



# The Infinite Canvas: Analyzing Networks in Virtual Space

Michael Thomas, Systems Architect, SAS

# About SAS

“SAS is the leader in analytics. Through innovative analytics, business intelligence and data management software and services, SAS helps customers at more than 83,000 sites make better decisions faster. Since 1976, SAS has been giving customers around the world **THE POWER TO KNOW**®.”



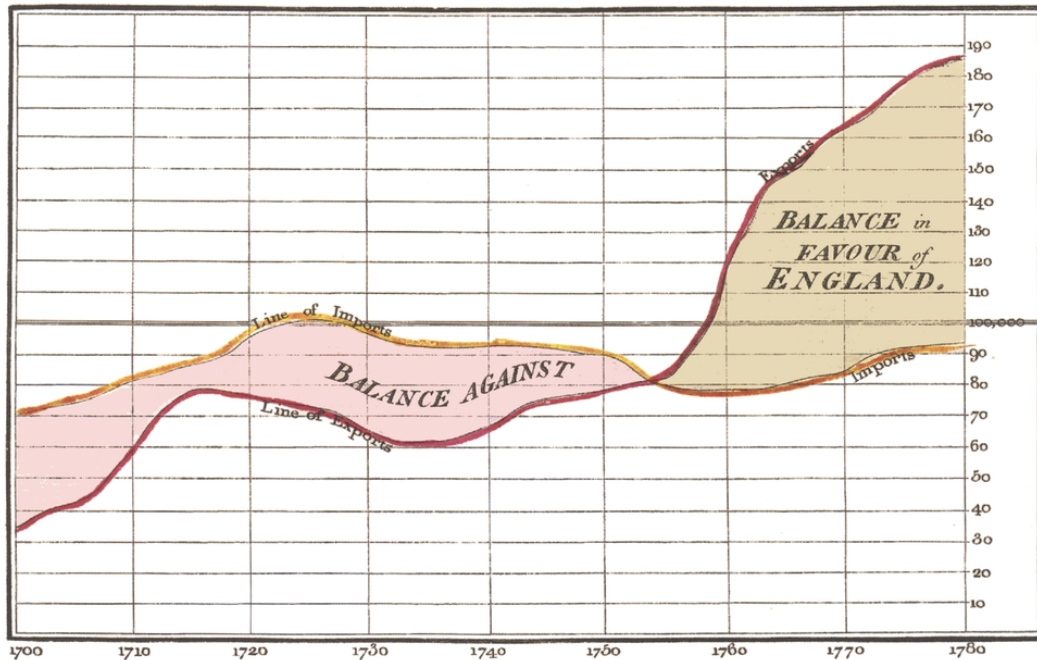
**THE  
POWER  
TO KNOW**®

- \$3.2+ Billion in Revenue
- 14,000+ employees
- Customers in 149 countries
- Cary, North Carolina

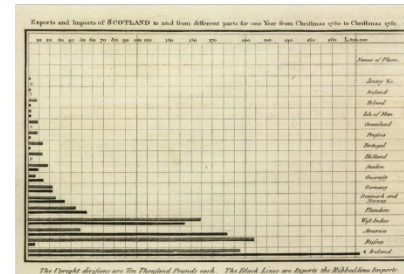


# Data Visualization, Big Data & Intelligent Reality

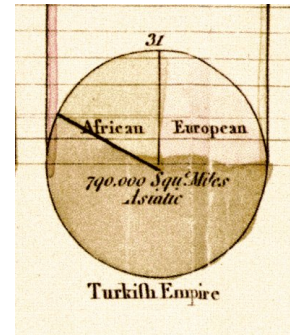
Exports and Imports to and from DENMARK & NORWAY from 1700 to 1780.



The Bottom line is divided into Years, the Right hand line into £10,000 each.  
 Published as the Act directs, 10<sup>th</sup> May 1786, by W<sup>m</sup> Playfair  
 No. 4. script 352, Strand, London.



The Upright diagonals are the Principal Exports each. The Black Lines are Reports the Balance Imports.



Work of William Playfair, inventor of bar, line, pie, area & circle charts from 1786-1801

# Intelligent Realities

## Augmented Reality. Mixed Reality. Virtual Reality. And Beyond.

“An intelligent reality is defined as a technologically enhanced reality that aids human cognitive performance and judgment.”

The screenshot shows a web browser displaying an article on the Control Engineering website. The article title is "Benefits of digitizing reality for workers in manufacturing". The sub-headline reads: "Digitizing reality is now possible for workers thanks to technology advances such as the Internet of Things (IoT). This new reality allows workers to benefit from augmented reality (AR), mixed reality (MR) and virtual reality (VR) to solve old problems in new and better ways." The author is Michael D Thomas, dated July 15, 2019. The article includes a diagram showing a worker using a tablet to interact with a virtual interface, and a photograph of a worker in a factory setting. A sidebar on the right promotes a white paper titled "WHITE PAPER: TAKE POE TO NEW DISTANCES WITH ONEREACH" and offers a "SUBSCRIBE" button for Control Engineering.

The screenshot shows a web browser displaying a blog post on the SAS website. The title is "Immersive analytics: yes or no?". The author is Michael Thomas, dated March 17, 2017. The post discusses the author's experience with immersive analytics (IA) since 2012, mentioning that they have been publishing on this topic since early 2014. The author notes that IA is an emerging research thrust focused on the use of virtual reality (VR), augmented reality and other new display and interaction technology to support analytical reasoning and decision making. A photograph of a man wearing a VR headset is included in the post. The SAS logo and navigation menu are visible at the top of the page.

# The Technology Terrain

*Augmented reality*

*Assisted reality*

*Mixed reality*

*Virtual reality/world*

Headsets

## Stereoscopic AR

- HoloLens
- Magic Leap
- Mira



## Monocles

- Glass Enterprise Edition
- Vuzix M300



## Smart phone VR



Samsung Gear VR



Google Cardboard

## High performance VR



- HTC Vive
- Oculus Rift

Flat screens



Pokémon Go



Video games



Tiled displays

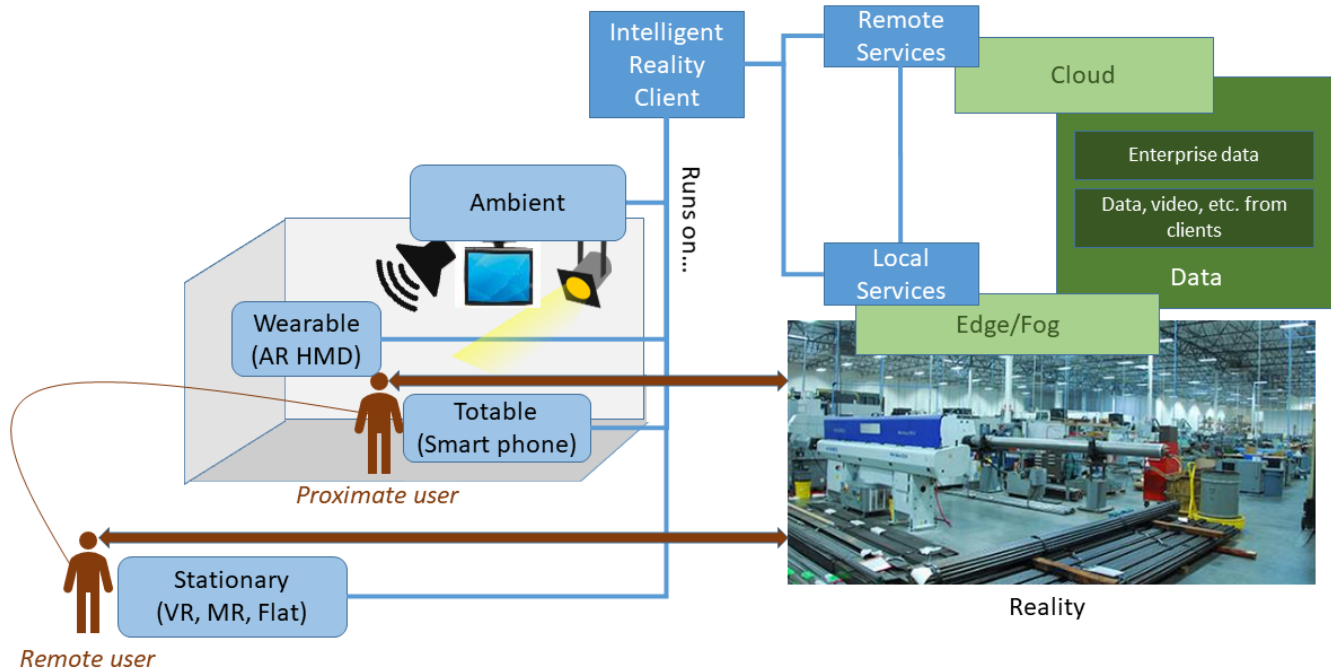


CAVE

*Mobile*

*Stationary experience*

# Intelligent Realities in an Industrial Setting



# Making Reality From Data



- Watching a movie on a digital screen is looking at data
- No one ever complains about 'data overload' when they get a new high def. TV
- ESP can push analytic output at the rate that high def screens can display it

# The place of 3D: Visualization across dimensionalities in chess



3D





# The place of 3D: Visualization across dimensionalities in chess

## Narrative

1. e4 d5 2. Nc3 d4 3. Nb5 Nc6 4. Nf3 Nf6 5. d3 a6 6. e5 axb5 7. exf6 gxf6  
8. Be2 e5 9. O-O Bg4 10. c4 bxc4 11. dxc4 Qd7 12. b4 Nxb4 13. h3 Bh5  
14. c5 Bxc5 15. Rb1 Bg6 16. Rb3 Bc2 17. Qxc2 Nxc2 18. Rxb7 Rg8 19.  
Bb5 c6 20. Rxd7 Kxd7 21. g4 cxb5 22. Nd2 h5 23. f3 d3+ 24. Kh2 hxg4  
25. hxg4 Rh8+ 26. Kg3 Ne3 27. Nb3 Nxf1+ 28. Kg2 Ne3+ 29. Kg1 Bb6  
30. g5 fxg5 31. f4 Nc4+ 32. Kf1 Rh1+ 33. Kg2 Rxc1 34. Nxc1 d2 35.  
fxe5 dxc1=Q 36. e6+ Kxe6 37. a4 Rd8 38. Kf3 Rd3+ 39. Ke2 Qe3+ 40.  
Kf1 Qf2#

[Event "2016 Triangle K-12 Chess Championships"]  
[Site "Raleigh, NC"]  
[Date "3/12/2016"]  
[Round "2"]  
[White "Yu, Daniel (611)"]  
[Black "Goldstein, Arav (1126)"]  
[Result "0-1 (black won)"]

*In blindfolded chess, 'Visualization' is internal to the mind, not external*

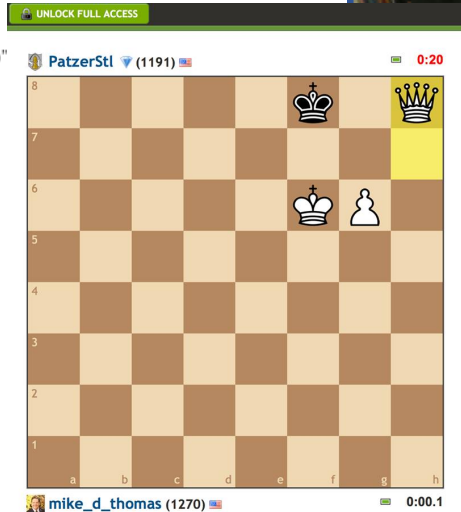


# The Place of 3D: Visualization Across Dimensionalities in Chess

## Narrative

1. e4 d5 2. Nc3 d4 3. Nb5 Nc6 4. Nf3 Nf6 5. d3 a6 6. e5 axb5 7. exf6 gxf6 8. Be2 e5 9. O-O Bg4 10. c4 bxc4 11. dxc4 Qd7 12. b4 Nxb4 13. h3 Bh5 14. c5 Bxc5 15. Rb1 Bg6 16. Rb3 Bc2 17. Qxc2 Nxc2 18. Rxb7 Rg8 19. Bb5 c6 20. Rxd7 Kxd7 21. g4 cxb5 22. Nd2 h5 23. f3 d3+ 24. Kh2 hxg4 25. hxg4 Rh8+ 26. Kg3 Ne3 27. Nb3 Nxf1+ 28. Kg2 Ne3+ 29. Kg1 Bb6 30. g5 fxg5 31. f4 Ne4+ 32. Kf1 Rh1+ 33. Kg2 Rxe1 34. Nxe1 d2 35. fxe5 dxc1=Q 36. e6+ Kxe6 37. a4 Rd8 38. Kf3 Rd3+ 39. Ke2 Qe3+ 40. Kf1 Qf2#

[Event "2016 Triangle K-12 Chess Championships"]  
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2D



3D



# Lots of “Flat” in Reality

- The back of the retina is flat
- Many techniques for showing multi-dimensional data on flat displays
- Netflix VR app shows regular movies on a virtual flat screen

*Analytics in VR doesn't necessarily mean 3D data visualization.*

*But reality does imply real-time change.*



# Data reality: Away from tradition and towards reality metaphors

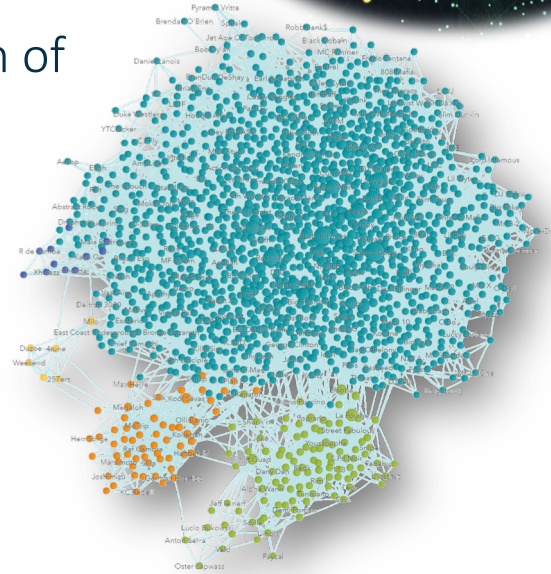
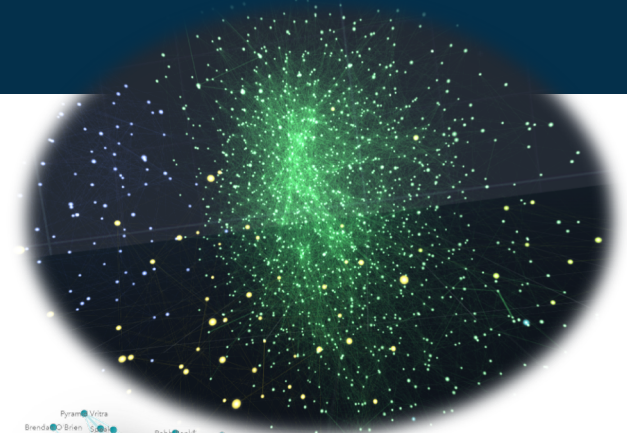
- 10 bar chart at 24 frames per second:  
240 events per second < 100K+ events per second ESP can push
- Instead, reality metaphors:
  - Mountains
  - Trees
  - Waves
  - Clouds
  - Murmurations
- Sonic:
  - Data driven 'earcons'
  - Sound positioned left/right
  - Pitter-patter of light rain vs. sound of a thunderstorm



# The Infinite Canvas

## Introduction

- Immersive, infinite, easily navigated visualization space
- Design challenges / effective implementation of VR
- Development team & company
- Why we built this & initial concepts



# The Infinite Canvas

## Virtual Reality concepts

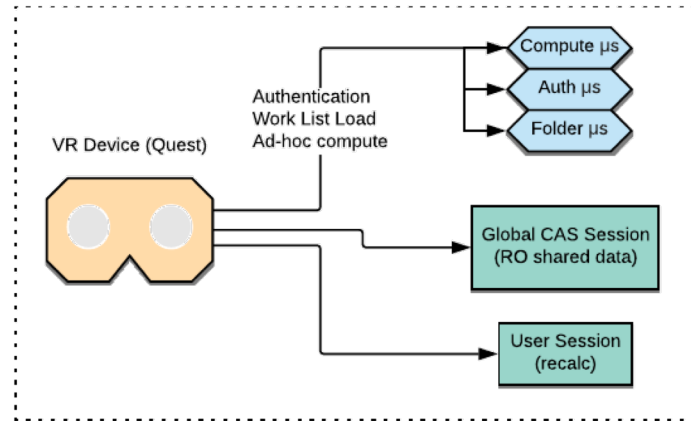
- Market players and Industries
- Requirements and blockers of the current-generation technology
- What the future has in store



# The Infinite Canvas

## Application Architecture

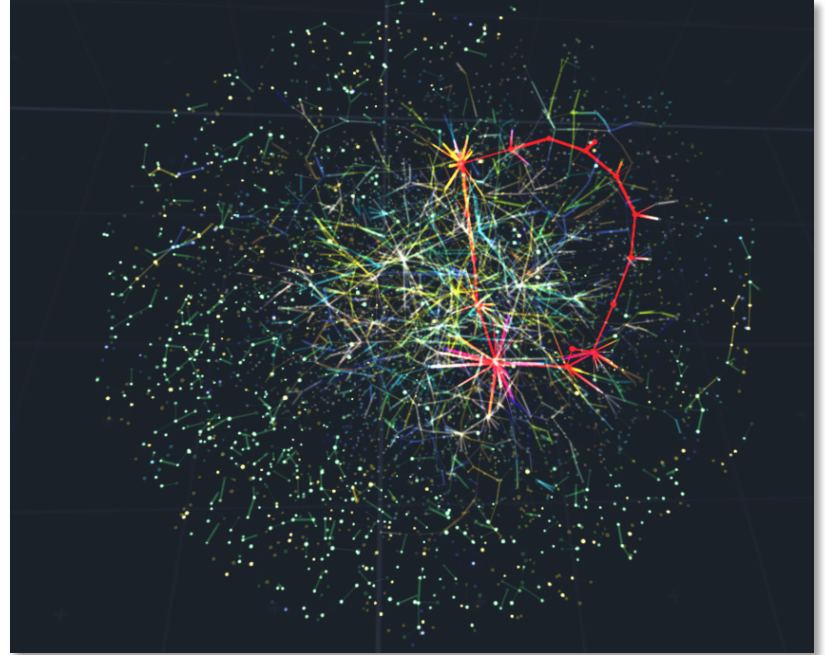
- 3D engine (Unity)
- Device (Oculus)
- Data platform - SAS Viya
  - Microservices + Authentication
- Graph layout and Compute
  - CAS + RESTful API communication



# The Infinite Canvas

## Data volume and Human Computation

- Why network graphs are useful
- How network graphs are special (vs list table or charts)
- Network visualization & human computation of relationships vs metrics

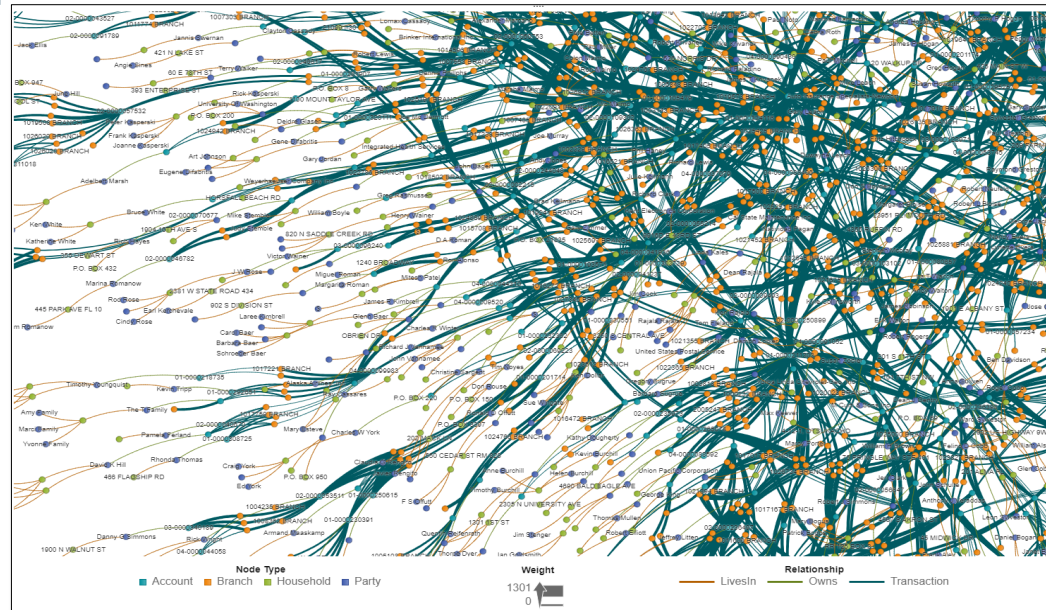




# The Infinite Canvas

## Social Network Analysis

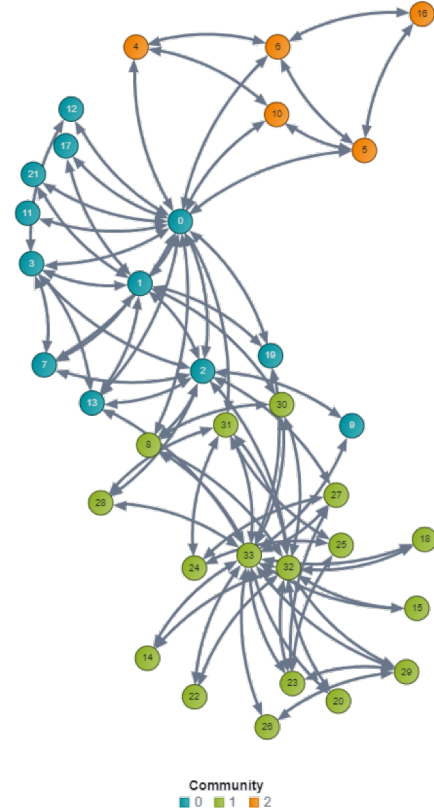
- Identify paths, connections and hubs
- Detect patterns and clusters of interest
- Concepts
  - Community Detection
  - Centrality
  - Key Actor Analysis
  - Cycle Detection



# The Infinite Canvas

## SNA Community Detection

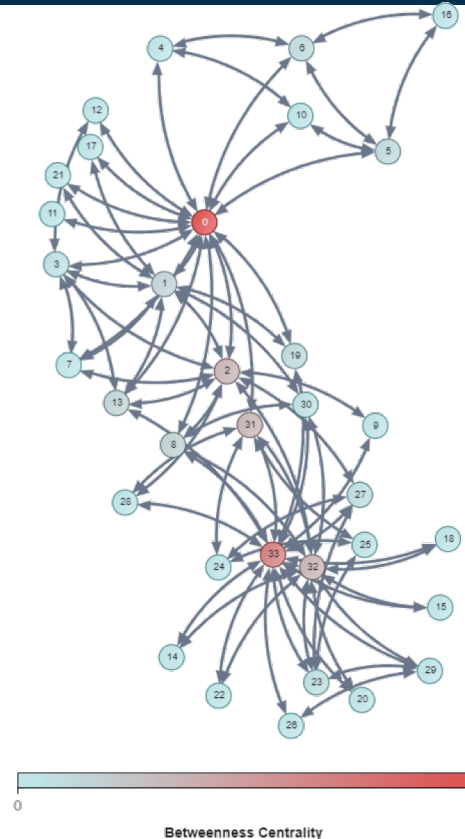
- Cluster / partition identities
- Detect common properties and/or similar preferences
- Commonly used for filtering or grouping



# The Infinite Canvas

## SNA Centralities

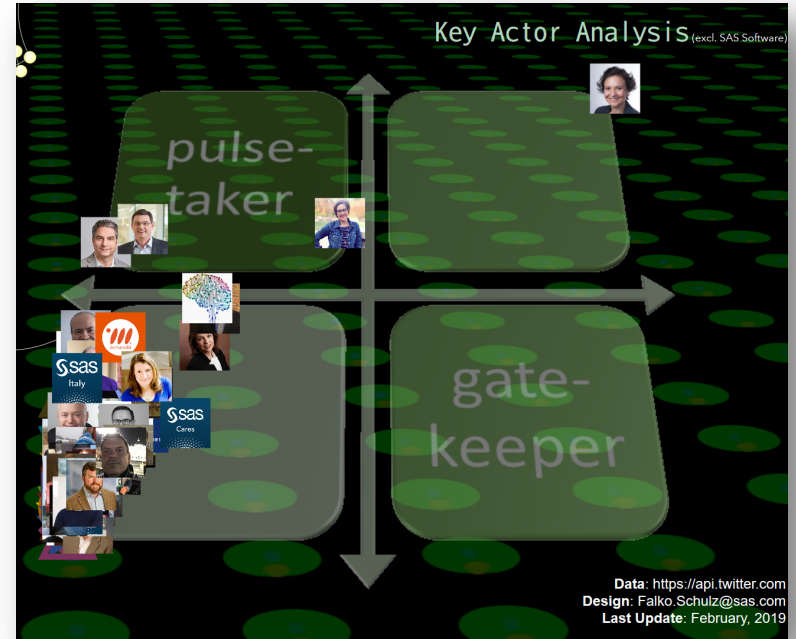
- **Degree** – *number of links to other actors*
- **Betweenness** – *number of shortest paths a node is on*
- **Eigenvector** - *proportional to the centrality of an actor's neighbors*
- **Closeness** – *distance to other actors*
- **Influence** – *degree centrality based on weights, indicates potential influence, performance, or ability to transfer knowledge*



# The Infinite Canvas

## SNA Key Actors

- Eigenvector centrality versus Betweenness
- High score on both measures = **high importance / hub**
- High Betweenness but low Eigenvector centrality = **gatekeeper**
- Low Betweenness but high Eigenvector centrality = **pulsetaker**



# The Infinite Canvas

## How this is implemented in VR

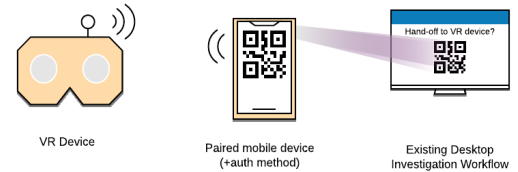
- An entirely separate canvas
- Natural controls for manipulation
- Extra dimension for data separation, courtesy of 3D Hypergroup projection
- Individual attributes less obvious



# The Infinite Canvas

## How it works in practice

- User works on problem, then puts on headset
- Virtual desk in big Virtual Box
- Picks up and handles the data
- Scales it, filters it, marks it, inspects detail
- Classifies data while narrating rationale





# Live Demo

## Virtual Reality

# The Infinite Canvas

## Initial Use Case: Financial Fraud Investigation

- Overview of existing problem
- Relation to social network analysis
- Investigation Workflow



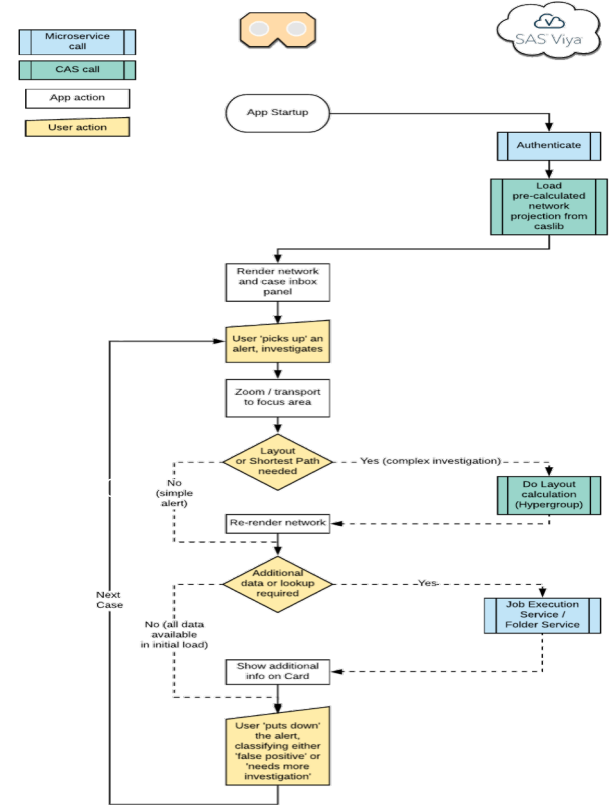


# The Infinite Canvas

## Investigation Workflow

- Fraud alert triage and processing
- Rate of throughput & self-doc workflow

[Marc Andreessen](#)



# Getting IN to Virtual Reality

“Virtual Reality is BY FAR the biggest delta I've ever seen between what it looks like from the outside vs what it feels like on the inside.”

-- Marc Andreessen, web pioneer, venture capitalist. Tweet on Oct. 25<sup>th</sup>, 2015

“Moreover, disparity between current-user satisfaction and non-user disinterest underscores a key challenge for VR: you have to ‘see it to believe it.’ In order to reach high satisfaction levels, VR has to first be tried. This presents marketing and logistical challenges to push that first taste.”

“How Do Consumers Really Feel About VR?” AR Insider, June 11, 2019

# The Infinite Canvas

## Conclusion / Q&A

- Virtual Reality benefits
- CAS as the Data Platform
- Other Advanced Analytics use cases
- Q&A

