Streaming Graph Solutions

February 2020

signalframe

SignalFrame Introduction

SignalFrame is a DC-based venture-backed technology startup founded to organize the landscape of wireless signals. Our SignalGraph platform adapts concepts from graph theory and streaming data management to overcome limitations of traditional graph databases to operate at scale while managing high rates of change.

Service Offerings

SignalGraph

Global Graph of Wireless Signals

Global Streaming Graph of **IoT signals** delivers a **digital index of the physical world**

Signals crowdsourced from consumer mobile apps, generating **25k signals per second** (2.5 billion per day) into a tumbling temporal graph, powering real-time services to Location, IoT intelligence, and National Security sectors.

Streaming Graph

Streaming Graph Technology for the Enterprise

Unlocking breakthrough technology behind SignalGraph to deliver **Streaming Graph capabilities to existing dataflows.**

Structured edge processing for data science, AI and real-time graph analytics.

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Today's Focus

Streaming is the Future of Data Management

Data flows in infinite streams: Denoting data as "Big" or "Small" reflects a legacy batch mindset where all data must first be stored. In practice, data streams are never-ending

Data value is highest 'NOW': Value degrades with age, and systems able to put data to work immediately will be most valuable

Drive advanced applications to the Edge: Everything that can be done at the edge should be done at the edge. Advance the art of Edge processing, not the art of data storage

Data Value Erodes over Time
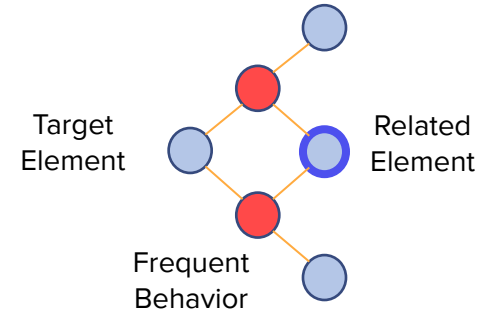
Value of Event — Age of Event

Now
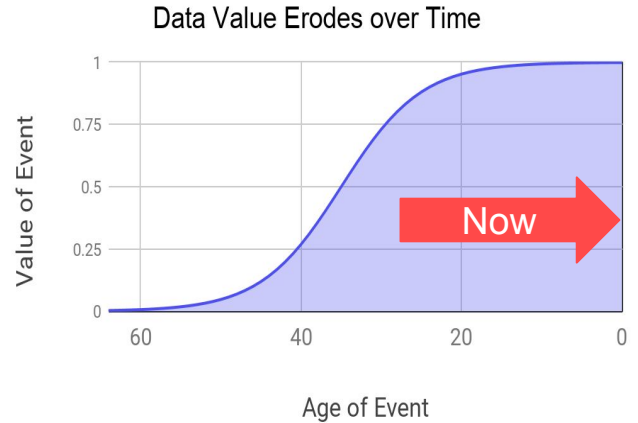
Data operations must drive applications to the **Edge of Now** to maximize value & utility
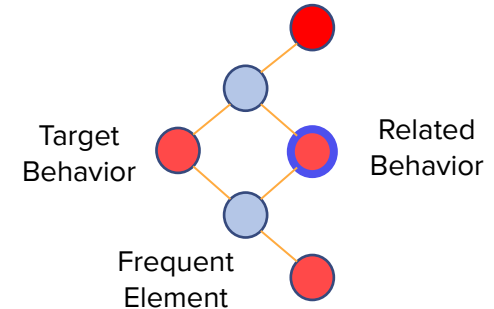
Graph Analytics exploit native relationships within data

- **Graph Architecture** encapsulates the rich and complex relationships billions of elements

- **Graph Analytics** expands analytics to neighboring elements and/or surface underlying facts hidden in graph data
  - relationships from interactions across data sources
  - non-obvious relationships
  - clustering, communities, and networks without supervision

- **Streaming Graph** *Graph Architecture* and *Streaming Data Management* techniques unlock *Graph Analytics* in highly-dynamic, large-scale data applications
  - Activate Graph analytic techniques in real-time
  - Operate streaming algorithms that operate on *change* within extended community and network level
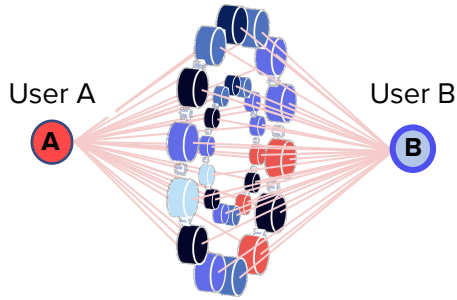
Community Detection

Target Element

Related Element

Frequent Behavior

Behavioral Clustering

Target Behavior

Related Behavior

Frequent Element

# Streaming Graph: Framework for Analytics at the Edge

Users related across all available attributes
(Demos, behaviors, tastes, etc.)

User A   User B

Users are related to one another through the sum total of **all available attributes**

Relationships are basis for defining **similarity** across users and groups of users, forming the edges of the graph

User Graph captures relationships across all users
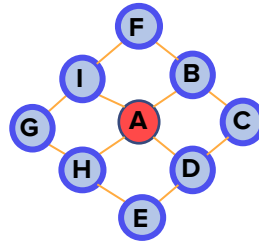
Graph relating all users built from aggregation of pairwise similarities established between every user

Graph constantly updated as new data arrives
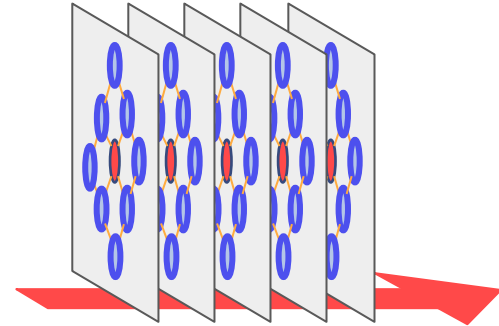
Graph maintains a **current** map of relationships as behaviors **change over time** within a sliding window

Streaming Graph: Graph Intelligence @ the Edge

Extend Streaming Graph Technology to your data

SignaFrame has pioneered a breakthrough in Graph data architecture
- Enabling massive-scale temporal graphs to operate in streaming mode.
- Maintains the natural structure of the data, all interrelationships within, and every change in this structure every second.
- Technology is backbone of IoT SignalGraph, ingesting 25k signals per second (2.5 billion per day) into a tumbling graph

Streaming Graph is fertile ground for your brightest minds, and it lives in real-time
- Architecture natively surfaces element embeddings and contextual details without supervision
- Rapid retrieval of networks and communities and related facts
- Graph embeddings for the basis for vector-based operations that are at the heart of neural networks and many advanced Deep Learning applications.

Streaming Graph Coexists with your data environment
- Streaming Graph taps existing inbound datastreams
- Maintains a sliding window that has a fixed cost structure not grow over time
- Lives in harmony with existing systems with easy API integrations.
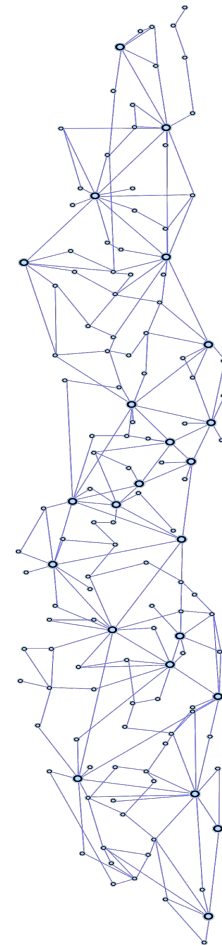
Data Done Better: Streaming Graph Advantages

Invest in the Edge
Do more with your data when it matters -- now. Advance the art of Edge processing, not the art of data storage.

Firm Ground for Data Science
Graph structure is robust, reflecting the rich tapestry of your data, its interrelationships and historical context -- and it is constantly up-to-date. Graph algorithms adapt to change, avoid overfitting, and thrive on changing relationships.

The Analyst / Data Scientist is in the Driver Seat
The Streaming Graph framework is programmable and adaptable, allowing your data scientists, analysts and managers to develop, test and deploy without cumbersome engineering development cycles. The power of AI is governed by your staff.

Streaming Graph Works for You

For the Data Scientist: Simplify & streamline development, testing and deployment

For the Chief Analytics Officer: Eliminate workflow uncertainty, solidify deadline commitments

For the CIO: Deliver edge services & real-time AI applications without disruption. Fixed-cost model scales by data flow and does not grow over time.

For the Enterprise: Amplify data and data science investments, accelerate return-on-data getting directive insights faster.
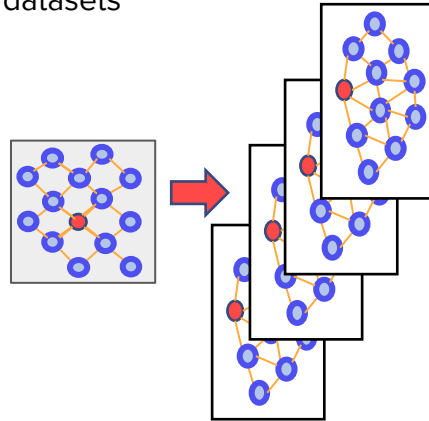
Case: Geospatial Fusion

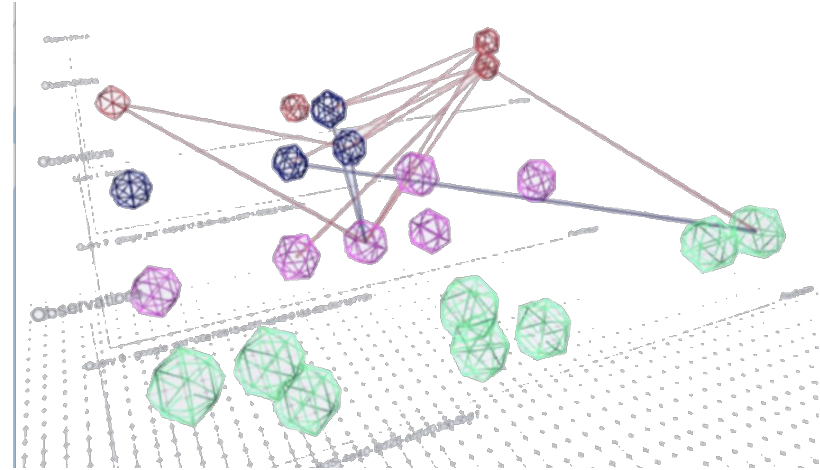# Geospatial Clusters: Universal Fusion Key

All geospatial events are keyed on time and space

Event co-occurrence in bounded geospace provides context for establishing embeddings across datasets

Embeddings-based analysis reveals relationships across elements in different data sources
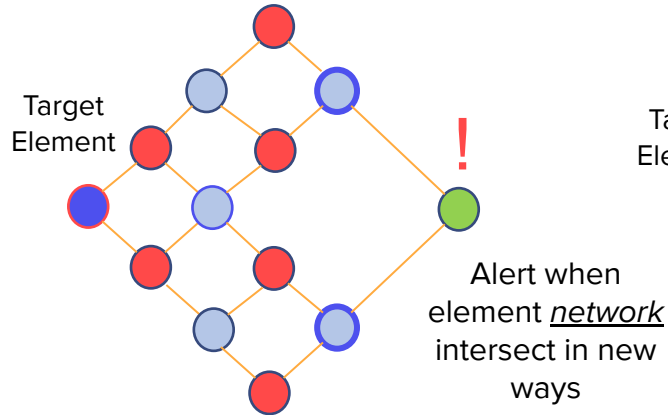
Community Network Analysis

Graph Algorithms operate at the community/network level, surfacing direct and indirect relationships with simple target seeds

- Define unsupervised communities seeded with known Target Elements and deploy algorithms that monitor behaviors of complete related community of assets

- Detect defined patterns of interaction without maintenance of community definitions

Monitor *behaviors* in within communities

Target Element

!

Alert when element *network* intersect in new ways

Monitor *intersections* of independent communities

Target Element A

!

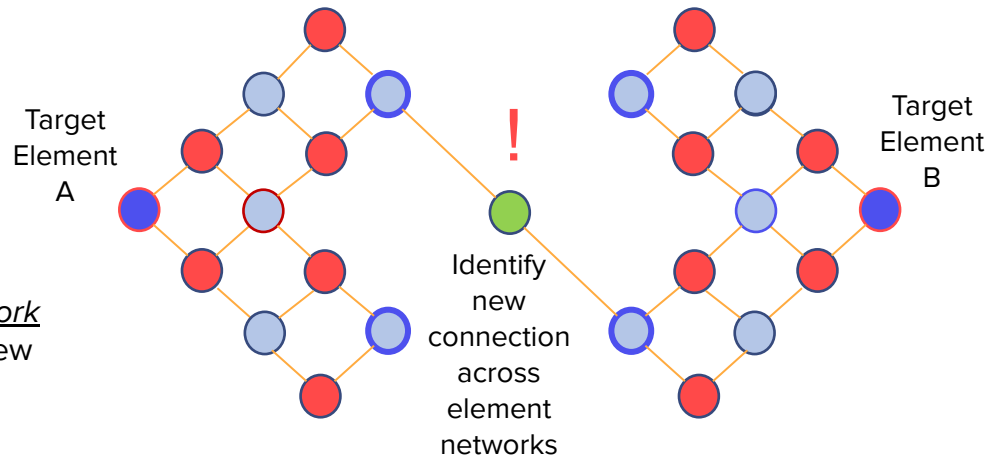Identify new connection across element networks

Target Element B

Geography Network Analysis

Graph Algorithms operate at the community/network level, surfacing direct and indirect relationships with simple target seeds

- Seed Target Geography to define unsupervised geography networks (places sharing communities), to identify Related Geographies and detect anomalous patterns

Monitor *geo networks* with simple seeds
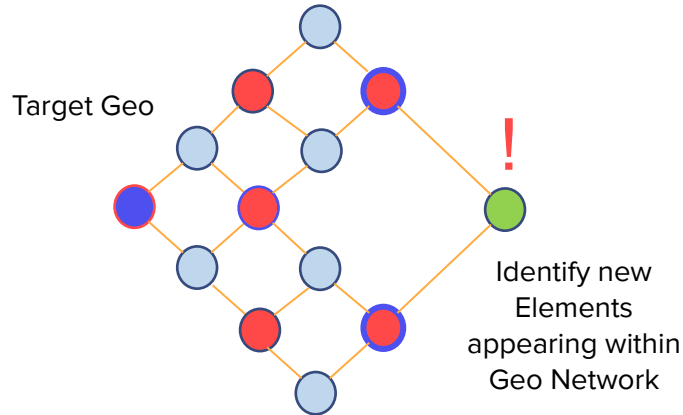
Identify overlaps across *geo networks*

Target Geo

!

Identify new Elements appearing within Geo Network

Target Geo A

!

New connection across networks

Target Geo B
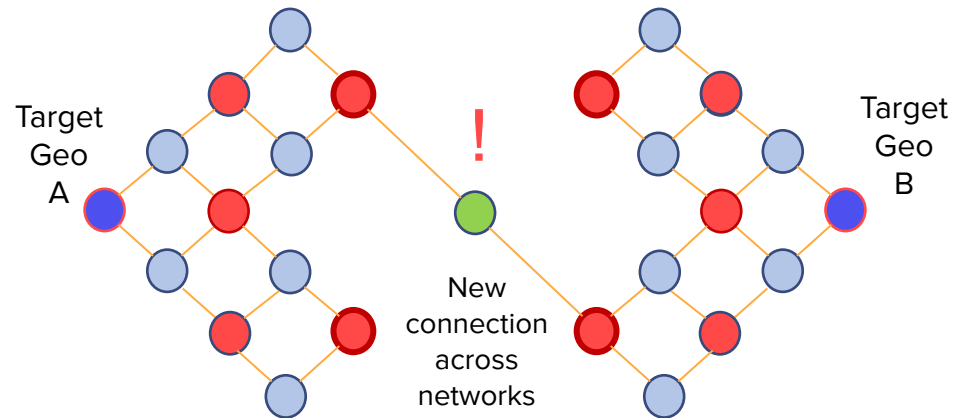
Case: Lookalike Modeling

Graph Likeness Streamlines Lookalike Modeling Process

Lookalike models seek to expand pools of segments for marketing activation

A better way to Lookalike
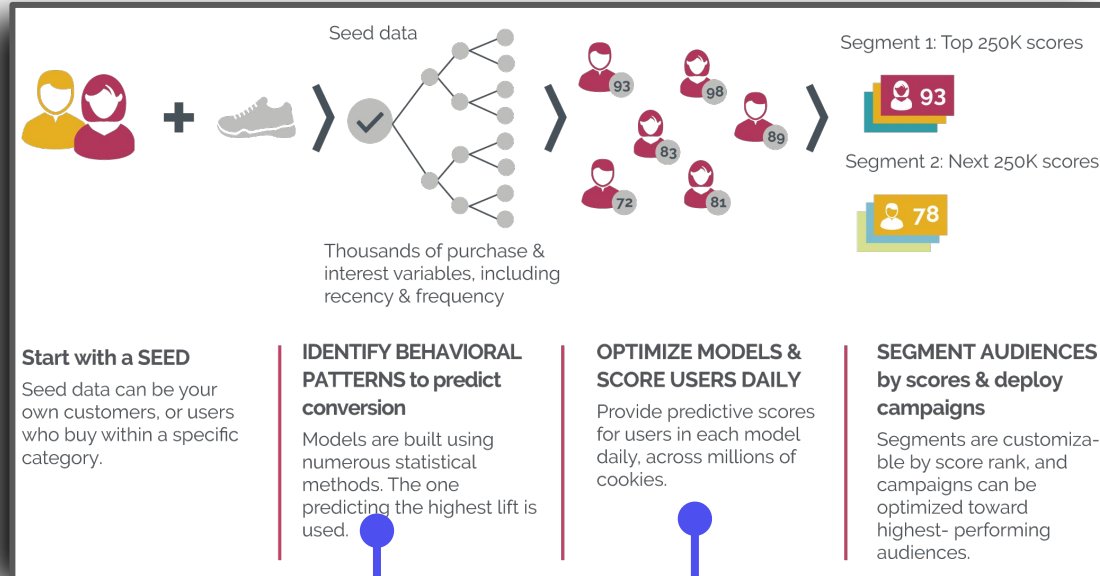The art and science of look-alike modeling is determining which parameters at what weight should enter into the model. Once built, models must be maintained to verify ongoing efficacy, often requiring re-training.

Both training and retraining can be subjective, manual and cumbersome, particularly as the number of models expands.

Streaming Graph Advantages:
- **Unsupervised management**: Models always current, no retraining required
- **Sliding scale for "likeness":** Easily move between specificity and reach requirements
- **Model-by-configuration**: Quickly test and compare alternatives

Seed data

93 98
83 89
72 81

Thousands of purchase & interest variables, including recency & frequency

Segment 1: Top 250K scores
93

Segment 2: Next 250K scores
78

Start with a SEED
Seed data can be your own customers, or users who buy within a specific category.

IDENTIFY BEHAVIORAL PATTERNS to predict conversion
Models are built using numerous statistical methods. The one predicting the highest lift is used.

OPTIMIZE MODELS & SCORE USERS DAILY
Provide predictive scores for users in each model daily, across millions of cookies.

SEGMENT AUDIENCES by scores & deploy campaigns
Segments are customizable by score rank, and campaigns can be optimized toward highest- performing audiences.

https://www.digilant.com/solutions-april-2019/proprietary-programmatic-solutions/
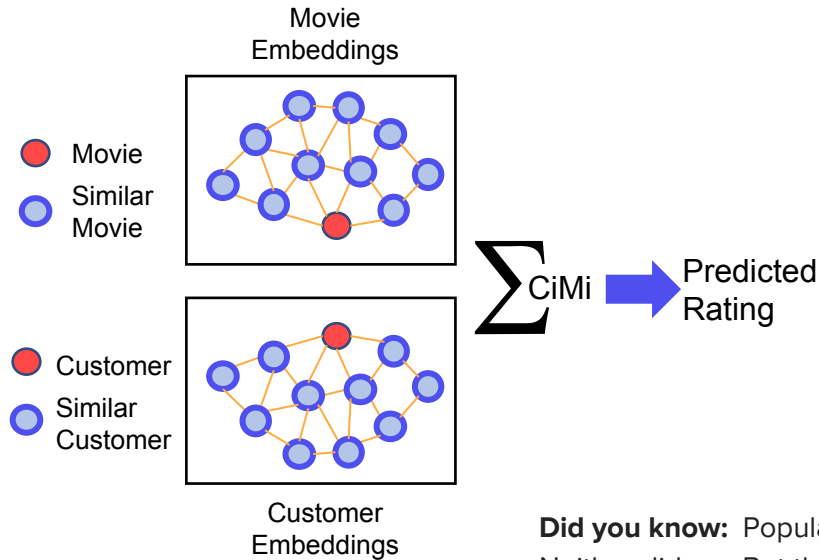
Key parts of the process are manual, subjective and time consuming

Graph Likeness applied: Recommender Systems

Replication of famous Netflix Prize Competition via Streaming Graph

In 2007 Netflix offered a prize for anyone who could improve the accuracy of customer ratings of films, offering a $1mm prize. After 2 years BellKor's Pragmatic Chaos won posting a root mean square error (RMSE) of **0.8567,** a 10.06% improvement over the **0.9525** benchmark.

Netflix Prize Dataset
17,770 Movies
480,189 Users
100,480,507 Ratings

Movie
Embeddings

● Movie

● Similar
Movie

$\sum$CiMi → Predicted
Rating

● Customer

● Similar
Customer

Customer
Embeddings

Graph Likeness approach delivered an **RMSE of 0.6472**

3x better than the winning team

Did you know: Popular movies are poor predictors of individual tastes? Neither did we But the data did, and the Graph allowed that to flow through the calculations.

15

Case: Global SignalGraph

The Global SignalGraph™ is the world's largest streaming graph platform

The world's largest database of wireless signals

10+ thousand device types
(electronics, wearables, cars, appliances, etc.)
6.5+ thousand venues and businesses
(restaurants, hotels, office buildings, travel hubs, etc.)

Global collection network
Processing **25k signals per second** (2.5 billion per day)
Available in **near real-time** (5 seconds)

30mm enabled smartphones → **2.5B+ daily WiFi and Bluetooth detections** → **SignalGraph™ platform** → **Real-time Services**
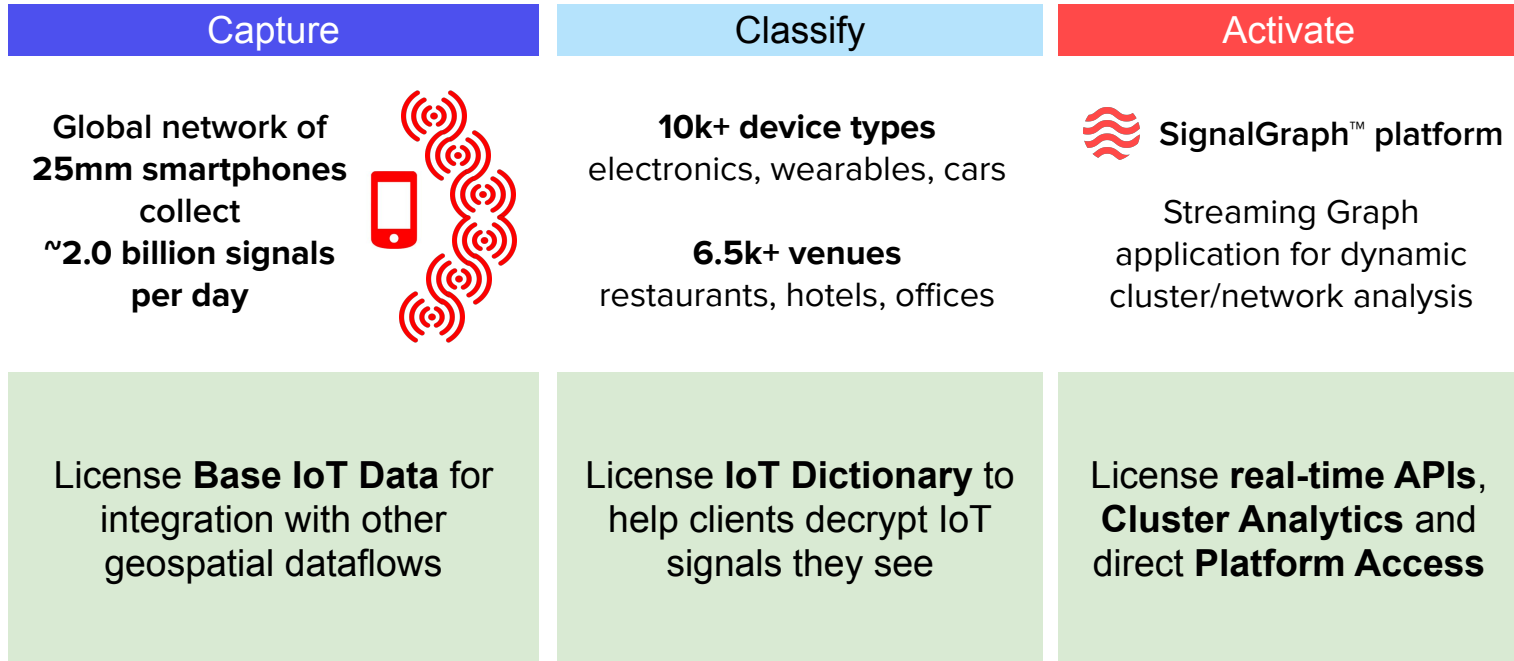
We **crowdsource** signal data collection through partner mobile apps, turning millions of enabled smartphones into a global signal-gathering network that continuously expands and refreshes the SignalGraph.

Our proprietary technology captures unstructured signal information, **decrypts and classifies signal identities** and maps the signal clusters to the physical world

The Global SignalGraph™ is the world's largest streaming graph platform

As wireless technology is embedded in everyday devices, they deliver a **digital imprint of the physical world**. SignalGraph continuously indexes billions IoT devices in a temporal graph

Capture	Classify	Activate
Global network of 25mm smartphones collect ~2.0 billion signals per day	**10k+ device types** electronics, wearables, cars **6.5k+ venues** restaurants, hotels, offices	**SignalGraph™ platform** Streaming Graph application for dynamic cluster/network analysis
License **Base IoT Data** for integration with other geospatial dataflows	License **IoT Dictionary** to help clients decrypt IoT signals they see	License **real-time APIs**, **Cluster Analytics** and direct **Platform Access**

Decrypting Wireless Signals

Industry's largest dictionary of IoT objects. Helping clients understand the real-world identity of IoT objects

Roku

If **Wifi** , MAC="**0a:05:81**" THEN

tv_media_adapter | roku

If **BLE** , MAC="**0a:05:81**" THEN

tv_media_adapter | roku

fitbit

If **BLE** SSID="**Alta**"
AND HAS A **4** character **alphanumeric**
prefix
THEN

fitness | wearable | fitbit

CHEVROLET

If **Wifi** SSID="**Corvette**"
, MAC="**bc:82:5d**"
AND CONTAINS **Corvette** THEN

car | chevrolet | corvette

If **Wifi** SSID="**Bolt**" , MAC="**bc:82:5d**"
AND CONTAINS **Bolt** THEN

car | chevrolet | bolt

chromecast

If **BLE** SSID="**cast**" , MAC="**fa:8f:ca**"
AND CONTAINS **cast** THEN

tv_media_adapter | google
chromecast

TESLA

If **BLE** , MAC="**a0:7d:ea**" THEN

car | tesla | model_3

If **BLE** , MAC="**a0:7d:ea**" THEN

tesla

GoPro

If **BLE** SSID="**GoPro**"
AND HAS A **4** character **numeric**
prefix
THEN

sports_action_camera | gopro

A Picture is Worth 1,000 Words

See More with Signals

Drill Crew
Arrived 4 days ago

Active Well Pad

Frac Crew
Arrived 2 days ago

# Earth Observation Offerings

Life of a signal
One signal, PsPatDri297, appeared at 25 different sites across 2019, typically remaining in that location for 2+ weeks.

Offering
SignalFrame defines and maintains signal clusters across 100s of thousands of similar signals and monitors when and where they are active.

Weekly reporting at a daily grain available for client-defined locations

Signal view of Land Development
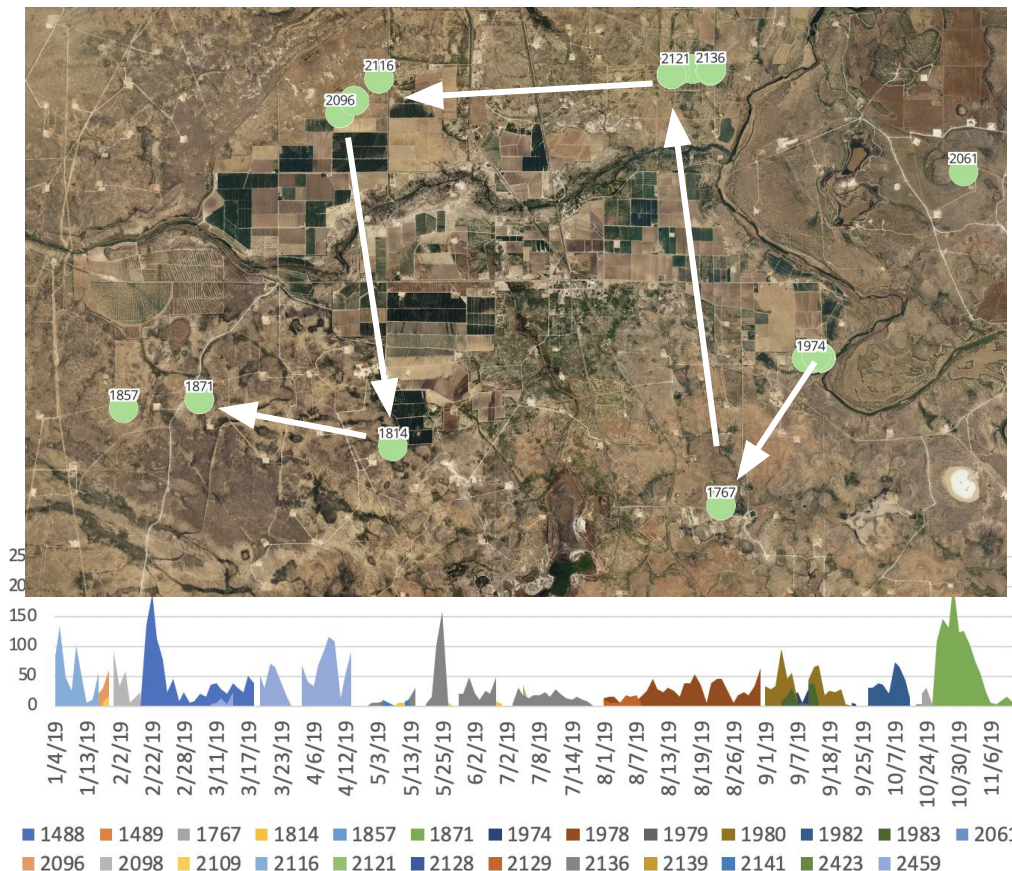
SignalGraph: A digital reference set for the real world

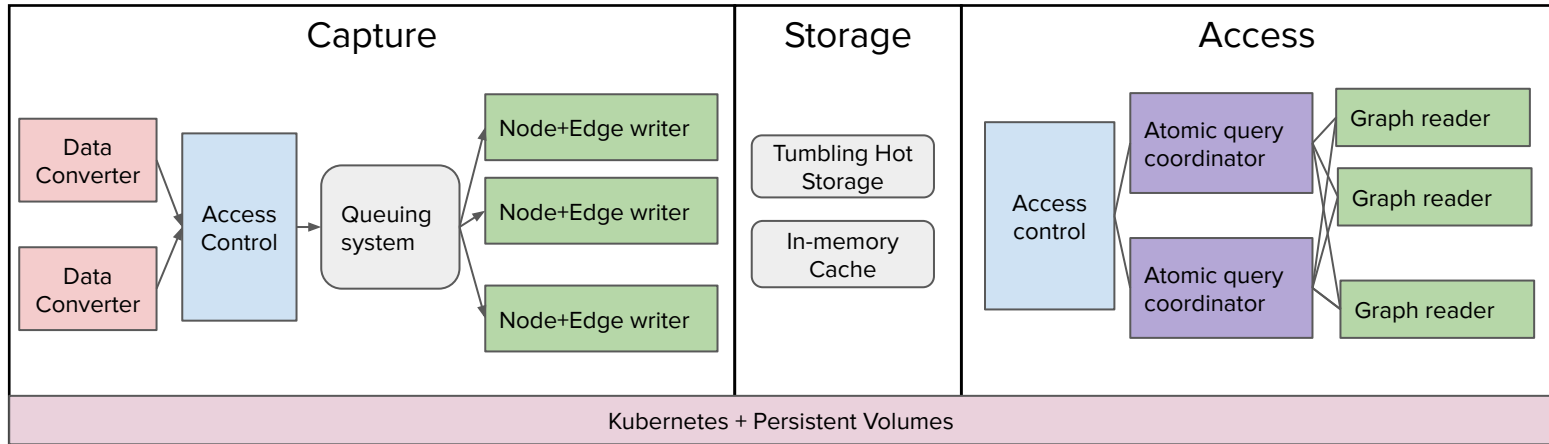**Precise Location: Place Attachment**

GPS fall short in indoor and dense urban environments. Location Intelligence is blind inside of malls and airports. SF integration provides directly actionable place-attachment data to supplement existing audience business
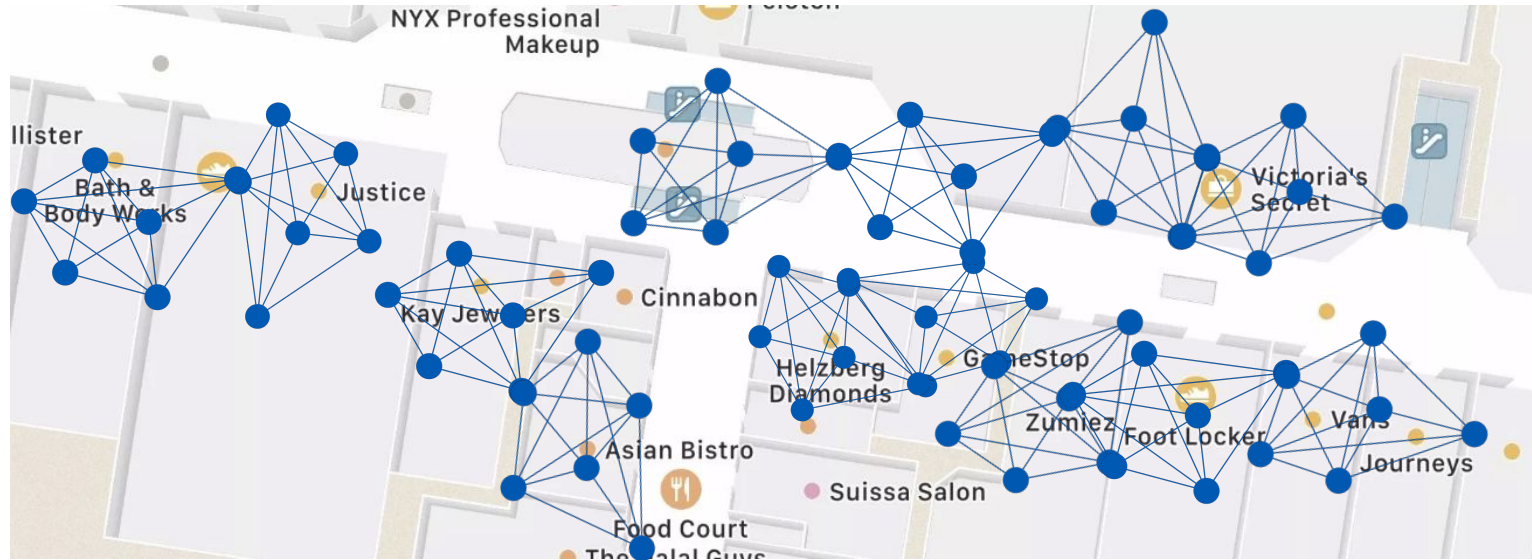
Architecture & Access

SignalFrame Streaming Graph Architecture
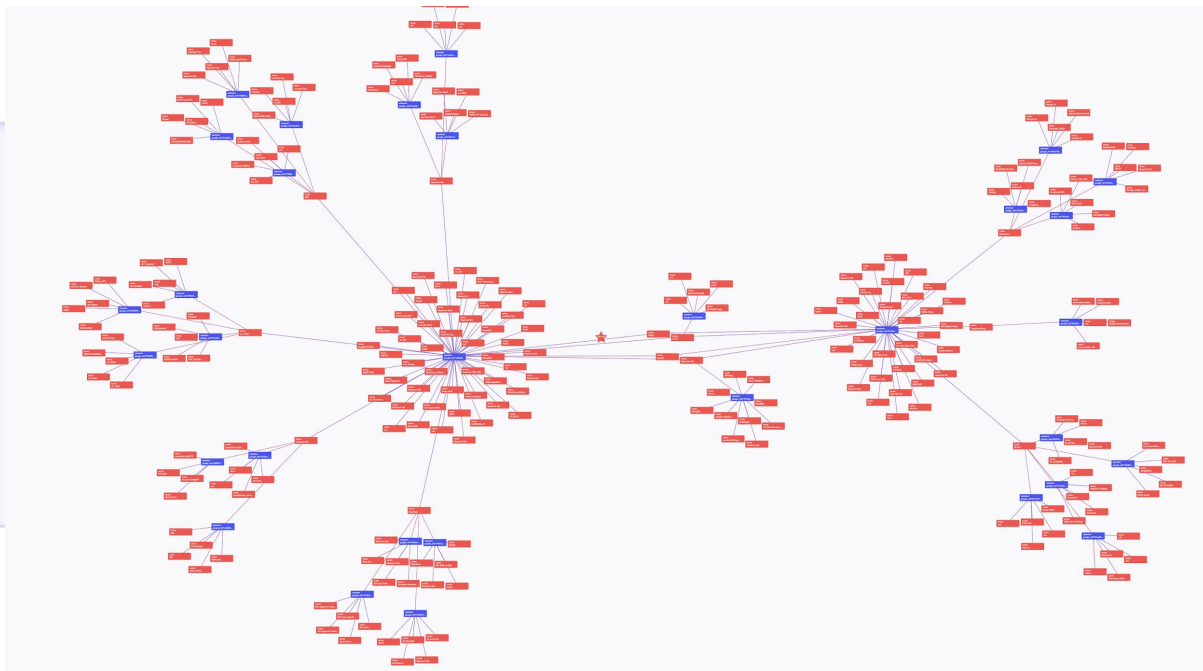
Power of the Graph at Scale

Simple queries deliver uncommon power to access relationships at the edge

Historical Query

SEED QUERY

```
UNARY(
  STARTTIME 2019-09-10T00:00:00Z
  ENDTIME 2019-09-18T23:59:59Z
  STARTNODES [Nyi Nyi__ac:84:c6:c3:51:7c__1]
  PATH [signal->observation
      LIMIT -1]
    [observation->signal
      LIMIT 10]
  RETURN GRAPH
)
```

Render Query

About us

Team

Leadership

CEO: Cameron Meierhoefer
Cameron joined SignalFrame in September 2018 from comScore (NASDAQ: SCOR), where he most recently served as COO. During his 18-year tenure, he helped build the internet research startup into a global source for trusted media measurement, driving development of many of the company's industry solutions spanning e-commerce, financial services, and media/advertising measurement products.

Co-founder and CTO: Srdjan Marinovic
As a senior researcher at ETH Zurich, Srjdan focused on logical security and privacy models, and distributed time-series event processing supported by Google and Kaba Security Industries. He holds a PhD from Imperial College London, where he worked on non-monotonic AI systems and symbolic trust-management algorithms.

**Co-founder and COO: Stillman Bradish**
Stillman brings expertise in wireless technologies, IoT applications, and proximity applications. He previously founded Radius Networks, a successful location technology company that helps businesses locate, engage and transact with customers for order delivery, messaging, and tracking. Stillman has been awarded several patents, with others pending around proximal services and signal systems.

Investors

BLAZAR VENTURES

GREYCROFT

RAZOR'S EDGE

NAV.VC

PJC

Verizon Ventures

Streaming Graph: Framework for Analytics at the Edge

Geographies related across all available behavior patterns

Geo A   Geo B

A   **B**
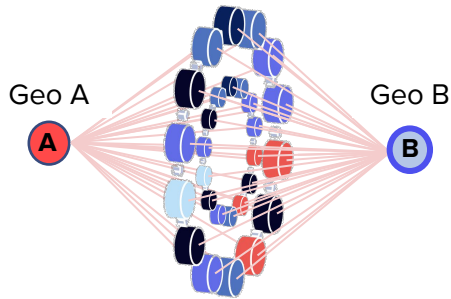
Geographies (defined through standard geohashes) are related to one another through the sum total of **all available attributes**
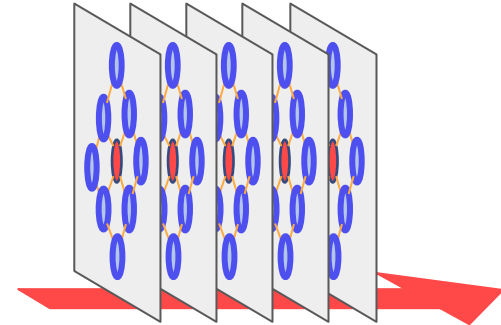
Relationships are basis for defining **similarity** across Geos and groups of geos, forming the edges of the graph

Geo Graph captures relationships across all Geographies
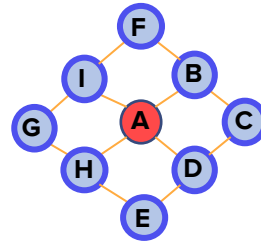
Graph relating all Geos built from aggregation of pairwise similarities established between every geography

Graph constantly updated as new data arrives

Graph maintains a **current** map of relationships as **risk changes over time**