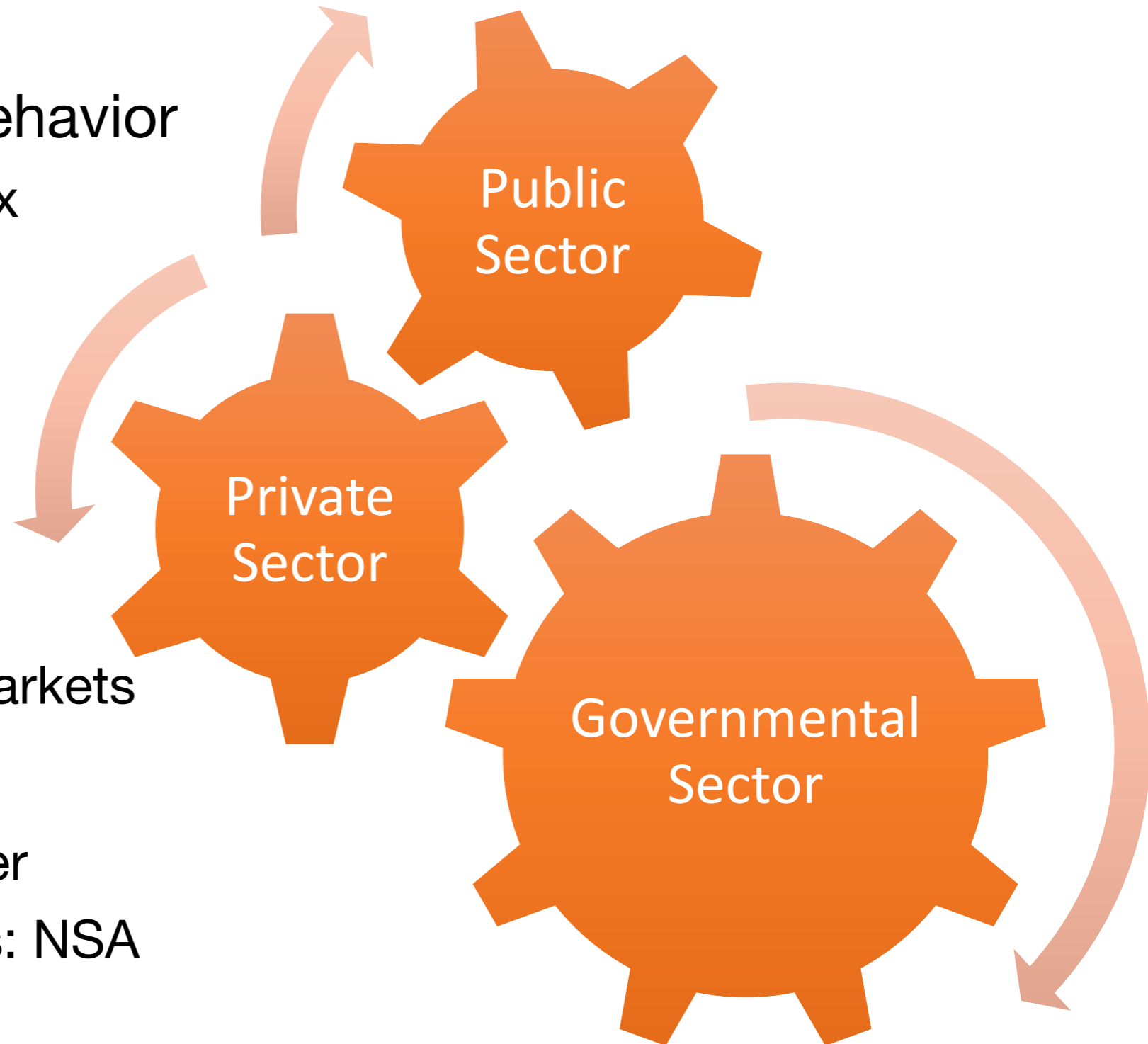
$$\overline{P}_v(k) \quad \overline{P}_d(k)$$

$$\overline{P}_v(M) \quad \overline{P}_d(M)$$



Trends in Data Science Approach to Governance

- High frequency data analytics
 - Financial systems
- Discovering patterns of behavior
 - Topological analysis: Netflix
 - Relational analysis: Target
- Users profiling
 - Marketing
 - Politics
 - Policymaking
 - Designing products and markets
- Conceptual analytics
 - Influencing behavior: Twitter
 - Text/Voice/Pattern analysis: NSA



Cities as Complex Systems

Holistic approach

Equilibrium and dynamics

Patterns and processes

Paradoxes and conflicts

Behavioral patterns

Collective actions

Agency and emergency

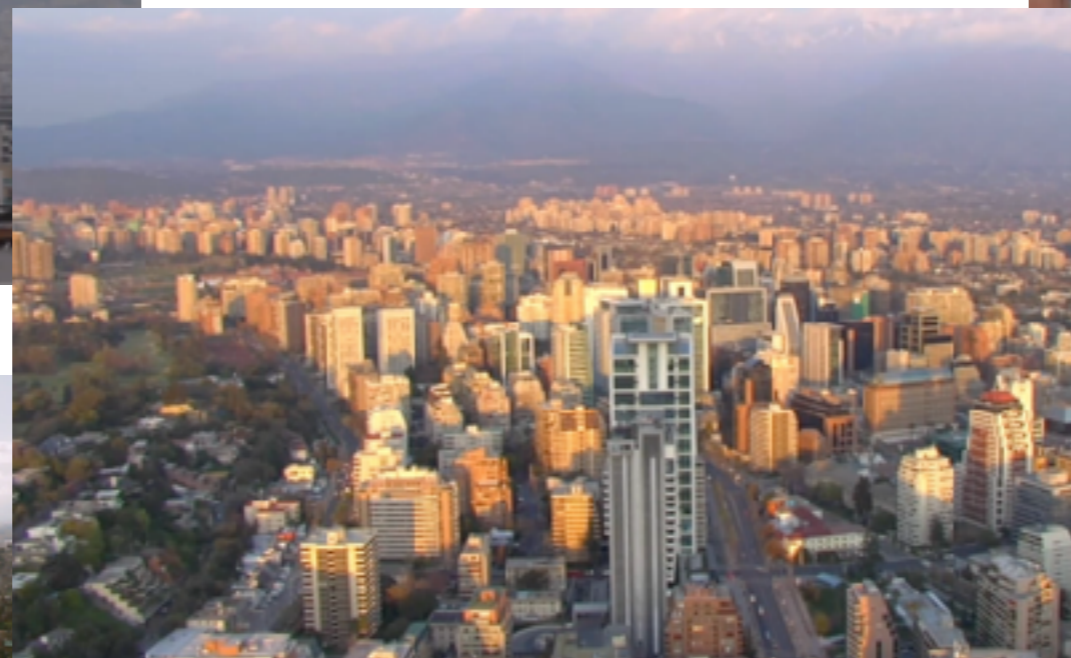
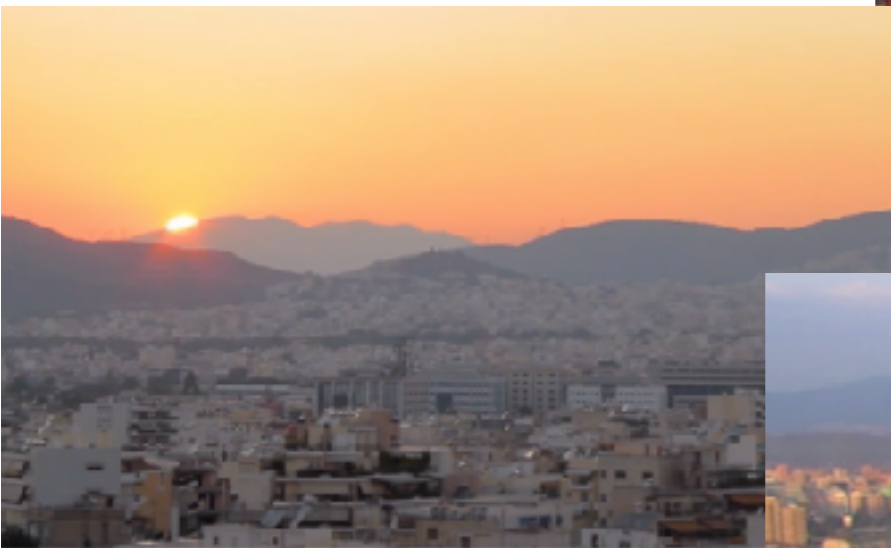
Connectivity and diversity

Autonomy and belonging

Competition and collaboration

Accessibility and segregation

Cities as a Platform for Transactions



Change is necessary for survival!

- Technological advancements
 - Transportation
 - Healthcare
 - Energy
 - Finance
- Disasters
- Maintenance
- Environmental concerns



Influencing Behavior: Transportation Systems

Successful cases around the world

- Trans Millennium project in Bogota to incentivize bus riders
 - Flexible development and protection of public interest
- Bikers' lane project in Bogota
 - Allocating budget based on public need
- Sunday project in Bogota
 - Closing down a part of city to traffic for encouragement of pedestrians
- Copenhagen protective plan for bikers
 - 37% of all work related commutes are on bikes and the number of bikers has doubled in 10 years (by 2010)
- Paying attention to cognitive sciences
 - Horizontal sight senses
 - Feeling of belonging
 - Sensations of public joy



Influencing Behavior: Energy Systems

Case of Tidy St., Brighton

- Using a non-technological approach:
 - Self-reporting on the site
 - Street visualization
 - Door-to-door training
- Application of simple principles:
 - Communal engagement
 - Peer pressure as an incentive force
 - Public education on consumption
- Emergence of technology:
 - Using sensors and digital visualization
- Study patterns of social behavior:
 - Influence the collective action
 - Engagement and interaction



Sensing and Action: Smart City

Case of Rio De Janeiro

- Human-centric city sensing:
 - Cameras and sensors all over the city
 - Situation room with relevant representatives
 - Crisis management
 - Social assistance
 - Security and safety
 - Utility services monitoring
 - Infrastructural services monitoring
 - Integrated and real-time operation



Hoboken: A Urban Governing Lab

- Hoboken is the perfect candidate to experiment with a full-scale smart city implementation across all aspects of urban living.
- The strong institutional support of the City government is key to the success of the project.
- First project of this scope in the U.S.



Fact Sheet

- Population (2011): 50,060.
- % change since 2000: +29.8%
- Median resident age: 31.2 years
- Median household income (2009): \$112,174
- Median NJ household income (2009): \$68,342
- Per capita income (2009): \$75,941
- Median home value (2009): \$579,045
- Cost of Living Index: 132



Sensing, Analyzing, and Learning

Improved Commuting Decisions



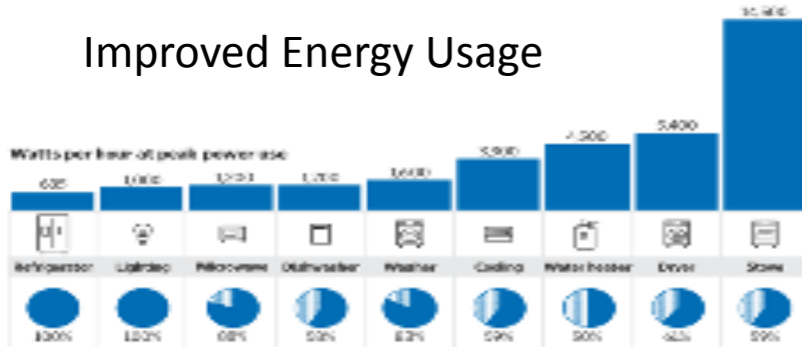
Improved Urban Governance and Participation



Improved Disaster Preparedness



Improved Energy Usage



Improved Urban Services



Strengthened Healthcare Delivery and Public Health



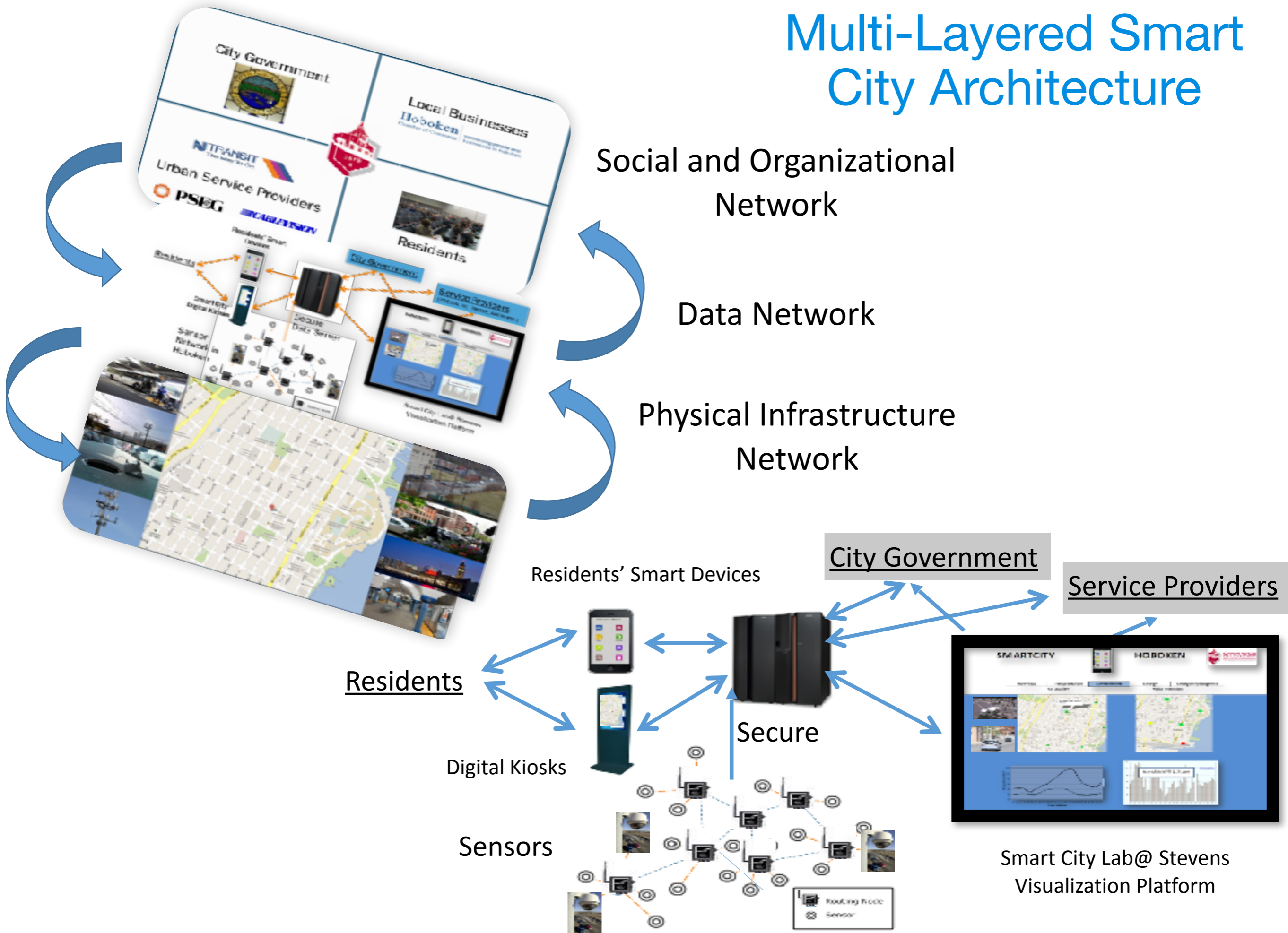
Strengthened Local Economy and Solutions Exchange



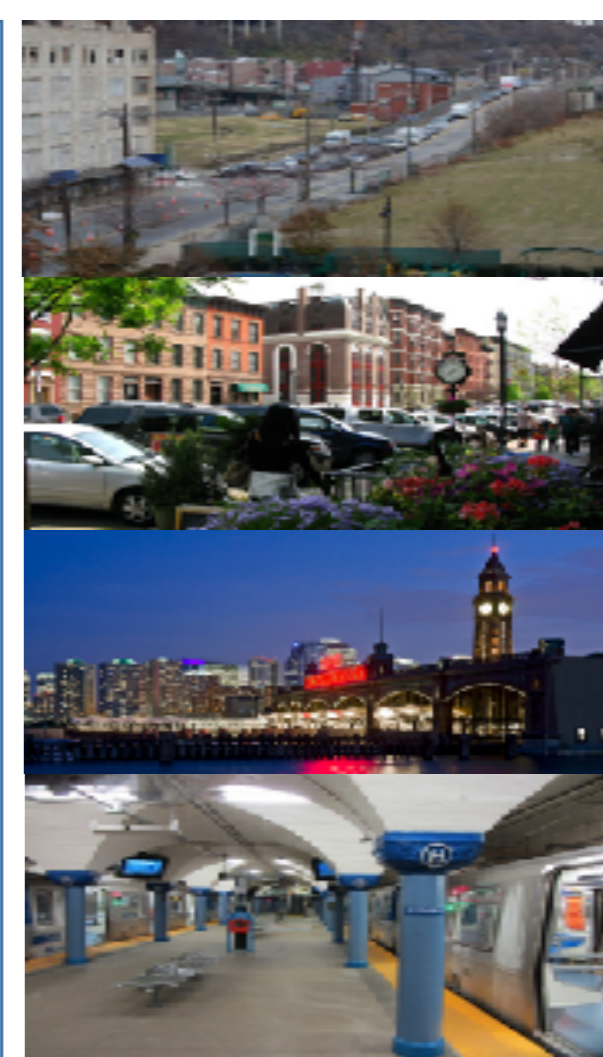
Strengthened Community



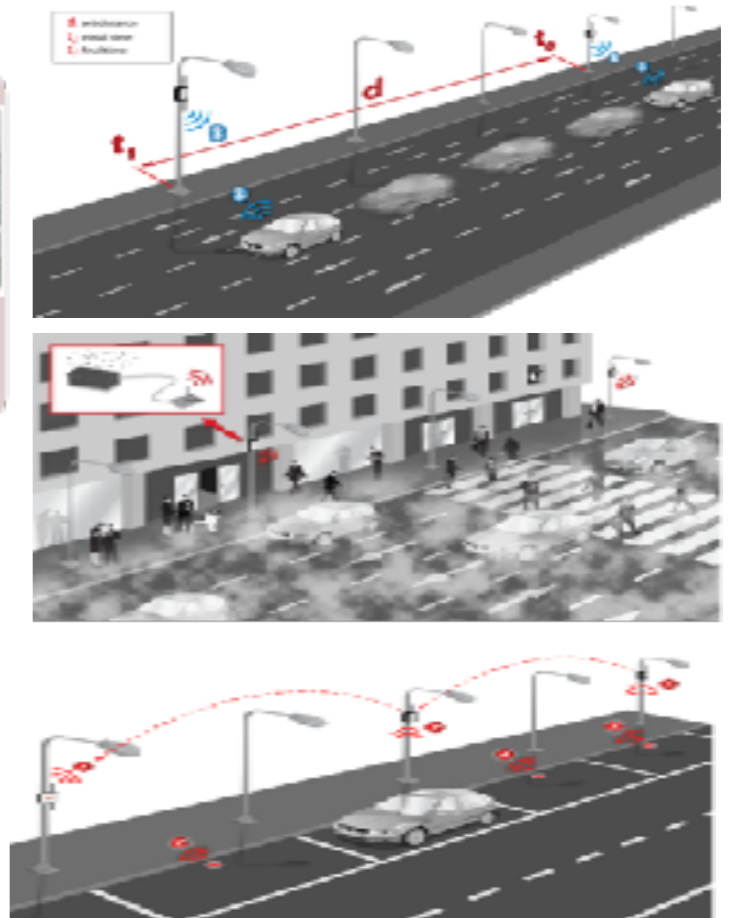
Multi-Layered Smart City Architecture



Plot



Security and Emergencies	Transportation and Infrastructure	Water and Energy Consumption	Environment and Noise/Air Pollution
Pressure/Weight, Bend, Vibration, Impact, Hall Effect, Tilt, Temperature, Liquid Presence, Liquid Level, Luminosity, Presence (PIR), Stretch	Structural health, traffic monitoring and parking management, Accelerometer, latitude, longitude, altitude, speed, direction, data/time and handling of ephemerals, Magnetic Field, Crack detection gauge, Crack propagation gauge, Displacement linear	Smart metering, Current metering, Water flow, Liquid level, Load cell, Ultrasound, Distance Foil	CO, CO2, O2, CH4, H2, NH3, Isobutane, Ethanol, Toluene, Hydrogen Sulfide, Nitrogen Dioxide, Ozone, Hydrocarbons, Microphone (dB SPL), Dust, PM-10, Ultrasound (distance measurement), Temperature, Humidity, Pressure



Smart Cities App

Open Source Platform with more than 35 Smart City functionalities for use and customization by any city



App

Individual Data

- Transportation Choices and Parking Behavior
- Energy consumption and Household Carbon footprint
- Emergency and Disaster Situational Data
- Crime and emergency (fire, medical) reporting
- Urban infrastructure issues
- Lifestyle choice data and Innovations Exchange Data

Sensors

Real-time Data

- Traffic conditions
- Transit conditions
- Pedestrian flows
- Air Quality, Noise and GHG Emissions
- Flooding data
- Abnormal Activity

Archival

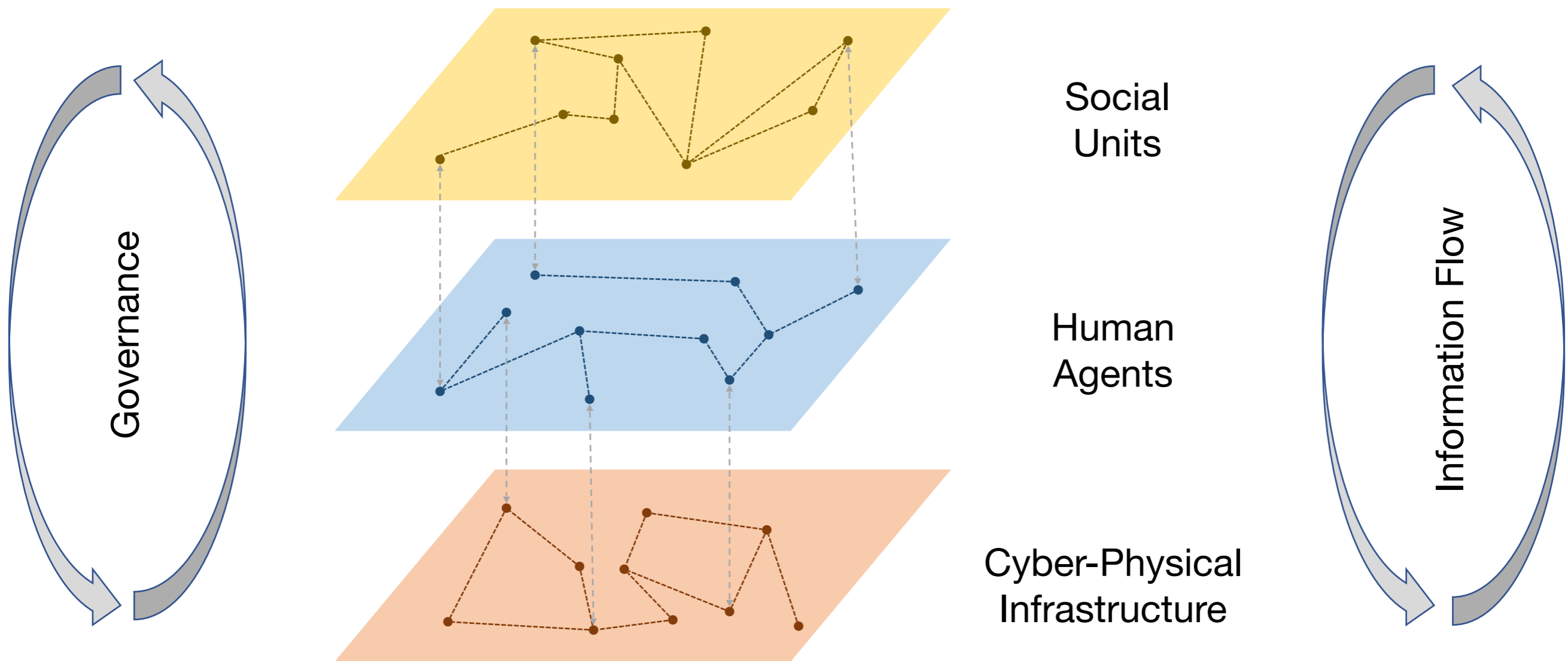
Historical Data

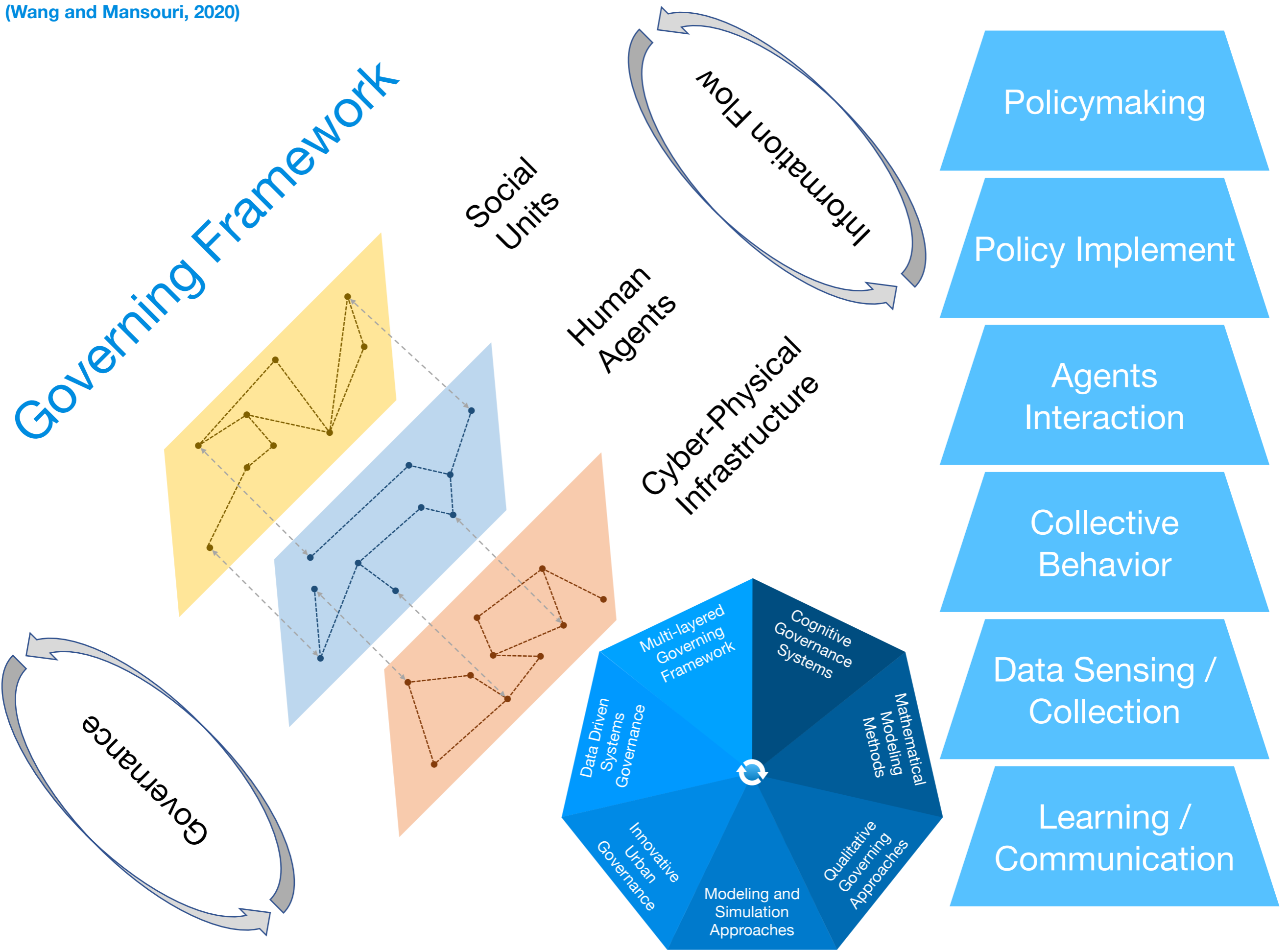
- Parking and accident data
- Fire and Police department reports
- Emergency planning data
- Flooding data (historical)
- Energy consumption data
- Health data
- Urban infrastructure maintenance data
- Startup and commercial activity data

Data Mining and Modeling

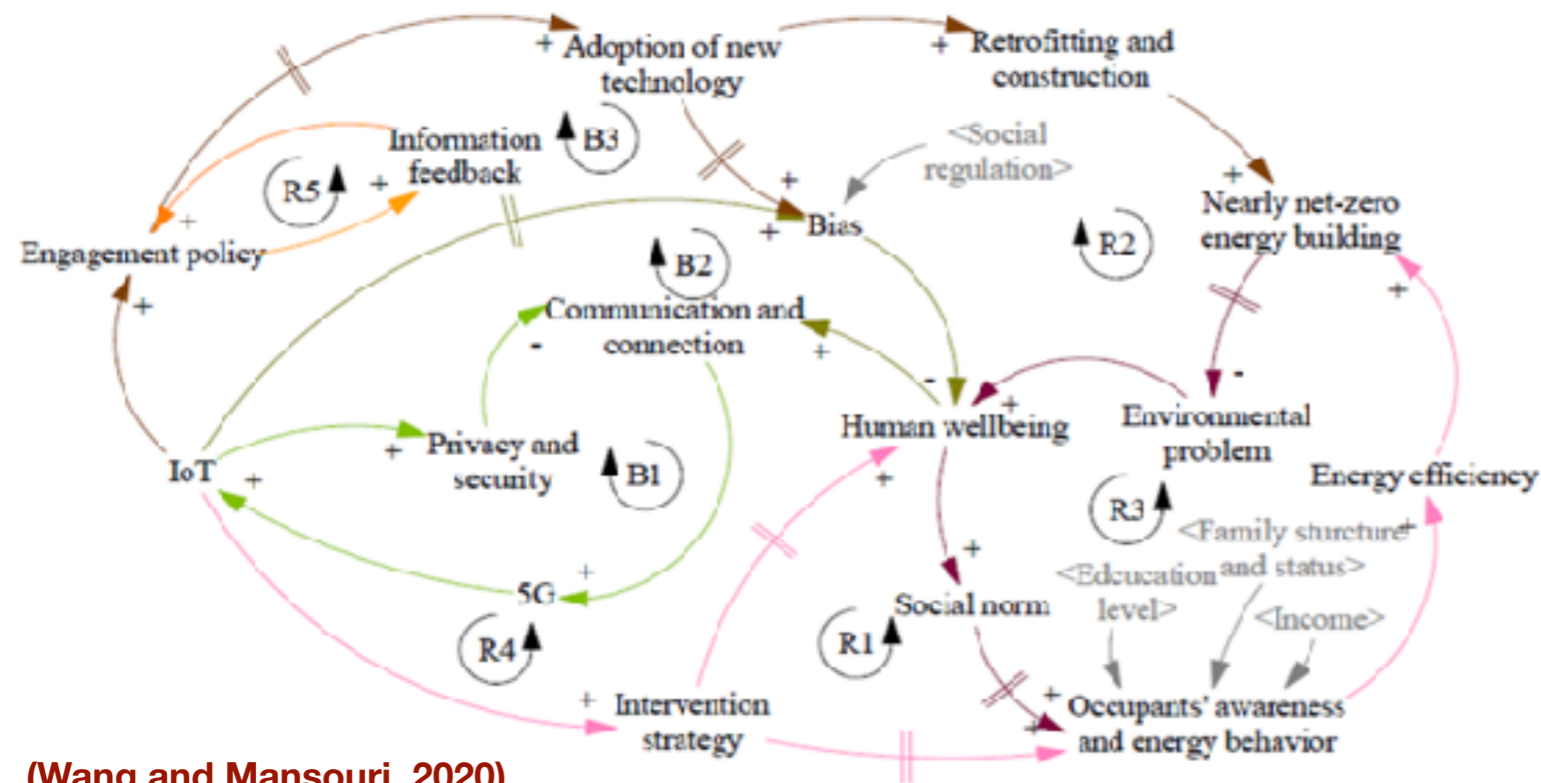
Multi-layered Governing Framework for Urban Systems

Dynamics and Hierarchical Structure





The case of Transportation: Advanced Traveler Information Systems

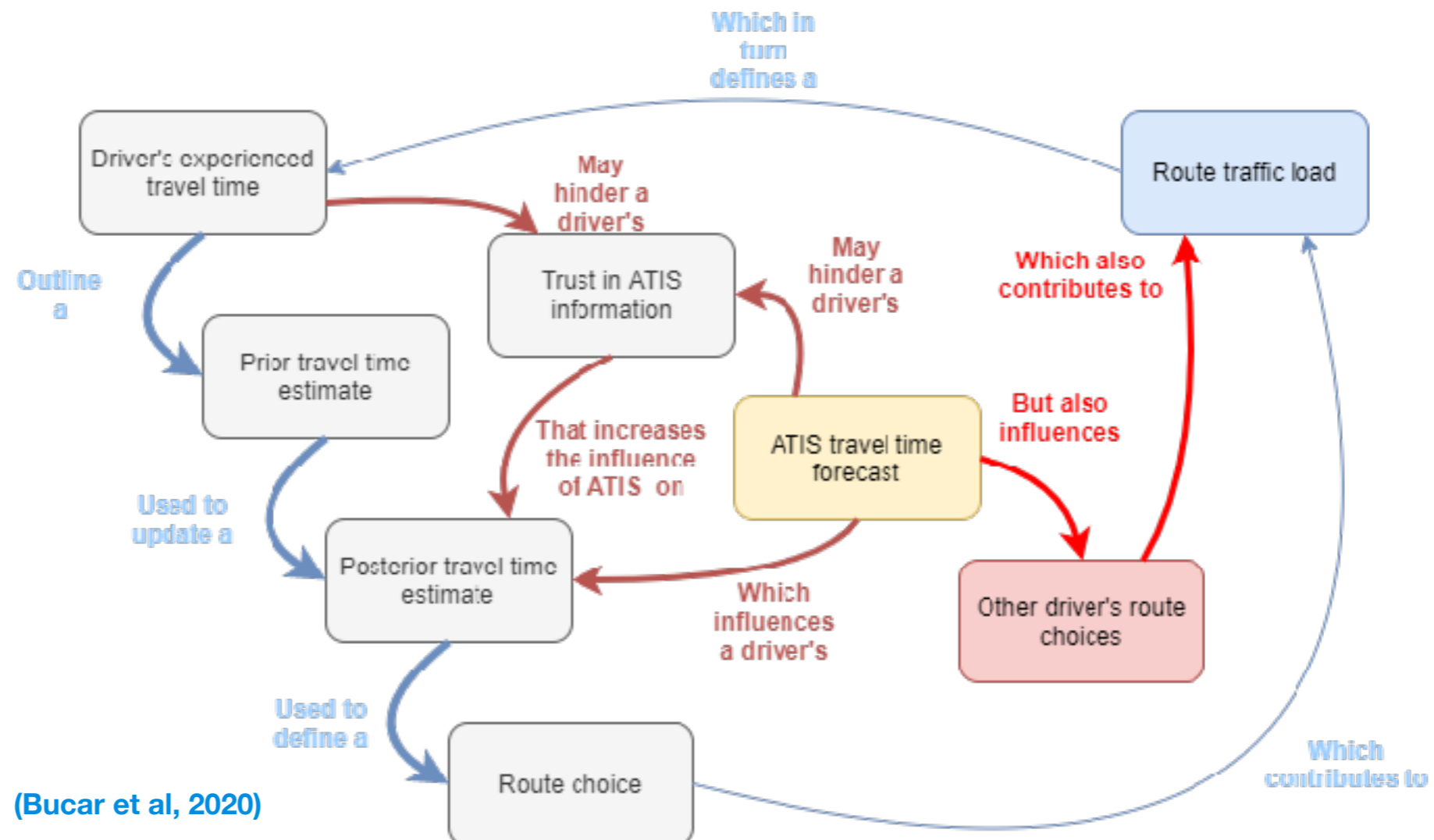


(Wang and Mansouri, 2020)

- A shared dynamic causal theory on collective behavior, policy, and technology: **The case of Energy Systems.**

- Social vs selfish equilibria: The Price of Anarchy

- Flash Crowd Effect: The Drawback of Perfect Information

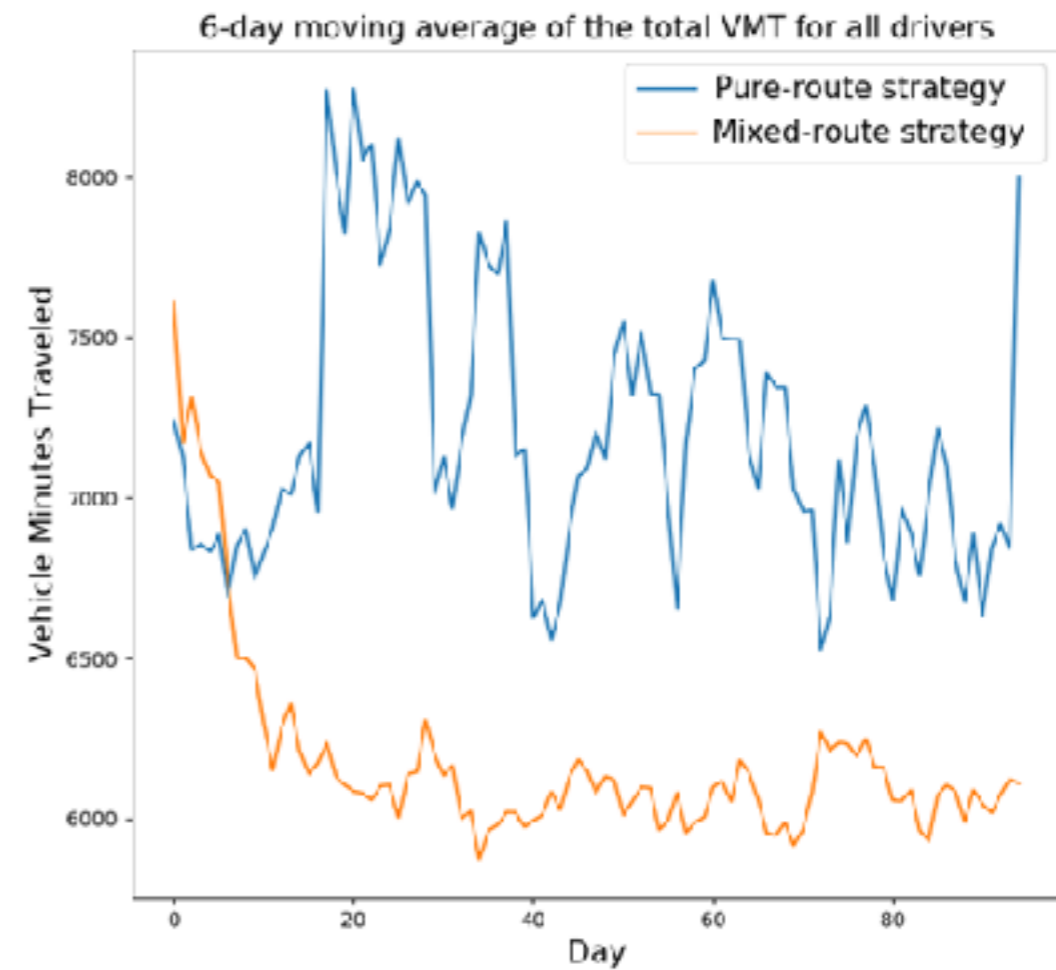
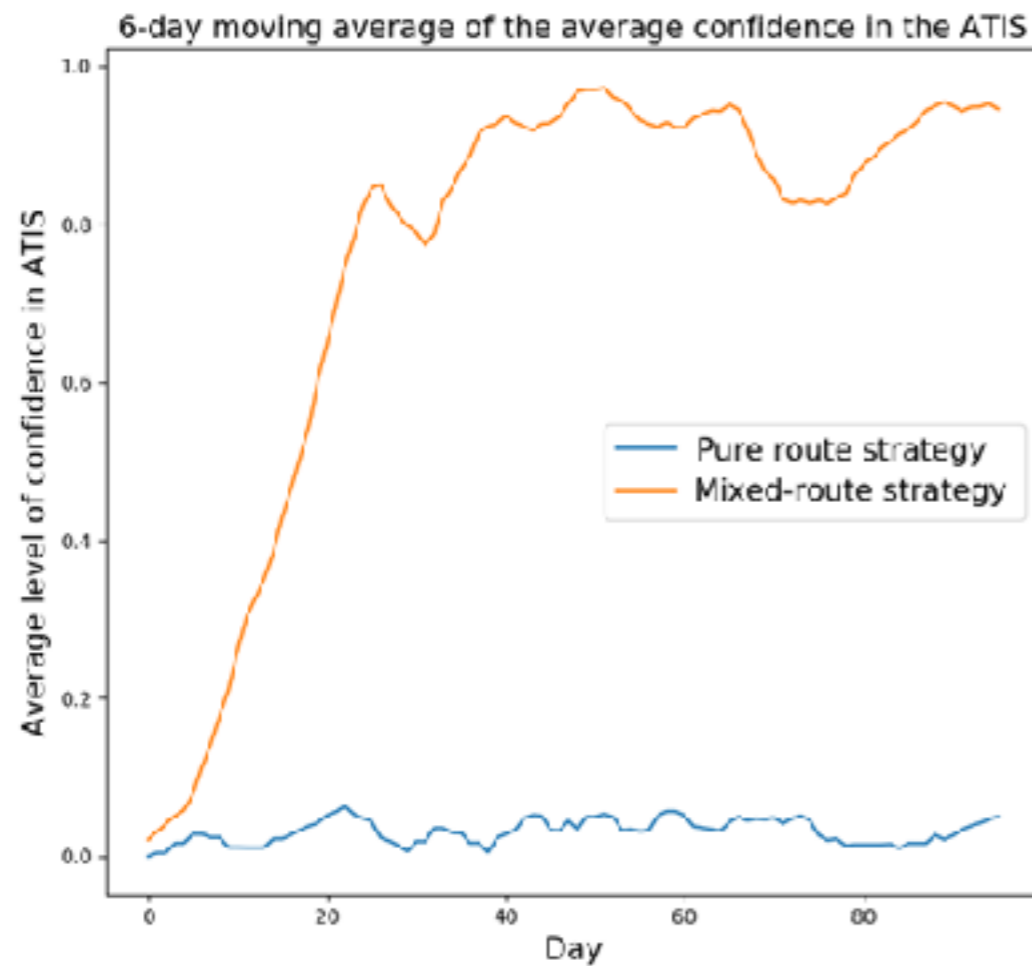


(Bucar et al, 2020)

Simulation Results

Pure shortest-path route choices within ex-ante ATIS may lead to:

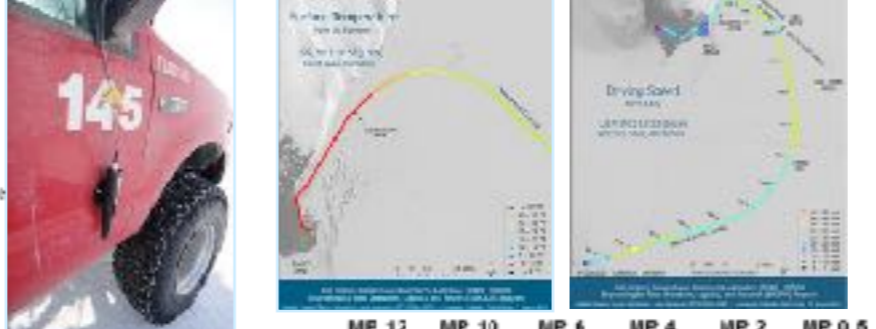
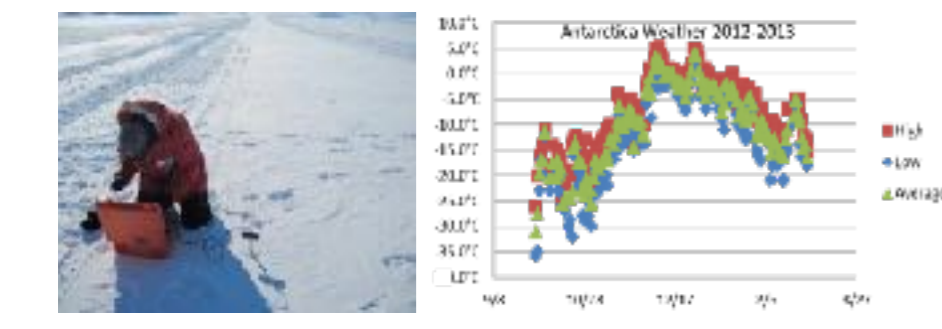
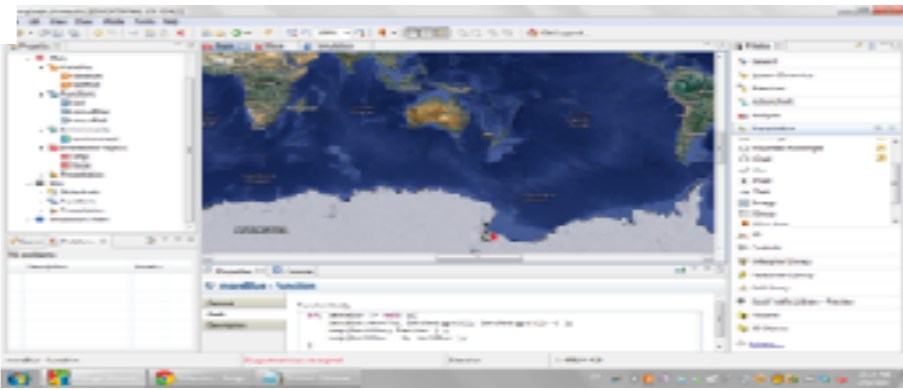
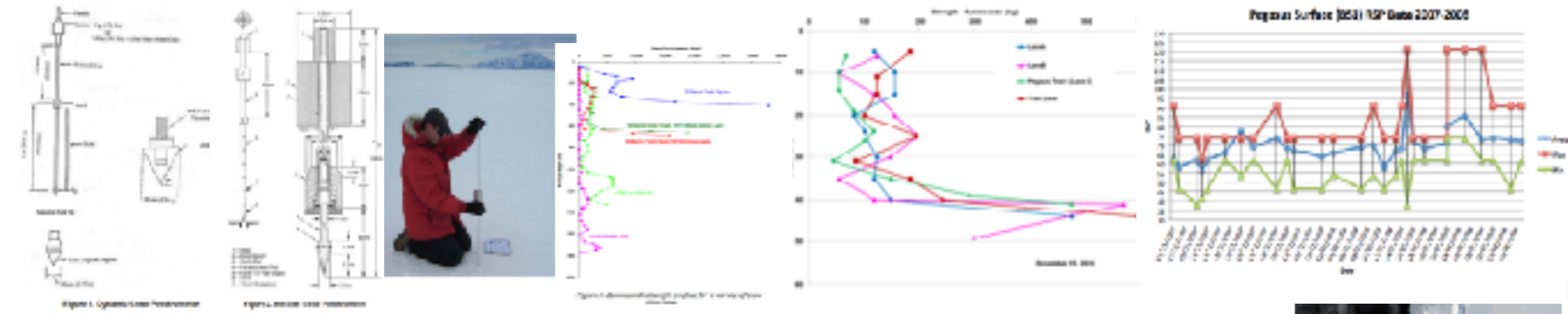
1. Decreased levels of trust in ATIS predictions
2. Increased delays for all drivers



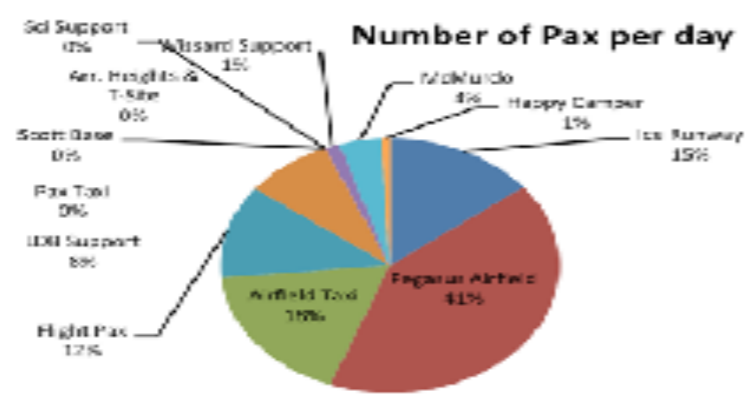
Antarctica: A Different Kind of Complexity



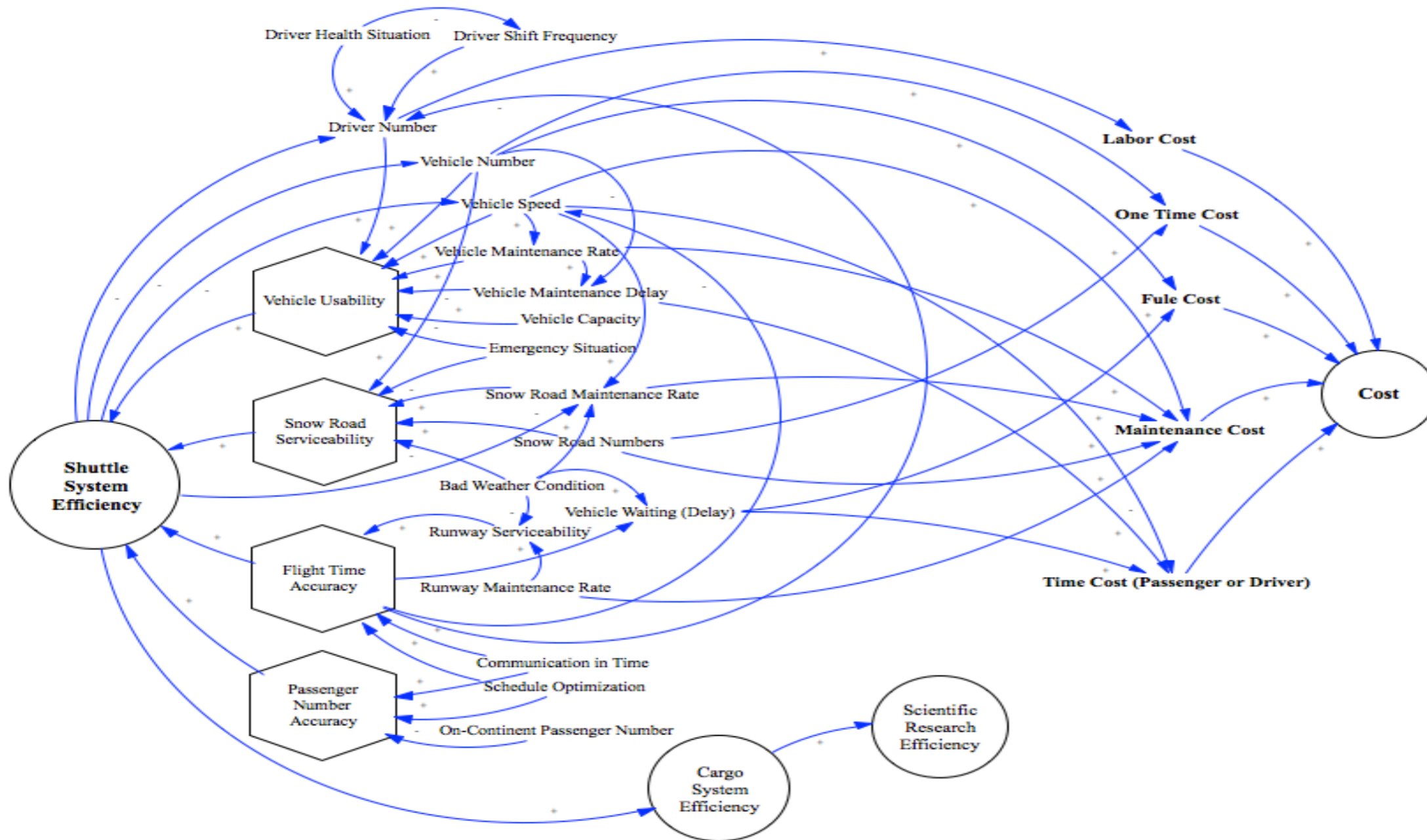
Virtual Journey



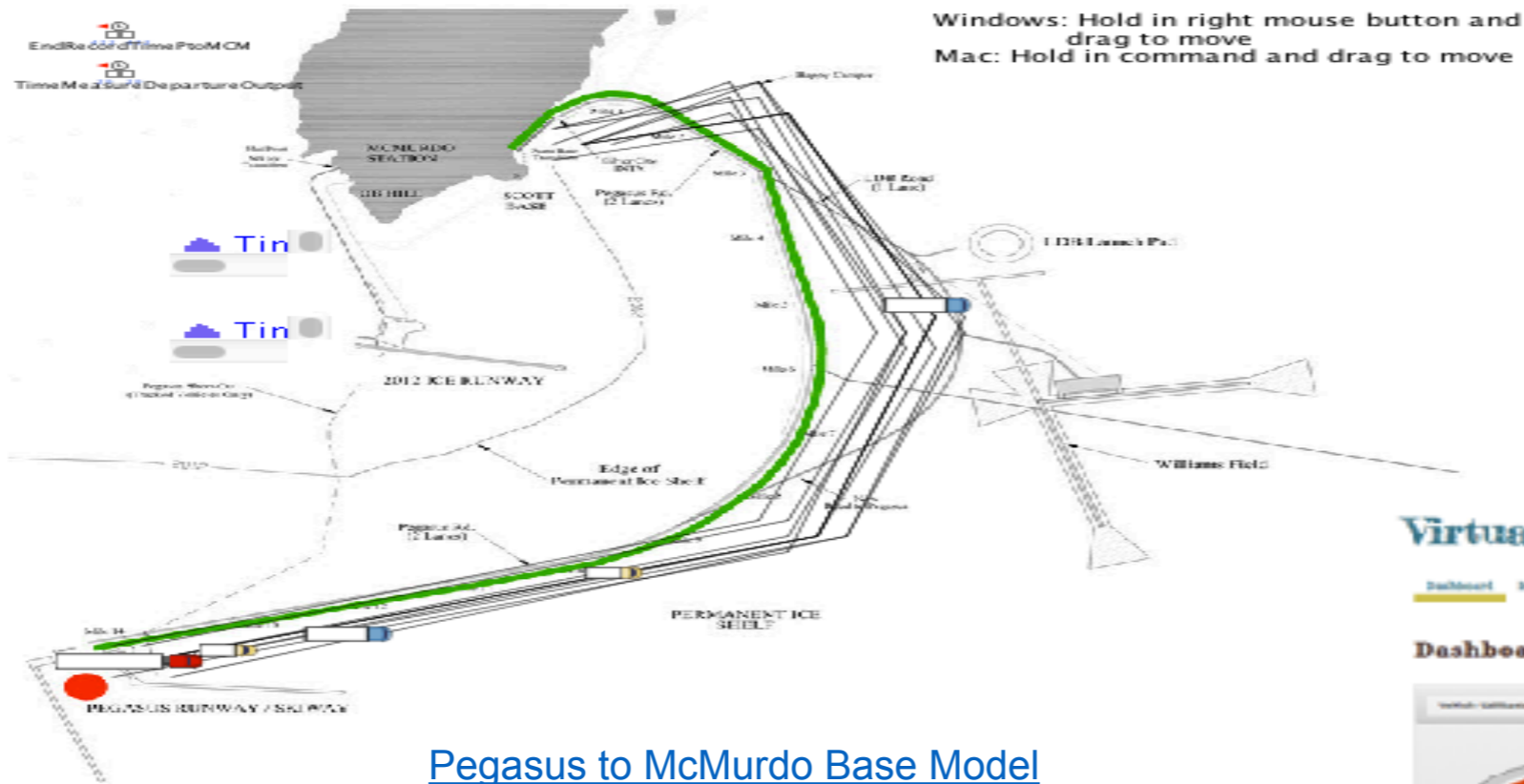
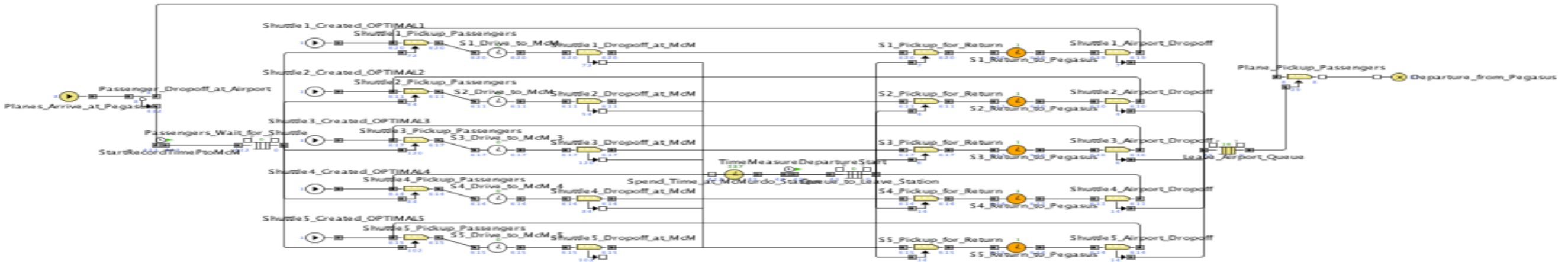
	MP 12	MP 10	MP 6	MP 4	MP 2	MP 0.5
Saurcay, November 12, 2011	1	4	1	0	0	0
Wednesday, November 16, 2011	3	3	2	0	0	0
Wednesday, November 23, 2011	3	3	1	1	0	0
Monday, November 28, 2011	0	0	0	1	0	0
Friday, December 02, 2011	0	2	1	2	0	0
Tuesday, December 06, 2011	4	6	2	2	0	4
Wednesday, December 07, 2011	10	0	0	4	0	4



Conceptual Modeling



Simulation Results and Dashboard



[Pegasus to McMurdo Base Model](#)

Pegasus to McMurdo Optimal

Pegasus to McMurdo Standardized Shuttle Model

Pegasus to McMurdo 4 Shuttles

Pegasus to McMurdo 6 Shuttles

Virtual Antarctica

[Dashboard](#) | [Interactive Maps](#) | [Report](#) | [Results](#) | [Weather](#) | [Systems Approach](#) | [About](#)

Dashboard

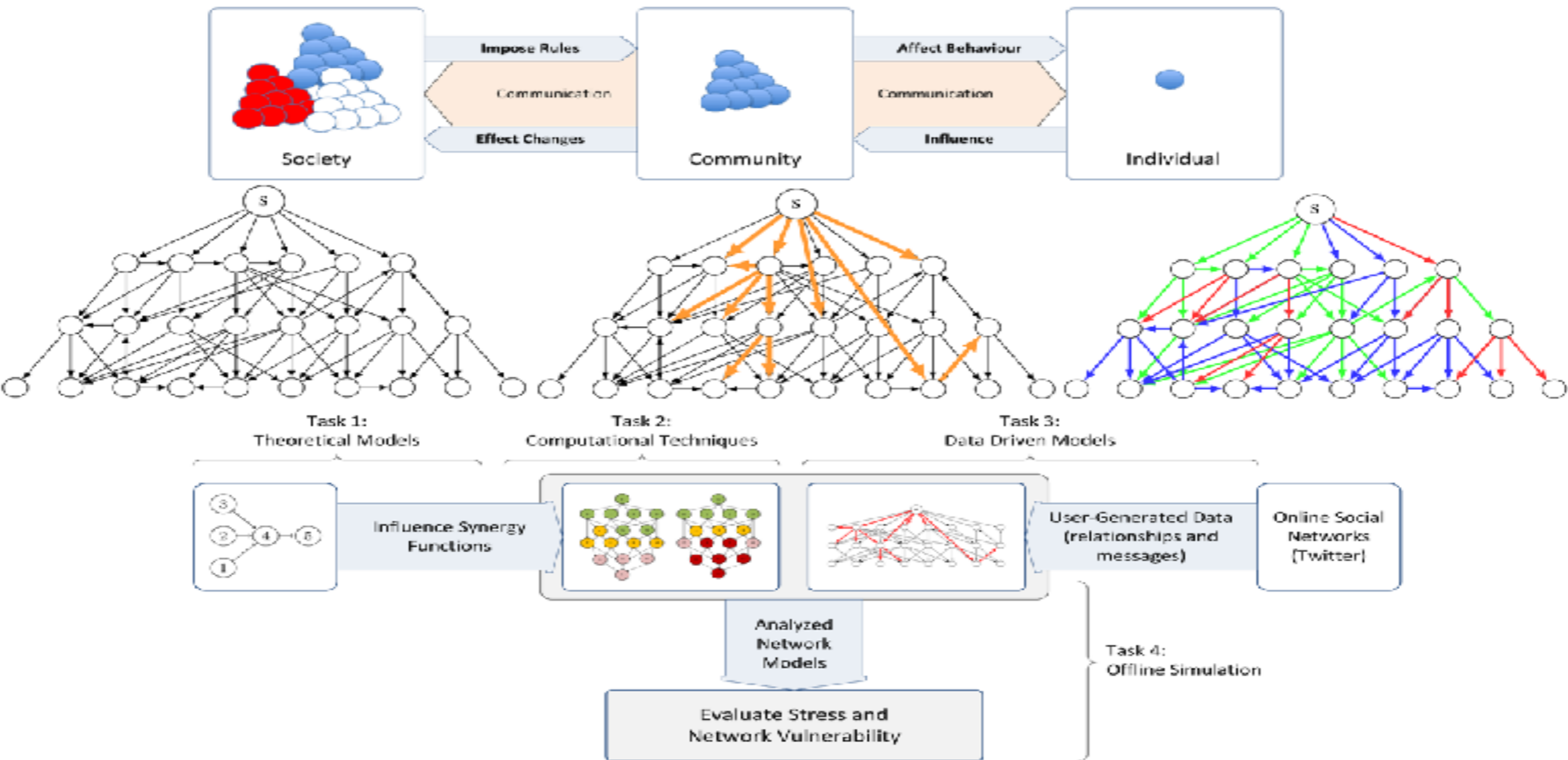


Smart City Lab @ Stevens

- Urban visualization platform and command center



Influencing Human Behavior in Social Networks

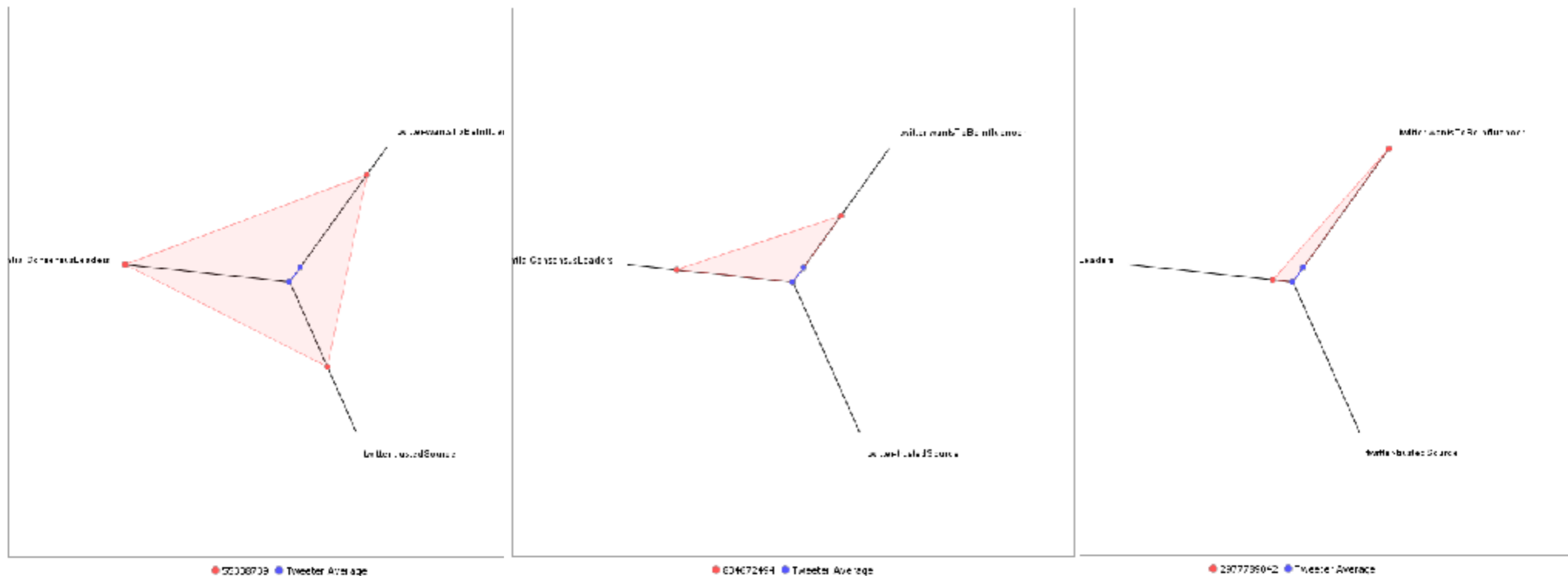


Following specific topic 2015

Top right: **Wants to be influenced** (high in degree) – Follower of lots of similar hashtags.

Top Left: **Consensus Leader** (high out degree) – Is followed by many on similar hashtags.

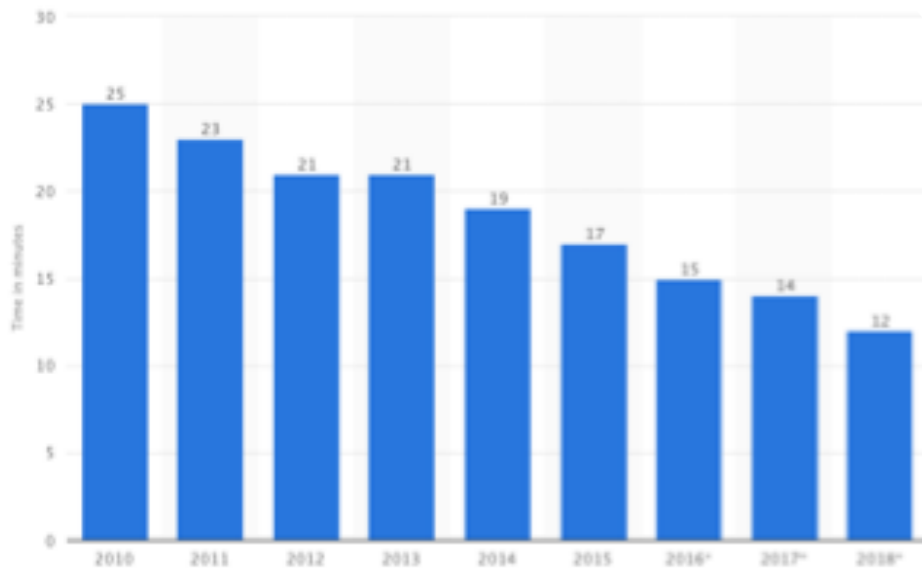
Bottom Right: **Trusted Source** – has high number of retweets with respect to the same hashtags.



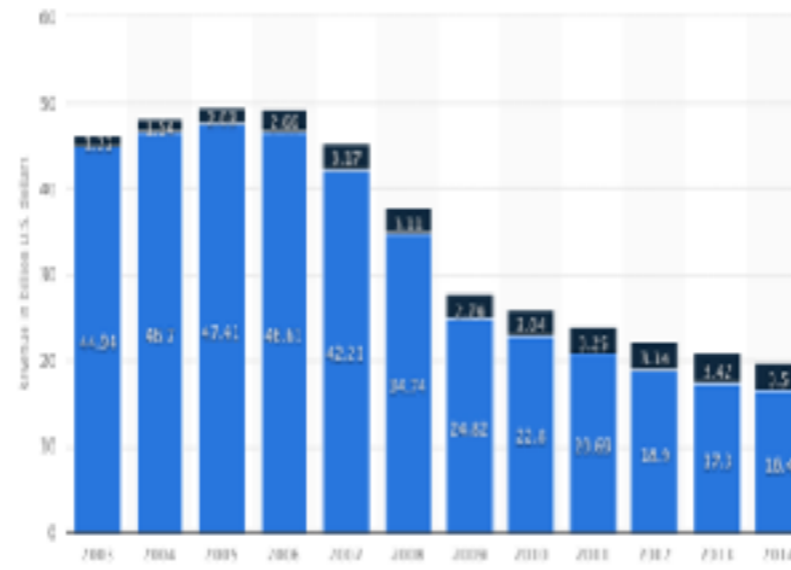
Information Governance

Case of Fake News

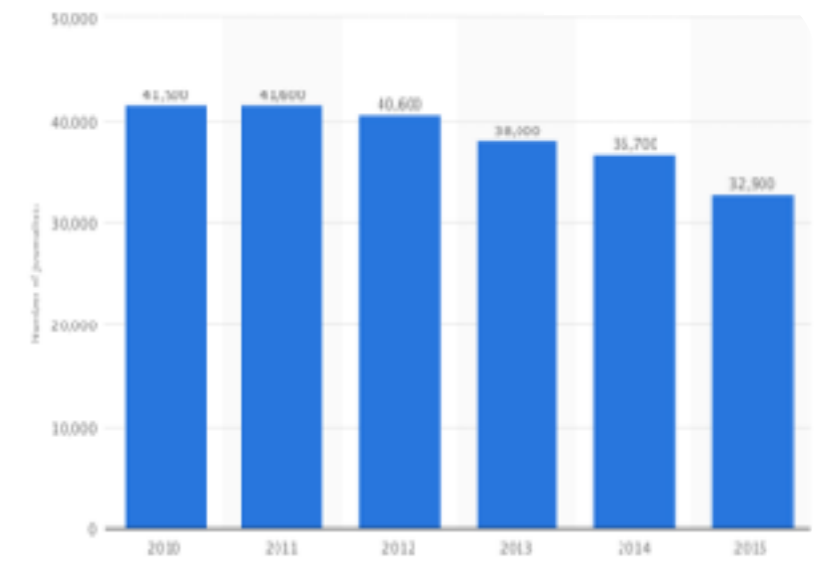
© Statista 2017



Time per Day



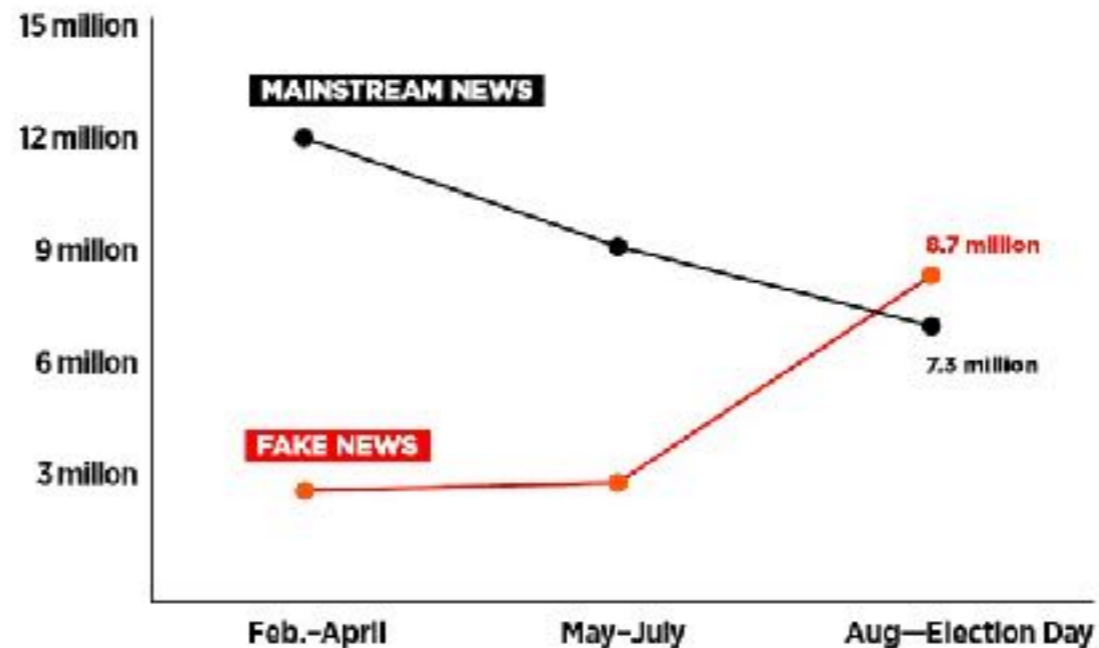
Revenue



Journalists

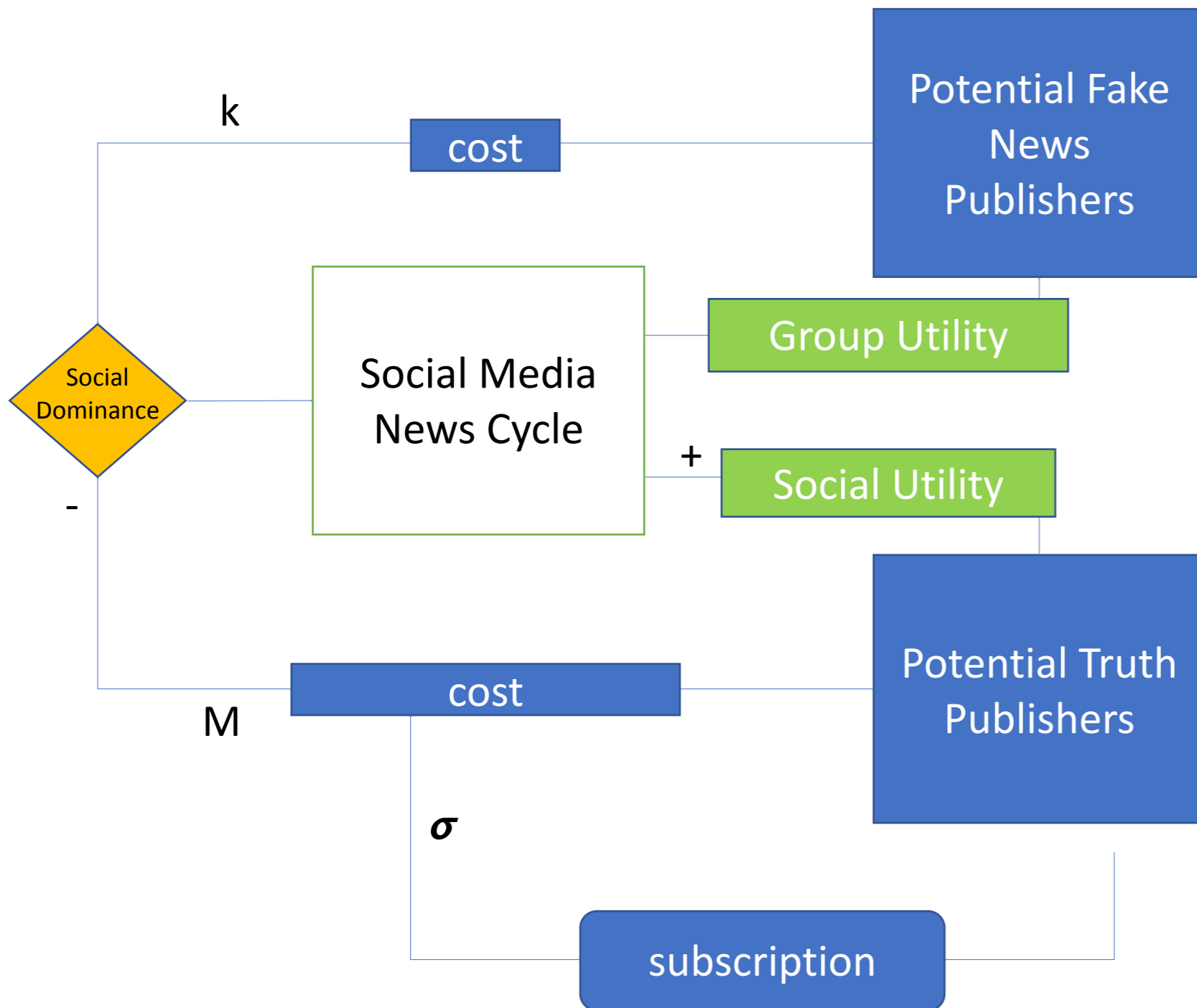
(Ehsanfar and Mansouri, 2017)

Total Facebook Engagements for Top 20 Election Stories



ENGAGEMENT REFERS TO THE TOTAL NUMBER OF SHARES, REACTIONS, AND COMMENTS FOR A PIECE OF CONTENT ON FACEBOOK SOURCE: FACEBOOK DATA VIA BUZZSUMO

Incentivizing Dissemination of Truth in Social Networks



- Truth vs Fake news in social networks
- Individual cost of authentication collective benefits of dominance
- Collective cost and individual benefits of failure
- Public good and volunteering
 - Game theoretic model
 - Volunteer's dilemma
- Model equilibriums
- Results

Mathematical Models

$$p_v(M) = \begin{cases} 1-c & \\ 1-a-c & \end{cases} \quad p_d(M) = \begin{cases} 1 & \text{if } M \geq k \\ 1-a & \text{if } M < k \end{cases}$$

$$p_v(k) = \begin{cases} 1-cf & \\ 1-a-cf & \end{cases} \quad p_d(k) = \begin{cases} 1 & \text{if } k \geq M \\ 1-a & \text{if } k < M \end{cases}$$

Regular agents: $\overline{P}_v(k)$ $\overline{P}_d(k)$

Fake news agents: $\overline{P}_v(M)$ $\overline{P}_d(M)$

Regular Users

$$\begin{aligned} \overline{P}_v(k) = & \sum_{M=k-1}^{N-1} \binom{N-1}{M} x^M (1-x)^{N-M-1} (1-c) \\ & + [1 - \sum_{M=k-1}^{N-1} \binom{N-1}{M} x^M (1-x)^{N-M-1}] (1-c-a) \\ & + \sum_{M=k-1}^{N-1} \binom{N-1}{M} x^M (1-x)^{N-M-1} \left(\frac{\sigma}{M+1} - \frac{\sigma}{N} \right) \end{aligned}$$

$$\begin{aligned} \overline{P}_d(k) = & \sum_{M=k}^{N-1} \binom{N-1}{M} x^M (1-x)^{N-M-1} \\ & + [1 - \sum_{M=k}^{N-1} \binom{N-1}{M} x^M (1-x)^{N-M-1}] (1-a) \\ & - \frac{\sigma}{N} * \sum_{M=k}^{N-1} \binom{N-1}{M} x^M (1-x)^{N-M-1} \end{aligned}$$

“Fake news” Users

$$\begin{aligned} \overline{P}_v(M) = & \sum_{k=M-1}^{F-1} \binom{F-1}{k} x^k (1-x)^{F-k-1} (1-cf) \\ & + [1 - \sum_{k=M-1}^{F-1} \binom{F-1}{k} x^k (1-x)^{F-k-1}] (1-cf-a) \end{aligned}$$

$$\begin{aligned} \overline{P}_d(M) = & \sum_{k=M}^{F-1} \binom{F-1}{k} x^k (1-x)^{F-k-1} \\ & + [1 - \sum_{k=M}^{F-1} \binom{F-1}{k} x^k (1-x)^{F-k-1}] (1-a) \end{aligned}$$

Fake news expected payoff:

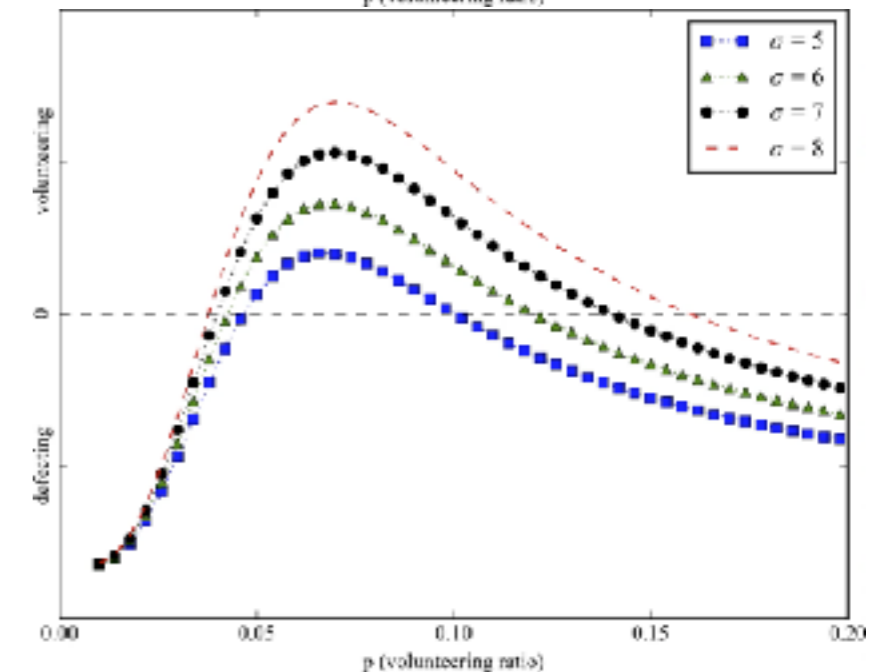
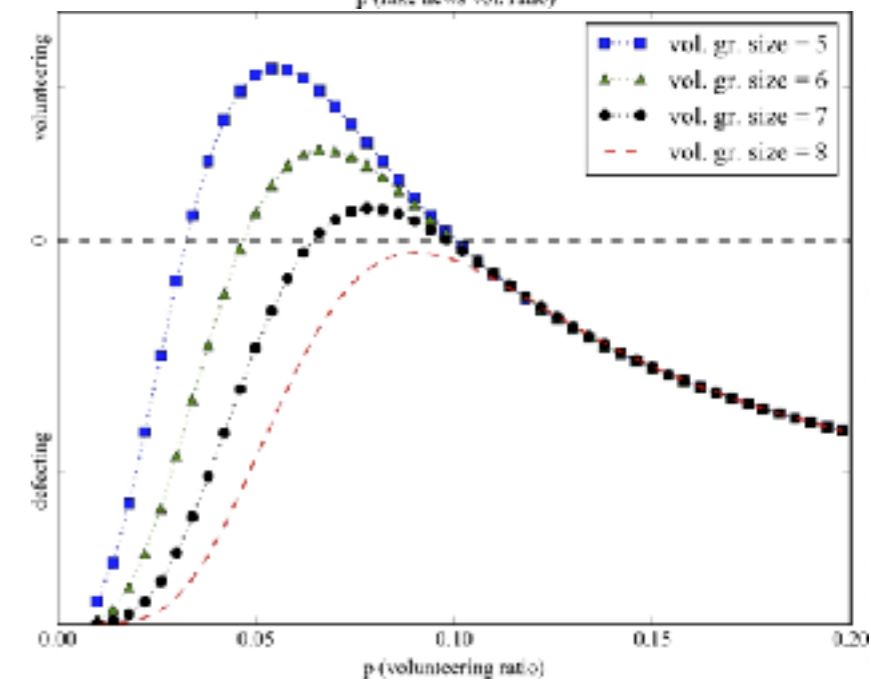
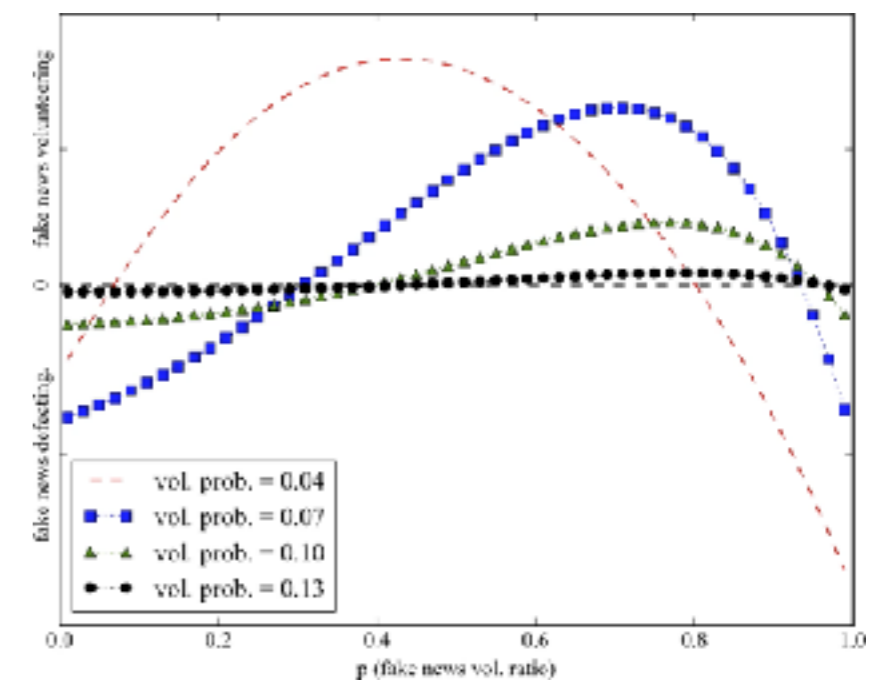
$$\begin{aligned} \overline{P}_v &= \sum_{M=0}^F \binom{N}{M} p^{*M} (1-p^*)^{F-M} \overline{P}_v(M) \\ \overline{P}_d &= \sum_{M=0}^F \binom{N}{M} p^{*M} (1-p^*)^{F-M} \overline{P}_d(M) \end{aligned}$$

- Maximum volunteering probability among regular users
- Lowering potential net payoff by the primary equilibrium
- Elastic stable secondary equilibrium points
- Elastic secondary equilibrium range

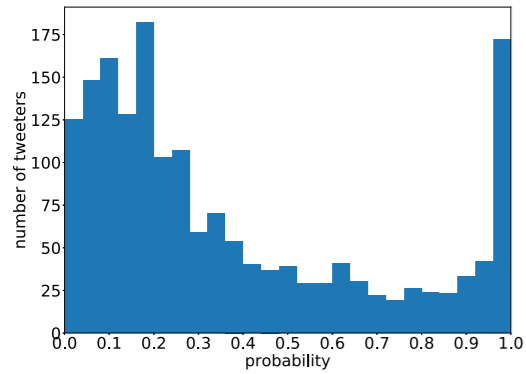
- Maximum group size for feasible volunteering
- Two sets of equilibrium points
- Inelastic equal equilibrium points
- Elastic equilibrium range

- Minimum reward for feasible volunteering
- Two sets of equilibrium points
- Elastic stable equilibrium points
- Inelastic equilibrium range

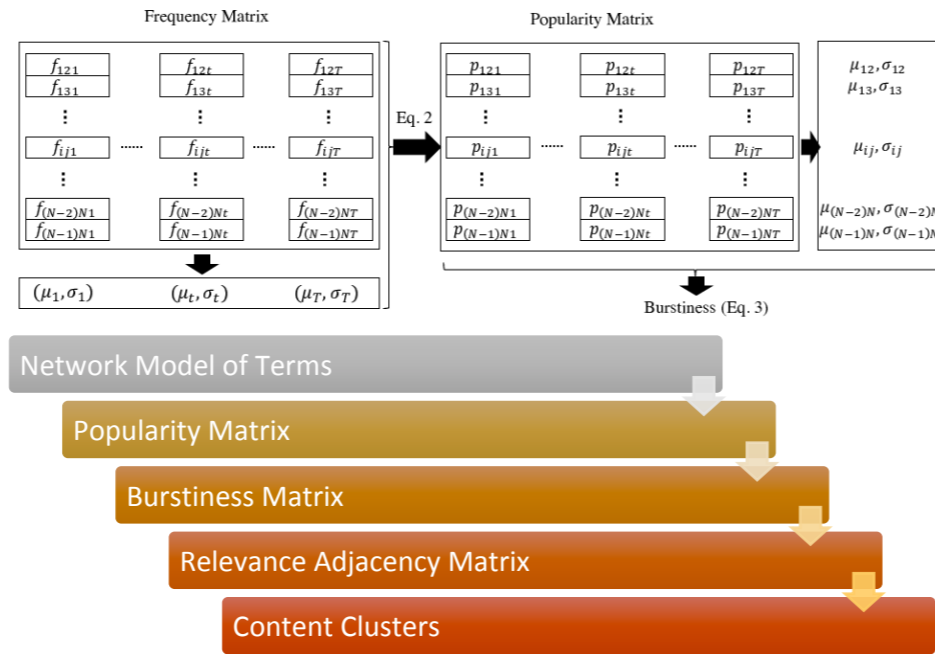
(Ehsanfar and Mansouri, 2017)



Influential Users and Clustering Content



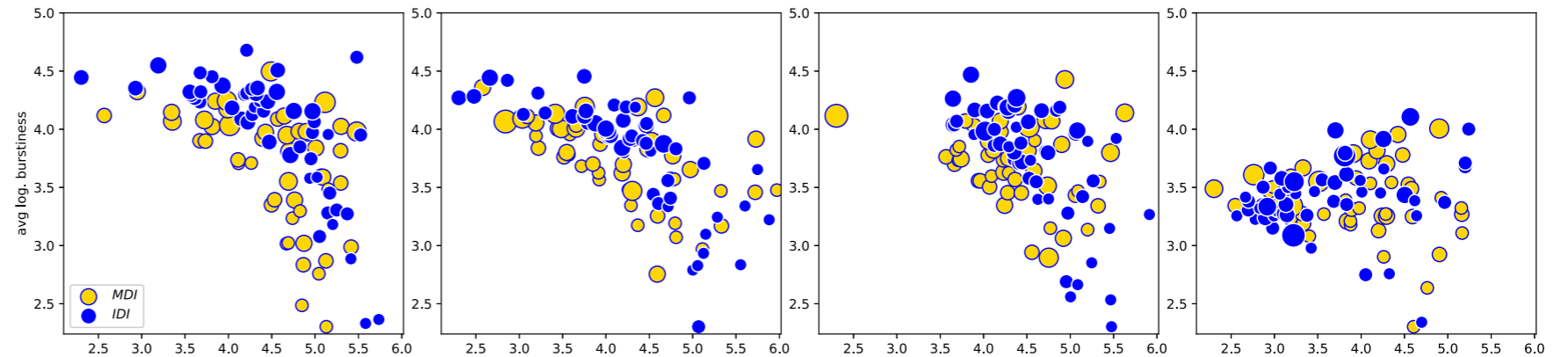
- | Interaction-Driven | Media-Driven |
|---|---|
| <ul style="list-style-type: none"> • Responsive • Interactive • Creative | <ul style="list-style-type: none"> • Suggestive • Reactive • Circulative |



Data Driven Models

Popularity vs Burstiness Time Frame Granularity

(Ehsanfar and Mansouri, 2017)



Daily Time Frames

- Higher granularity
- Dominant IDI

Monthly TF

- Lower Granularity
- Dominant MDI

Data Visualization Approach

Temporal Map of Clustered Topics

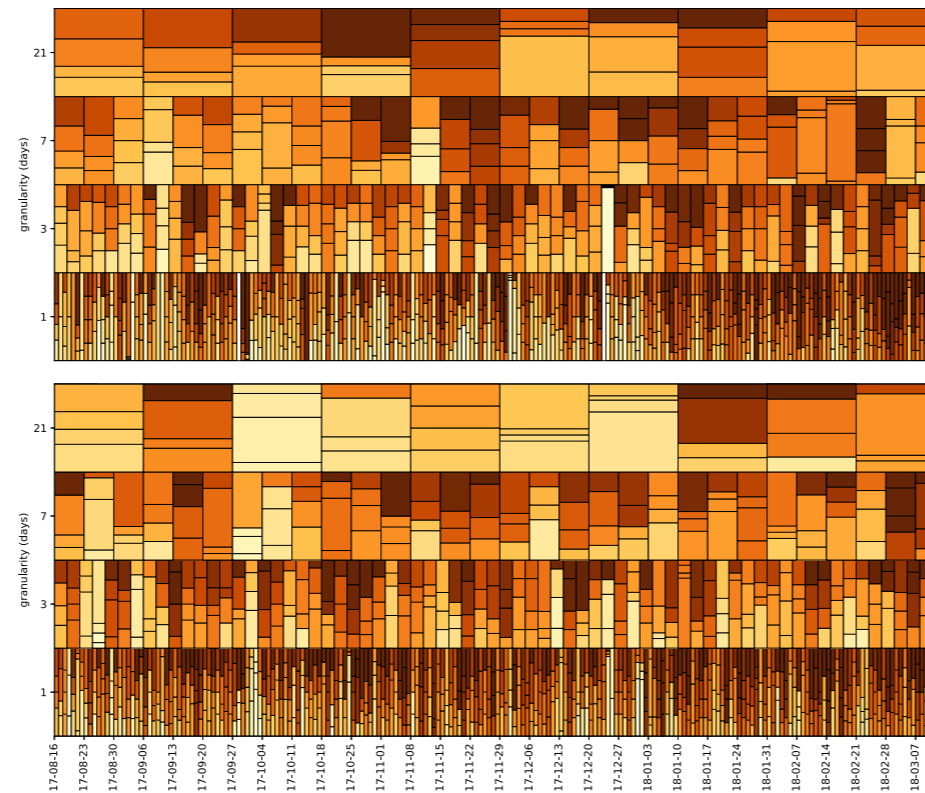
MDI

- Longer content TF
- Consistent
- Subjects: Political



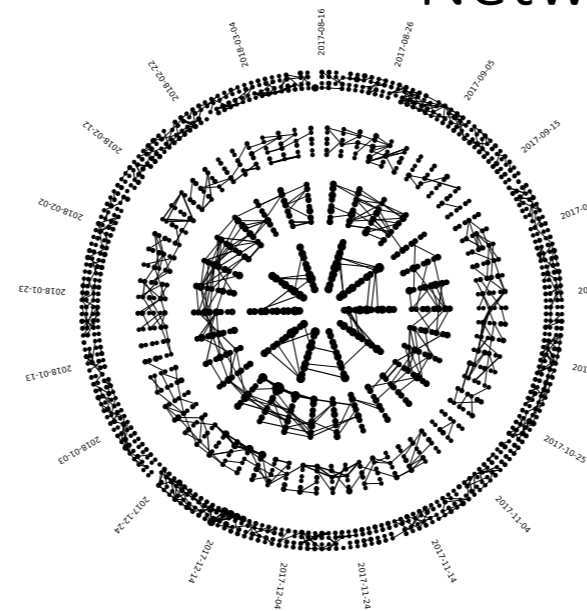
IDI

- Lower contentTF
- Dynamic
- Subjects: Social/Economical/ Life Style

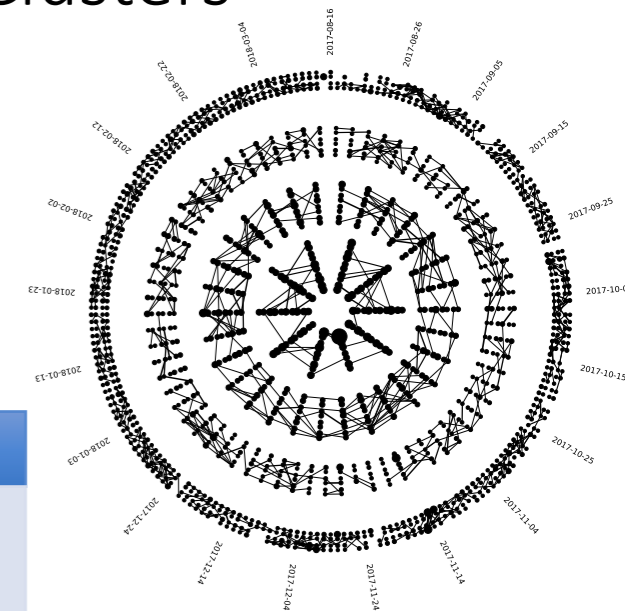


Networked Model of Clusters

(Ehsanfar and Mansouri, 2017)



- | MDI |
|---------------------------|
| • Temporal: |
| • Higher-level connection |
| • Hierarchical: |
| • Stronger connection |



- | IDI |
|---------------------------|
| • Temporal: |
| • Lower-level connections |
| • Hierarchical: |
| • Weaker connections |

Theoretical Approach: *Time to Dominance*

Mathematical Model

Effects of:

Network

History

External Influence

$$U(i, j, t) = \alpha U_N + \beta U_E + \gamma U_H$$

$U_N(i, j, t)$: Ratio of agent j friends who chose option i

$U_E(i, j, t)$: General ratio of agents who chose option i

$U_H(i, j, t)$: Ratio of how many times agent j chose option i in the past

Network vs. History

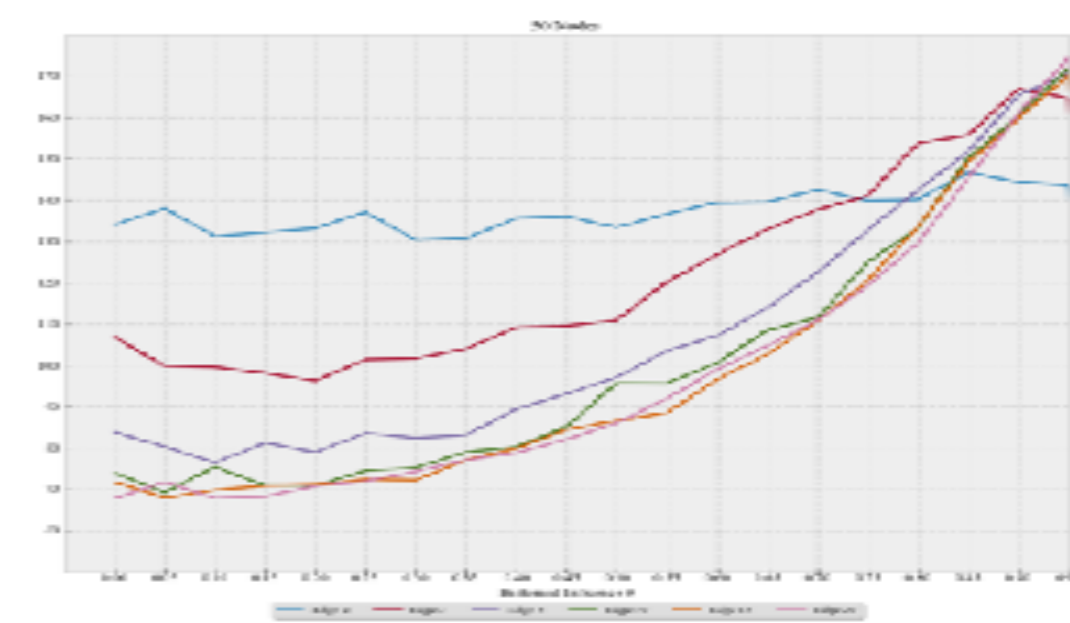
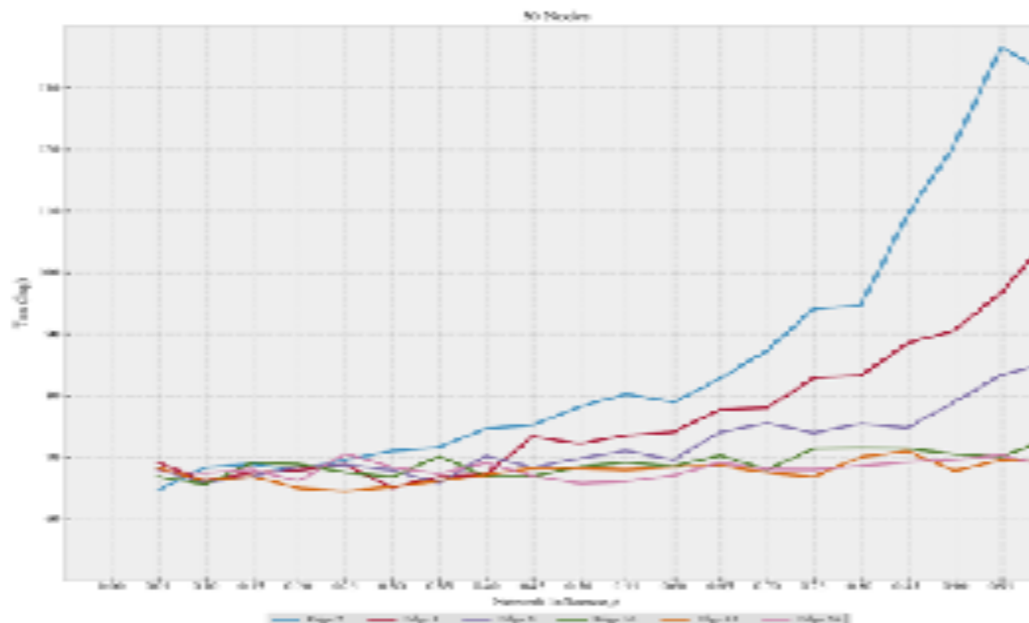
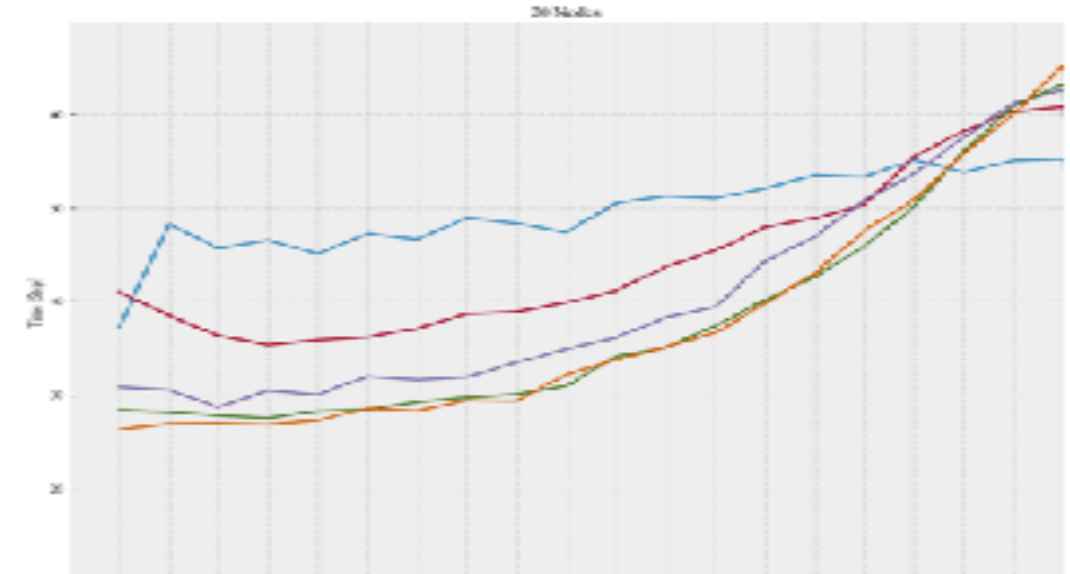
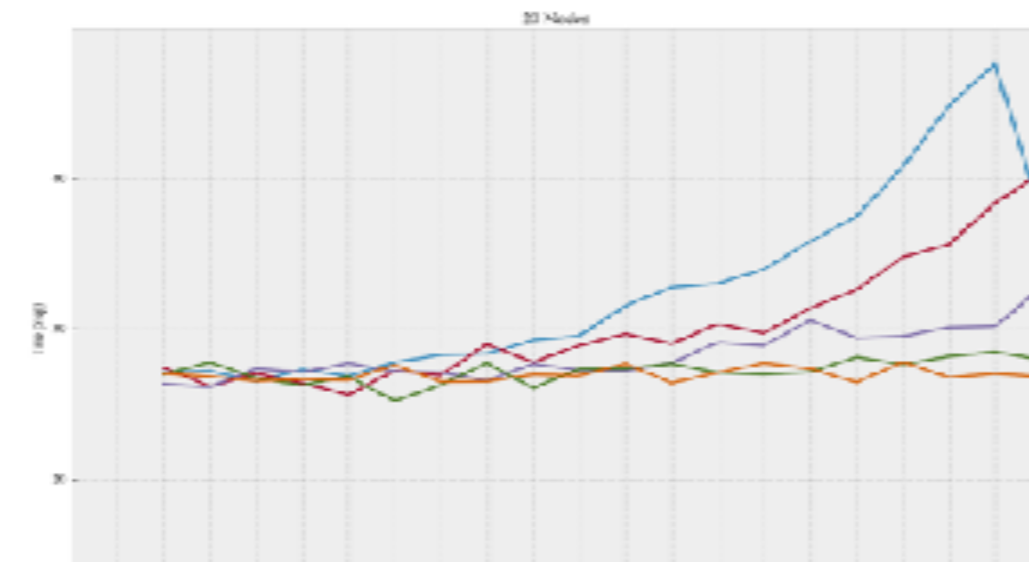
- Social Networks

- Uber

(Vesaghi and Mansouri, 2020)

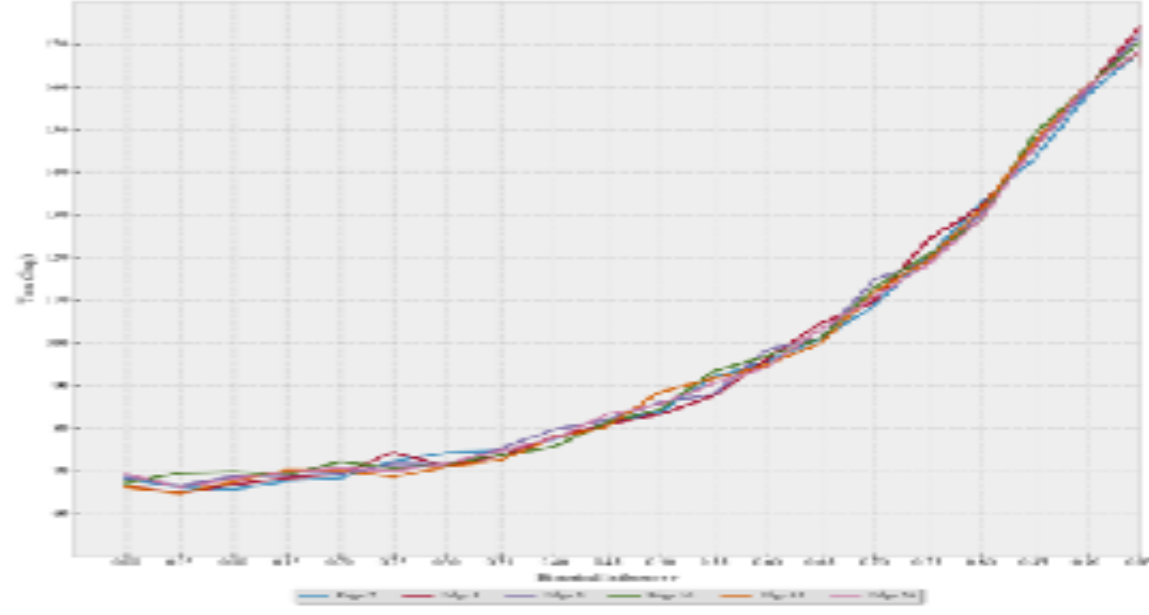
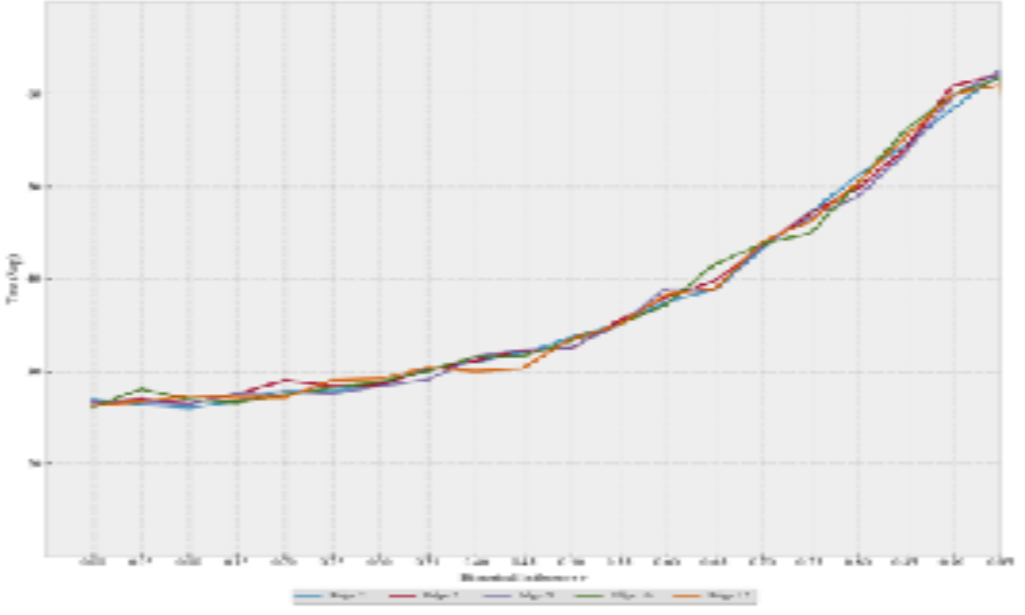
Network vs.
External
Influence

- VHS vs Betamax
- Wireless family plans
- Game consoles
- Back lives matter



History vs. External Influence

- MS vs. Mac
- Bank vs. ATM



Effect of Initial Conditions (Diversity)

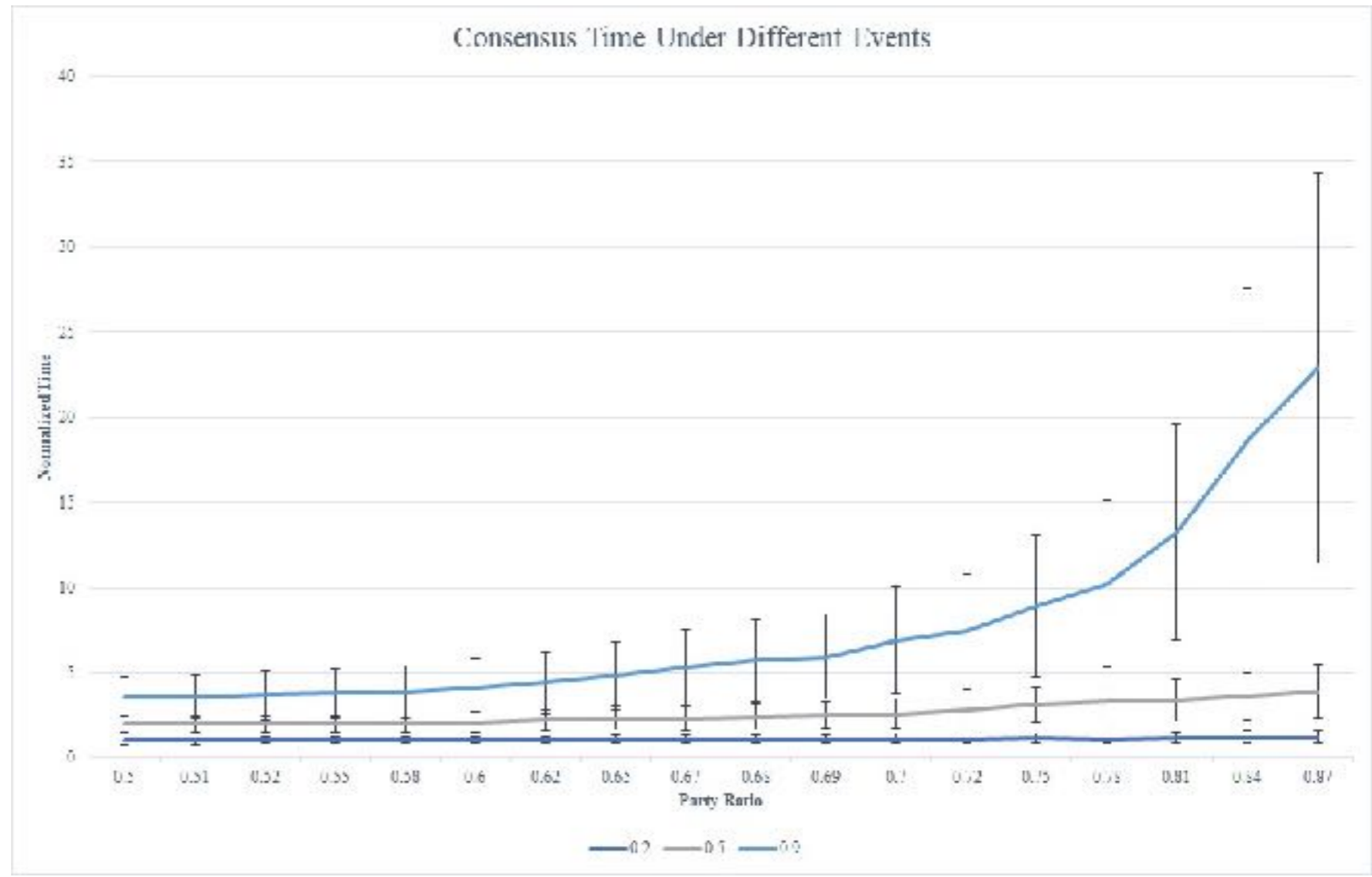
(Vesaghi and Mansouri, 2020)

Partisanship or Party Ratio:

$$\Phi = \max_i \left(U_N(i, j, t) \right)$$

Highest ratio of an option that is chosen by agent j friends.

- Interracial marriage (1880-1960) and gay marriage (1990-2010)



Effect of Different Events (Fortification)

- Gridlock in politics (One Castle)
- Climate change debate (Two Castle)
- Women right to vote (One Castle)

Comparison of Network effect vs External effect vs History effect:

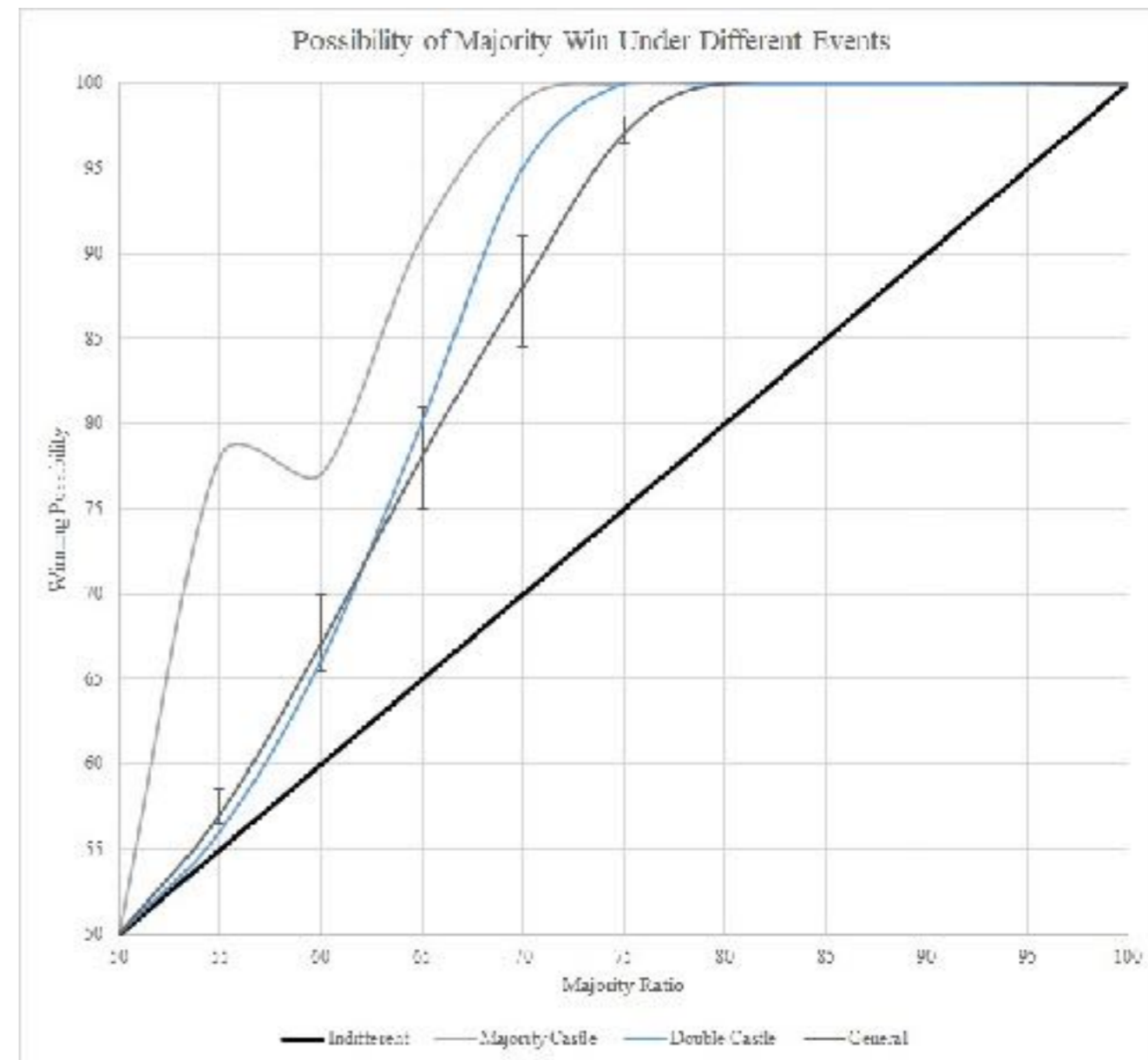
1- The results are consistent over different network structures (Node, edge, ...)

2- Increasing the network effect increases the consensus time.

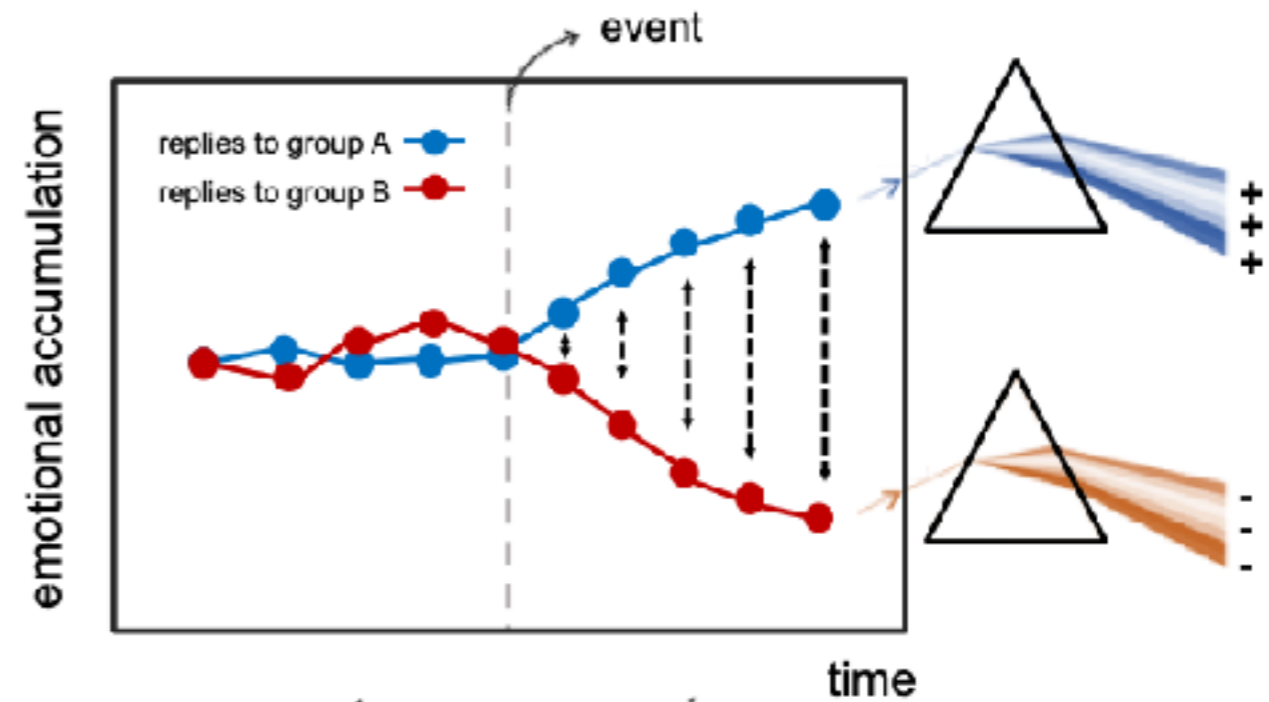
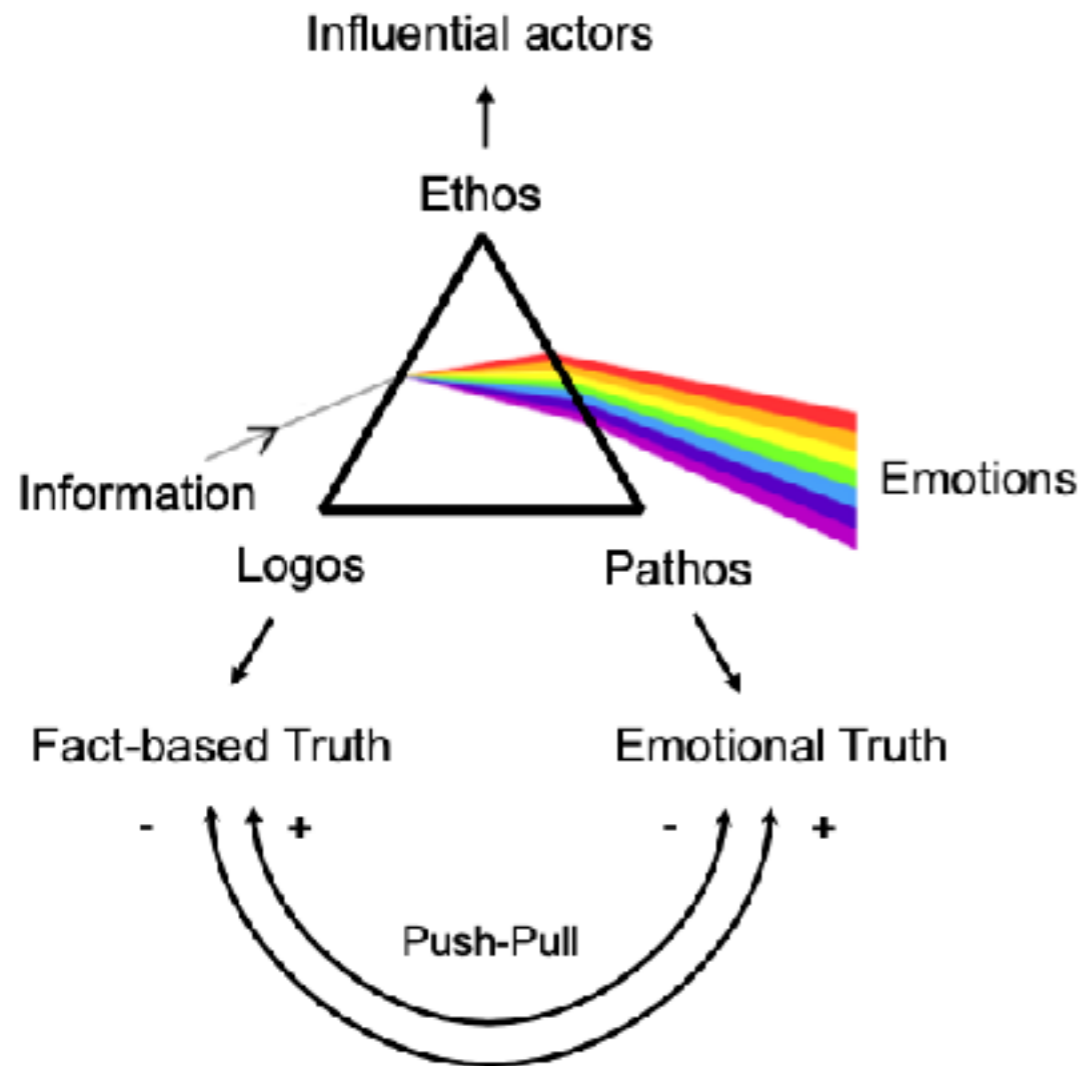
3- Increasing the history effect increases the consensus time.

4- Decreasing diversity increases the consensus time.

5- Forming Castles increases the probability of majority to dominate.



The Emotional Factor in the Post-Truth Era

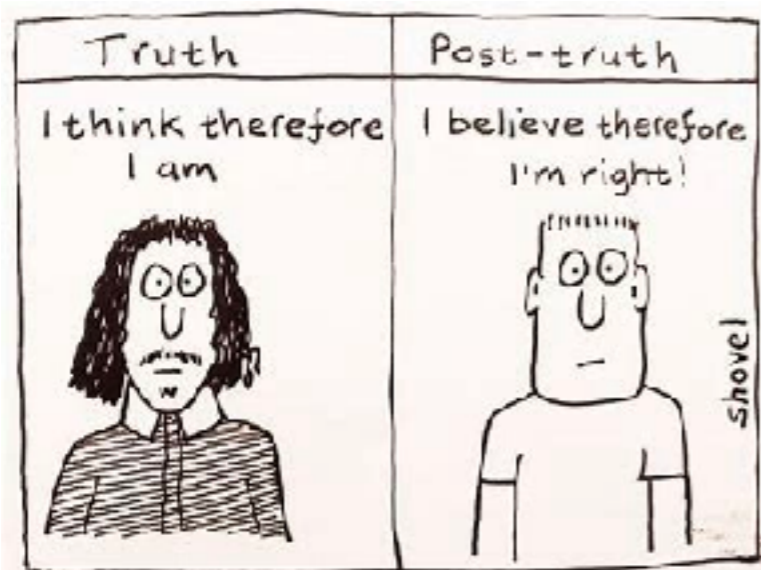


$$CS_t^{T_a} = \sum_{i=1}^t sen_i^{T_a} \quad CS_t^{T_b} = \sum_{i=1}^t sen_i^{T_b}$$

$$p_t^{T_a, T_b} = \left| \frac{CS_t^{T_a}}{N_t^{T_a}} - \frac{CS_t^{T_b}}{N_t^{T_b}} \right|$$

where:

$$N_t^{T_a} = \sum_{i=1}^t r_i^{T_a} ; N_t^{T_b} = \sum_{i=1}^t r_i^{T_b}$$



The dilemma of being true

Thank you for your attention!