Locational Analytics and Big Data: Foundations, Emerging Applications, and Research

Overview of Spatial Big Data and Analytics
(9:10-9:55am)

Applications and Examples of Spatial Big Data and Analytics
(9:55-10:15am)

Break

Research Opportunities in Location, Analytics, Big Data and GIS for IS Researchers
(10:25-10:45am)

Overview of Spatial Big Data and Analytics

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Pre-ICIS Workshop on Locational Analytics and Big Data:
Foundations, Emerging Applications, and Research

Sponsored by SIGGIS
Association for Information Systems

Fort Worth, Texas, December 13, 2015

New IDC Forecast Sees Worldwide Big Data Technology and Services Market Growing to $48.6 Billion in 2019, Driven by Wide Adoption Across Industries

November 09, 2015 08:30 AM Eastern Standard Time

FRAMINGHAM, Mass.--(BUSINESS WIRE)--The Big Data market continues to exhibit strong momentum as businesses accelerate their transformation into data-driven companies. This momentum is driving strong growth in big data-related infrastructure, software, and services. A new forecast from International Data Corporation (IDC) sees the big data technology and services market growing at a compound annual growth rate (CAGR) of 23.1% over the 2014-2019 forecast period with annual spending reaching $48.6 billion in 2019. And a new IDC Special Study examines spending on big data solutions in greater detail across 19 vertical industries and eight big data technologies.

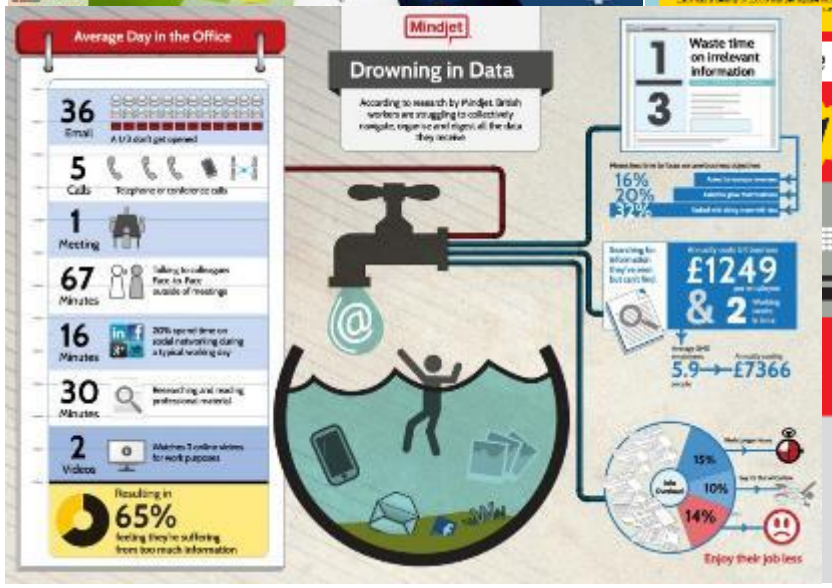
“The ever-increasing appetite of businesses to embrace emerging big data-related software and infrastructure technologies while keeping the implementation costs low has led to the creation of a rich ecosystem of new and incumbent suppliers”

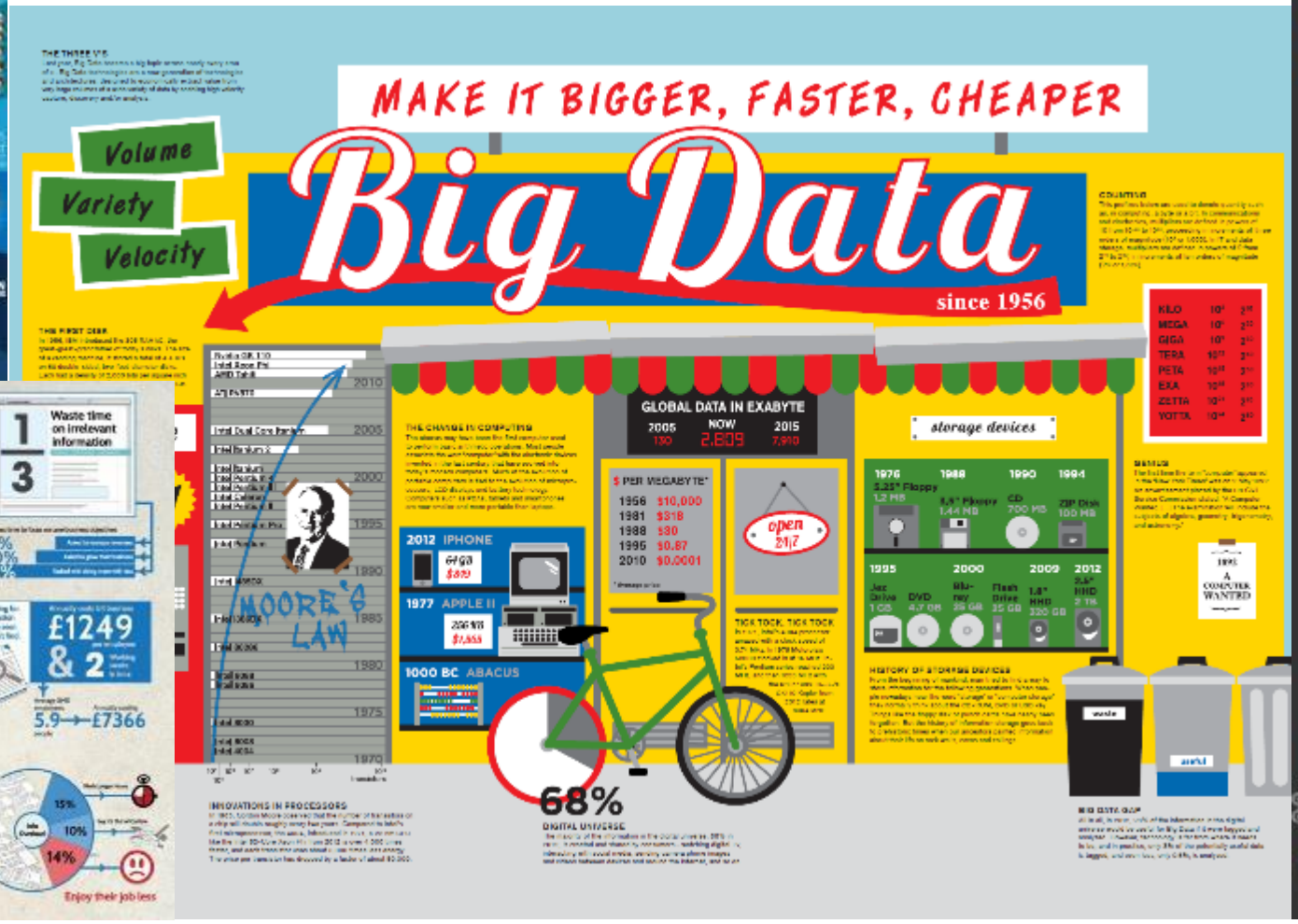
"The ever-increasing appetite of businesses to embrace emerging big data-related software and infrastructure technologies while keeping the implementation costs low has led to the creation of a rich ecosystem of new and incumbent suppliers," said Ashish Nadkarni, Program Director, Enterprise Servers and Storage and co-author of the report with Dan Vesset, Program Vice President, Business Analytics & Big Data. "At the same time, the market opportunity is spurring new investments and M&A activity as incumbent suppliers seek to maintain their relevance by developing comprehensive solutions and new go-to-market paths."

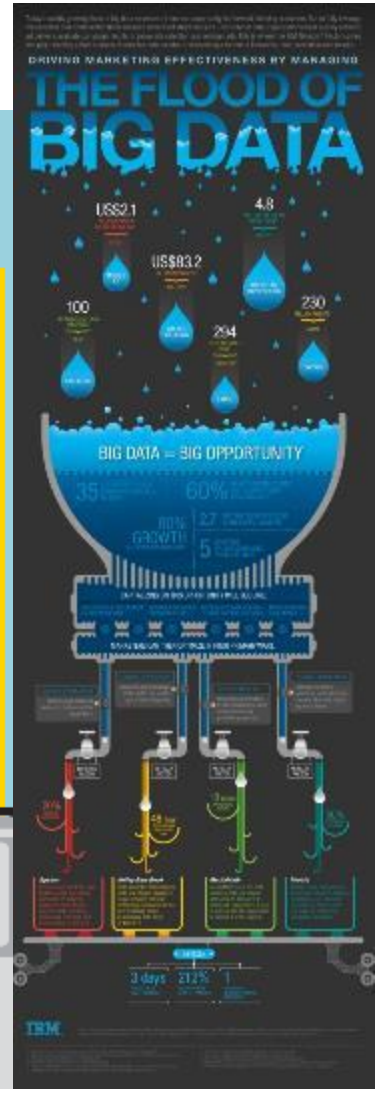
All three major big data submarkets – infrastructure, software, and services – are expected to grow over the next five years. Infrastructure, which consists of

Big Data – A Brief Review

Perhaps you've seen these before?








IN 60 SECONDS...
1 NEW DEFINITION IS ADDED ON Urban
1,600+ READS ON Scribd
13,000+ HOURS MUSIC STREAMING ON PANDORA
12,000+ NEW ADS POSTED ON craigslist
370,000+ MINUTES VOICE CALLS ON skype
98,000+ TWEETS
320+ NEW twitter ACCOUNTS
100+ NEW Linked in ACCOUNTS
1 associatedcontent NEW ARTICLE IS PUBLISHED
THE WORLD'S LARGEST COMMUNITY CREATED CONTENT!!
6,600+ NEW PICTURES ARE UPLOADED ON flickr
50+ WordPress DOWNLOADS
695,000+ facebook STATUS UPDATES
125+ PLUGIN DOWNLOADS
79,364 WALL POSTS
510,040 COMMENTS
1,700+ Firefox DOWNLOADS
694,445 SEARCH QUERIES
168 MILLION EMAILS ARE SENT
60+ NEW BLOGS
1,500+ BLOG POSTS
70+ DOMAINS REGISTERED
25+ HOURS TOTAL DURATION
600+ NEW VIDEOS
100+ Answers.com
40+ YAHOO!
QUESTIONS ASKED ON THE INTERNET...
13,000+ iPhone APPLICATIONS DOWNLOADED
20,000+ NEW POSTS ON tumblr.
THE LARGEST
New Craigslist Ads
Google
Google Search
GO-Globe.com

The FOUR V's of Big Data

From traffic patterns and music downloads to web history and medical records, data is recorded, stored, and analyzed to enable the technology and services that the world relies on every day. But what exactly is big data, and how can these massive amounts of data be used?

As a leader in the sector, IBM data scientists break big data into four dimensions: **Volume, Velocity, Variety and Veracity**

Depending on the industry and organization, big data encompasses information from multiple internal and external sources such as transactions, social media, enterprise content, sensors and mobile devices. Companies can leverage data to adapt their products and services to better meet customer needs, optimize operations and infrastructure, and find new sources of revenue.

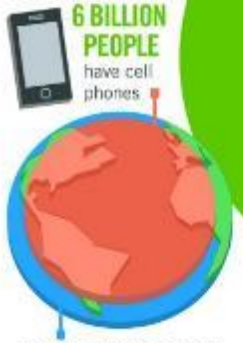
By 2015
4.4 MILLION IT JOBS
will be created globally to support big data, with 1.9 million in the United States

Volume
SCALE OF DATA

40 ZETTABYTES
[43 TRILLION GIGABYTES]
of data will be created by 2020, an increase of 300 times from 2005

It's estimated that
2.5 QUINTILLION BYTES
[2.3 TRILLION GIGABYTES]
of data are created each day

6 BILLION PEOPLE
have cell phones



Most companies in the U.S. have at least
100 TERABYTES
[100,000 GIGABYTES]
of data stored

Variety
DIFFERENT FORMS OF DATA

As of 2011, the global size of data in healthcare was estimated to be
150 EXABYTES
[161 BILLION GIGABYTES]

30 BILLION PIECES OF CONTENT
are shared on Facebook every month

By 2014, it's anticipated there will be
420 MILLION WEARABLE, WIRELESS HEALTH MONITORS

4 BILLION+ HOURS OF VIDEO
are watched on YouTube each month

400 MILLION TWEETS
are sent per day by about 200 million monthly active users

Velocity
ANALYSIS OF STREAMING DATA

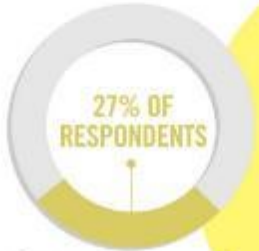
The New York Stock Exchange captures
1 TB OF TRADE INFORMATION
during each trading session

Modern cars have close to
100 SENSORS
that monitor items such as fuel level and tire pressure

By 2016, it is projected there will be
18.9 BILLION NETWORK CONNECTIONS
– almost 2.5 connections per person on earth

Veracity
UNCERTAINTY OF DATA

1 IN 3 BUSINESS LEADERS
don't trust the information they use to make decisions



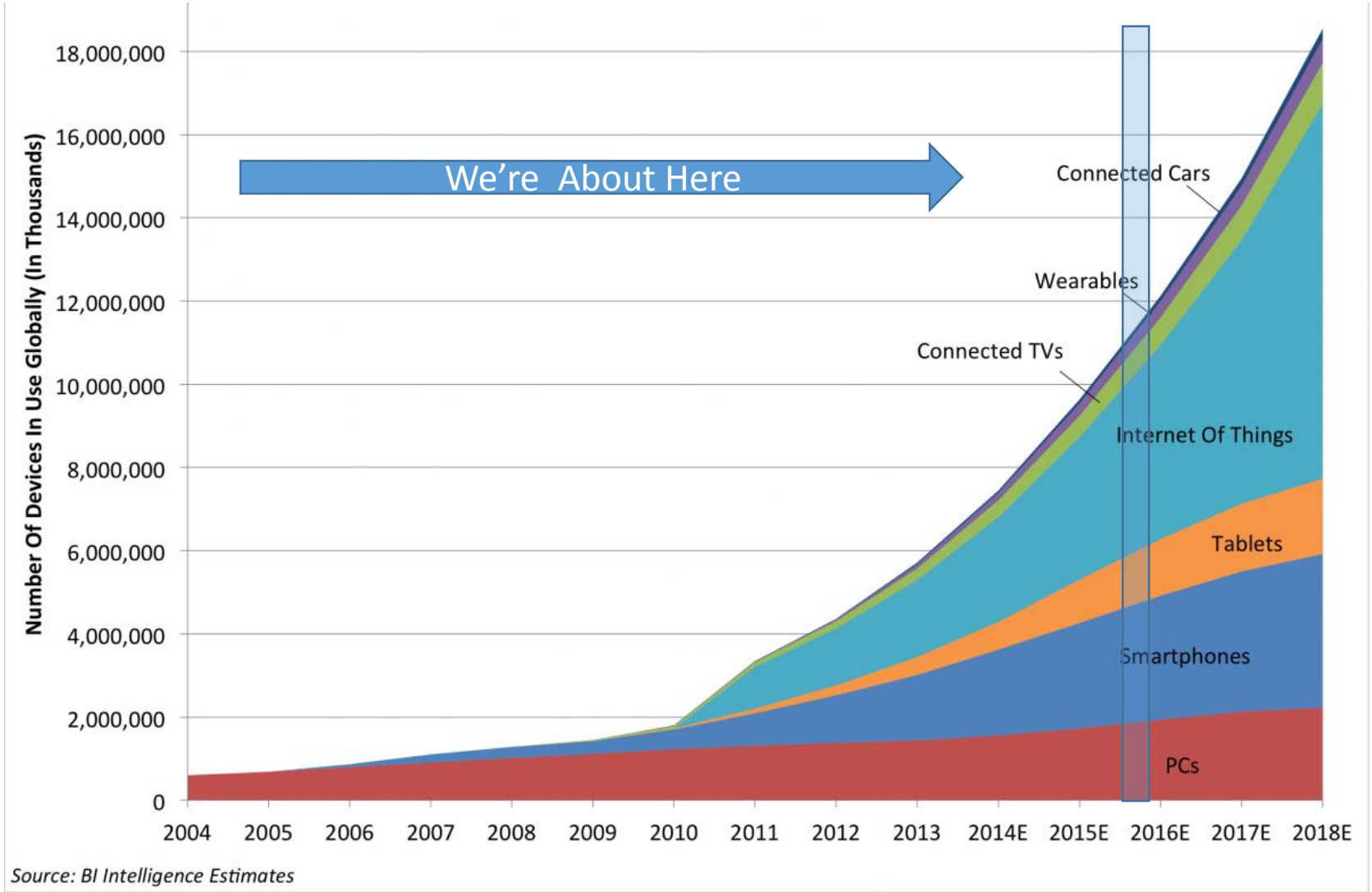
in one survey were unsure of how much of their data was inaccurate

Poor data quality costs the US economy around
$3.1 TRILLION A YEAR

Sources: McKinsey Global Institute, Twitter, Cisco, Gartner, EMC, SAS, IBM, MEPTEC, QAS

IBM

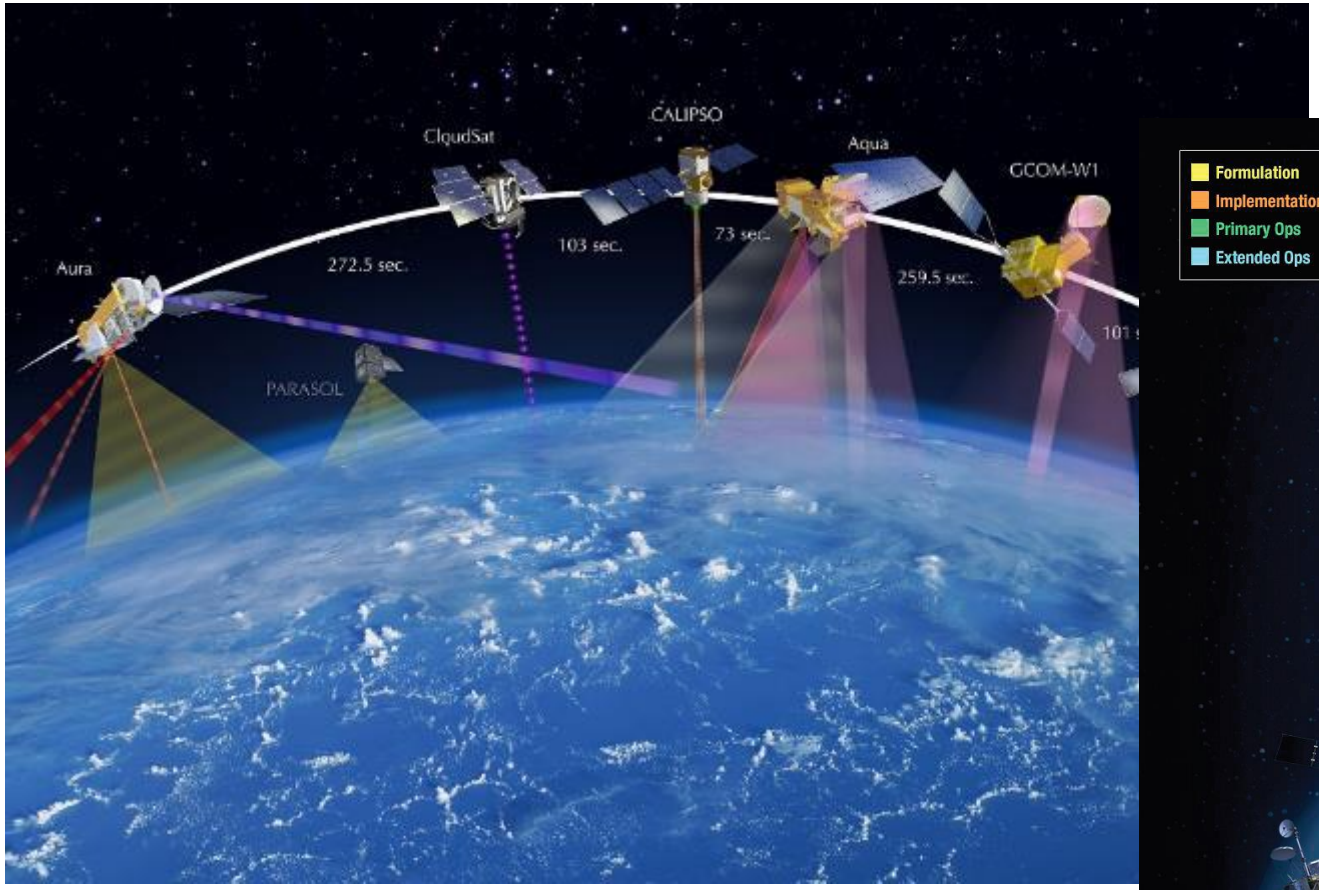
Where is this Big Data coming from? It's the Internet of Everything…



Where is this Big Data coming from?
It's User-Generated Content…

Where is this Big Data coming from?
It's Sensor Data…

Where is this Big Data coming from?
It's Sensor Data…



Where is this Big Data coming from?
It's Connected Data…

Where is this Big Data coming from?
It's all these "Smart" "Things"…

Where We Are…Devices

- PCs
- Tablets
- Smartphones
- Connected TVs
- Connected Cars
- Wearables

Where We're Going…'Things'

- Smart homes
- Smart cities
- Smart offices
- Smart factories

Big Data – A Brief Review

So, we know that “big data” is BIG…

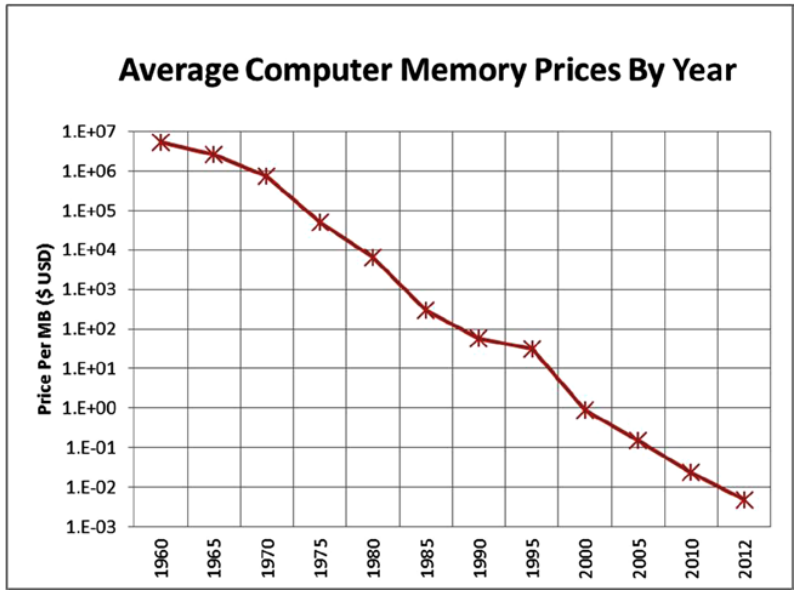
1 kilobyte	1,000
1 megabyte	1,000,000
1 gigabyte	1,000,000,000
1 terabyte	1,000,000,000,000
1 petabyte	1,000,000,000,000,000
1 exabyte	1,000,000,000,000,000,000
1 zettabyte	1,000,000,000,000,000,000,000

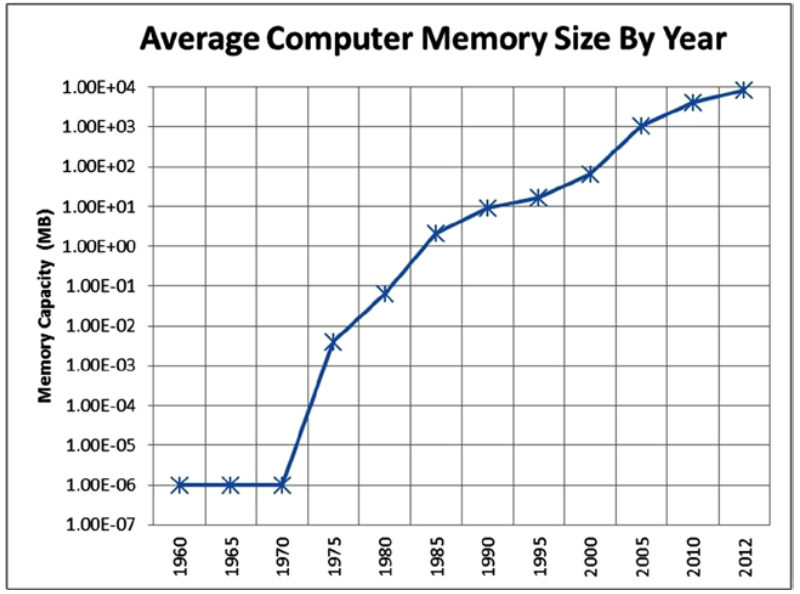
How do we Manage and Analyze Big Data?

Big Data Analytic Platforms

What is enabling them?

- Lower Cost
- Greater Storage (HD and RAM)
- Faster Input / Output Operations
- Faster Processing
- Increased Bandwidth



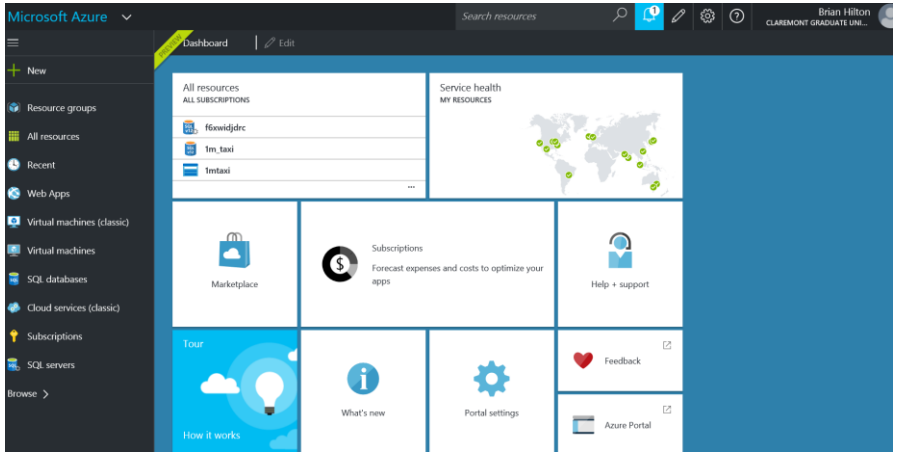


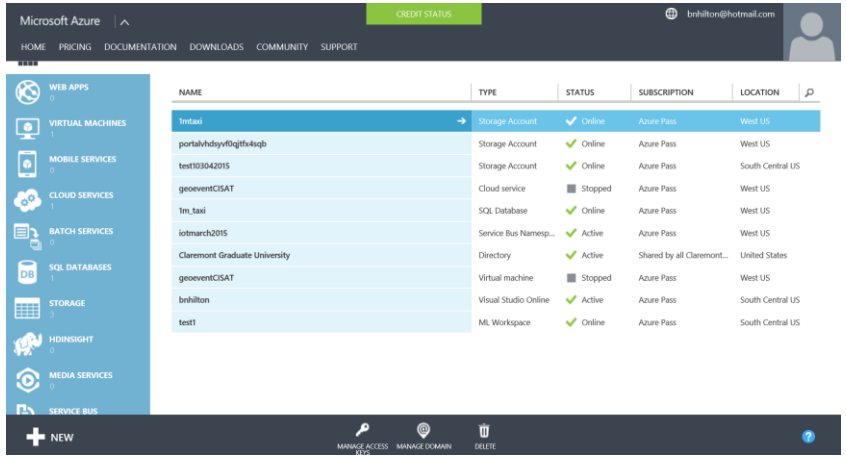
Since 1990, the average price per MB of memory has dropped from $59 to 0.49 cents – a 99.2% price reduction.
At the same time, the capacity of a memory module has increased from 8MB to a 8GB.

Big Data Analytic Platforms

What is enabling them?

- Cloud / Distributed Computing
- New Data Management Tools (Hadoop, etc.)
- New Technologies (Spark, etc.)
- Ease-of-Use (Browser-based, etc.)

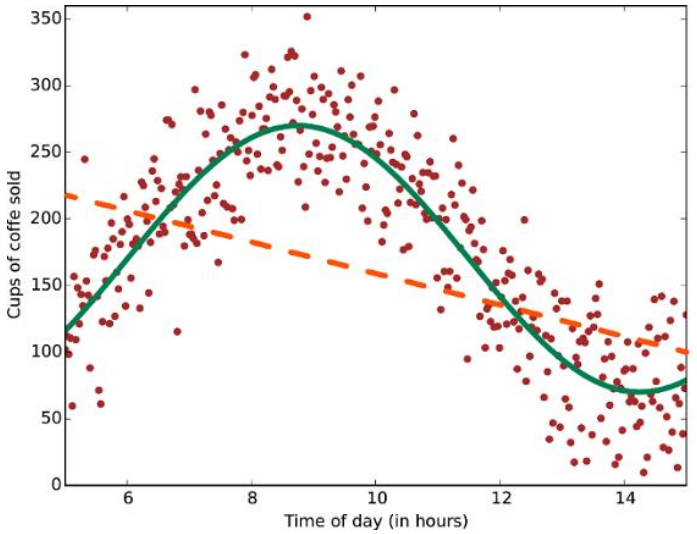


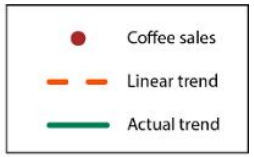


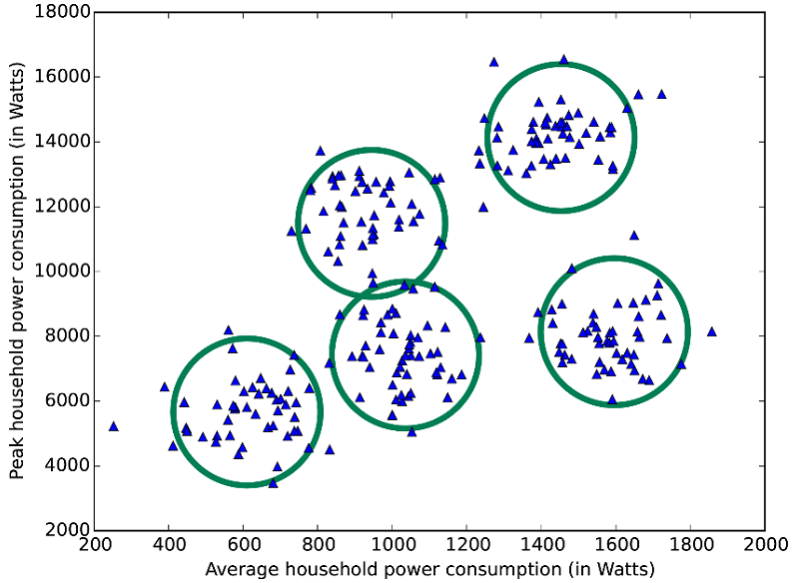
Big Data Analytic Platforms

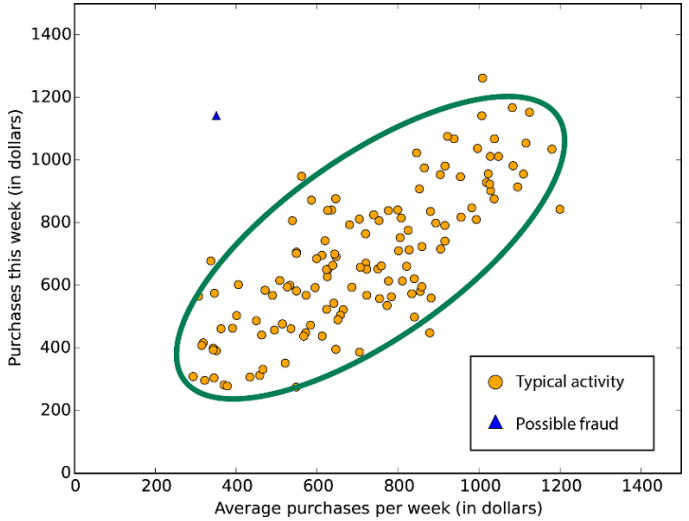
What is enabling them?

- Analytic Techniques / Methods
  - Classification
  - Clustering
  - Regression
  - Simulation
  - Content Analysis
  - Anomaly Detection
  - …

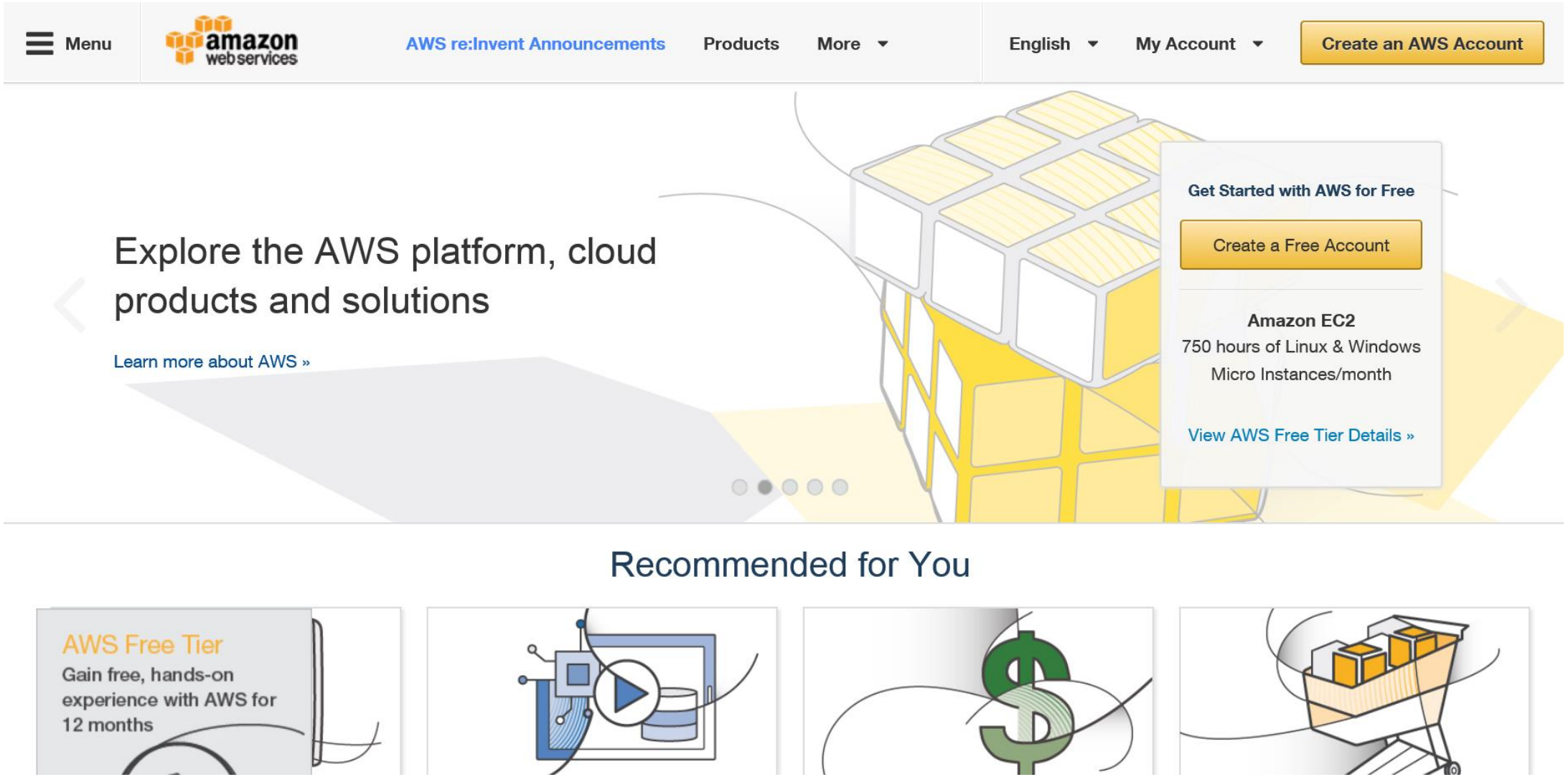




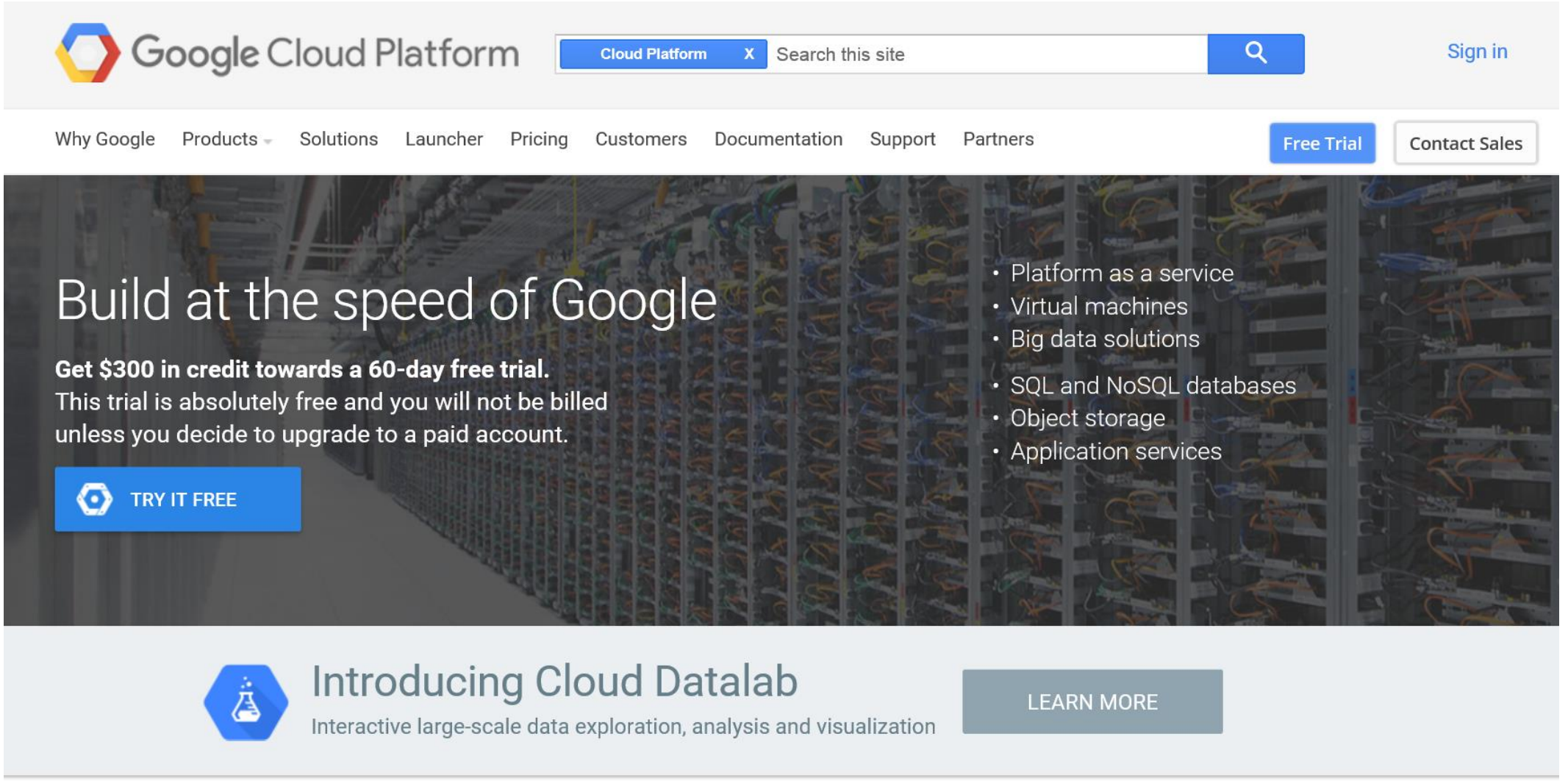




Big Data Analytic Platforms



Big Data Analytic Platforms



Big Data Analytic Platforms

Hewlett Packard Enterprise

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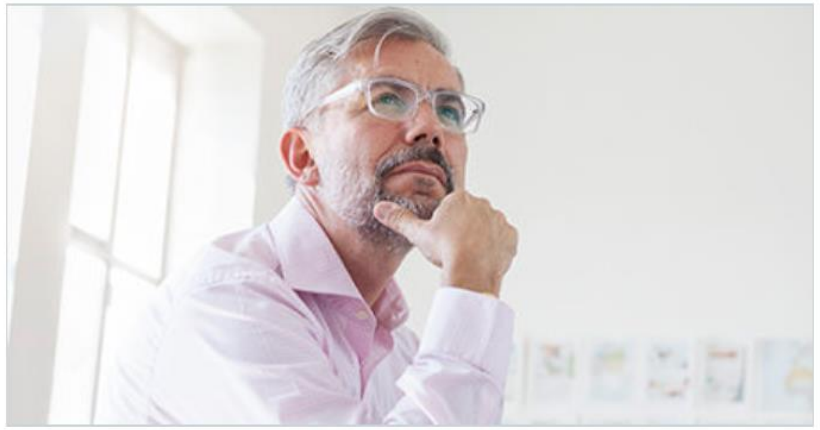
Software Home | Security | Big Data Software | Operations Management | App Lifecycle | Services & Support

BIG DATA PLATFORM

HP Haven, the industry's first comprehensive, scalable, open, and secure platform for Big Data analytics enables you to deliver actionable insight where and when it is needed to drive superior business outcomes and gain competitive advantage.



Seize the Data

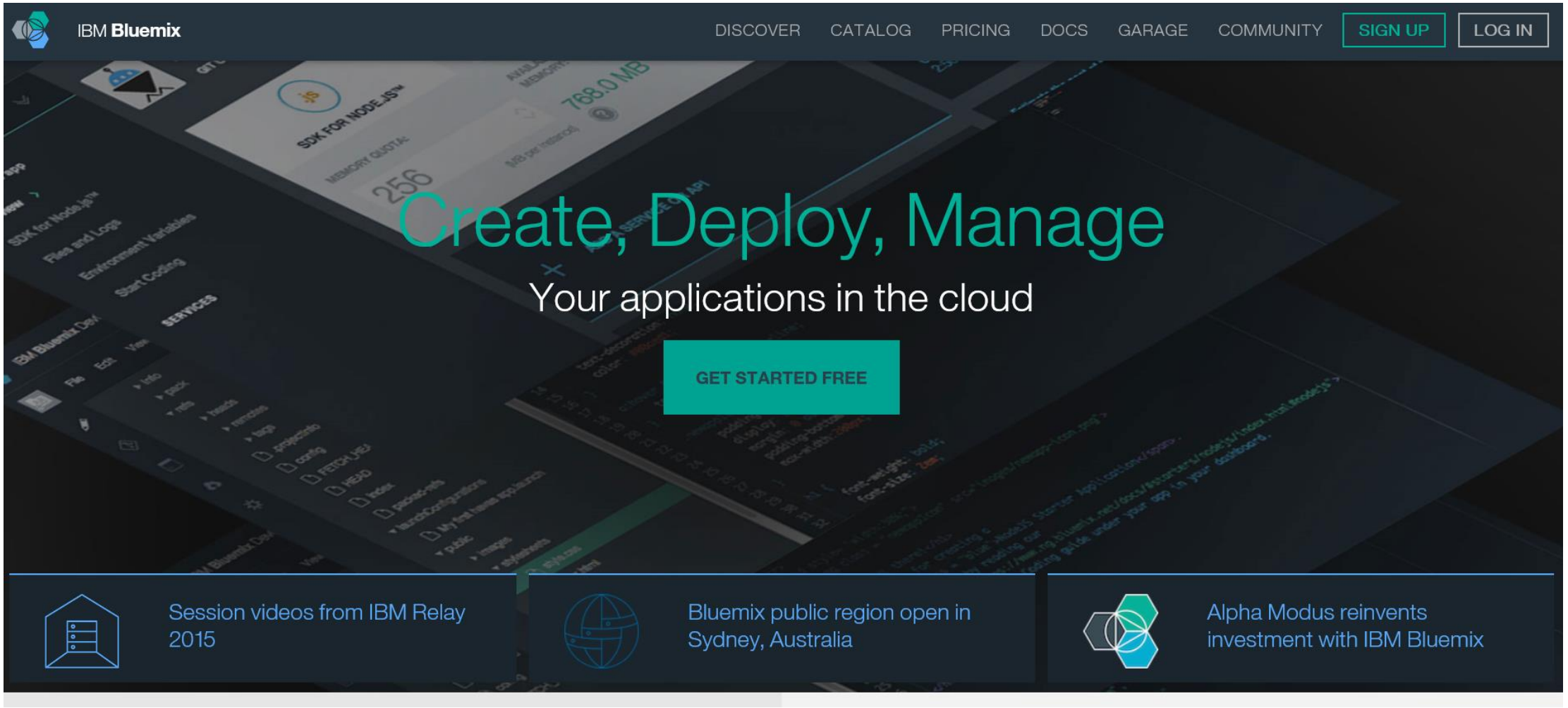
Delivered via the cloud and on-premise, HP Haven is designed to harness 100% of your data—business, human, and machine—to extract business value from all your data to gain competitive advantage today and power the next generation of applications and services for tomorrow.

(PDF 3209KB)

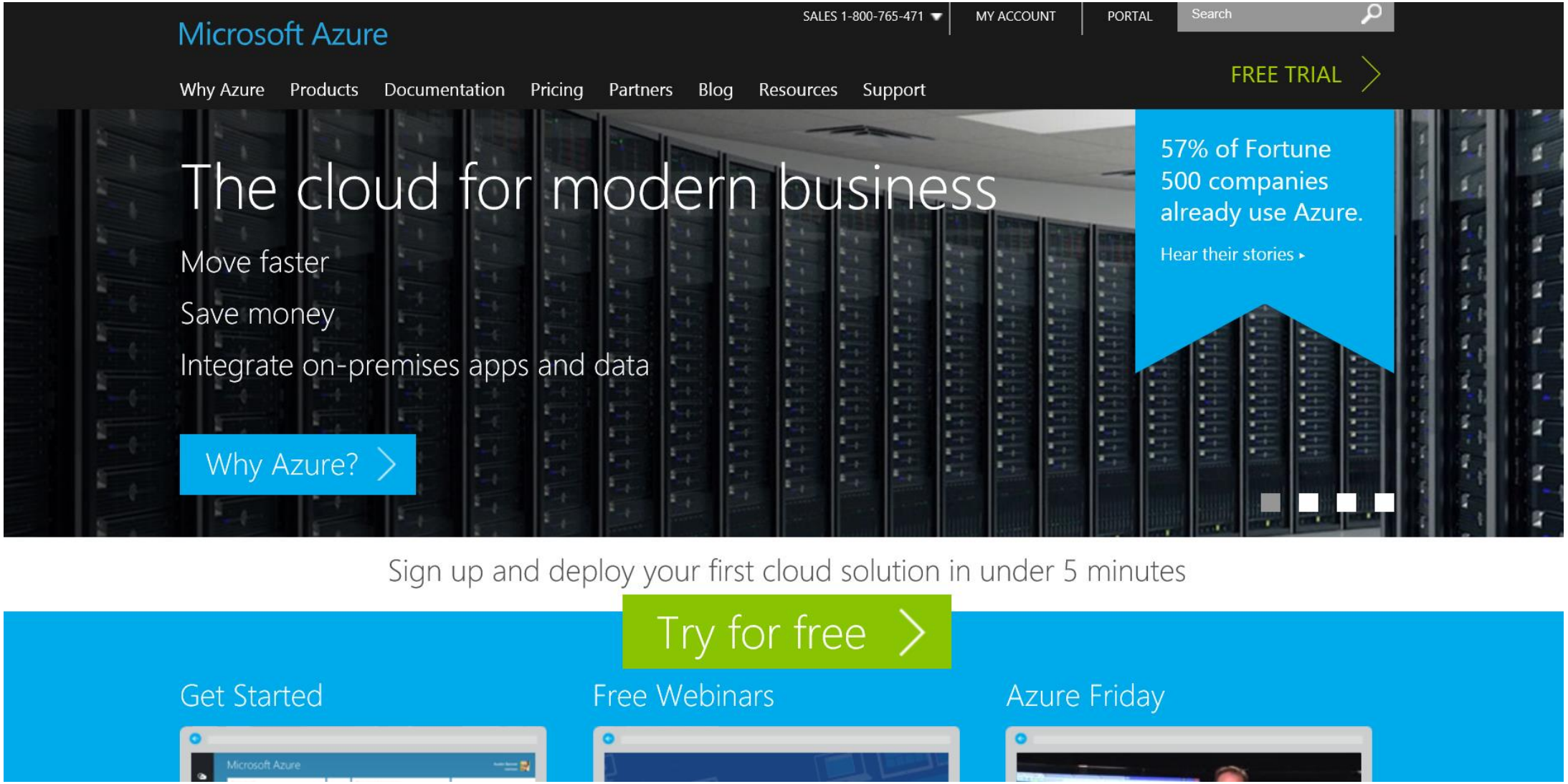
Download the White Paper

1-877-686-9637 (Sales) | 1-800-633-3600 (Support) | Contact a Sales Expert | Live chat (offline) | Have a question?

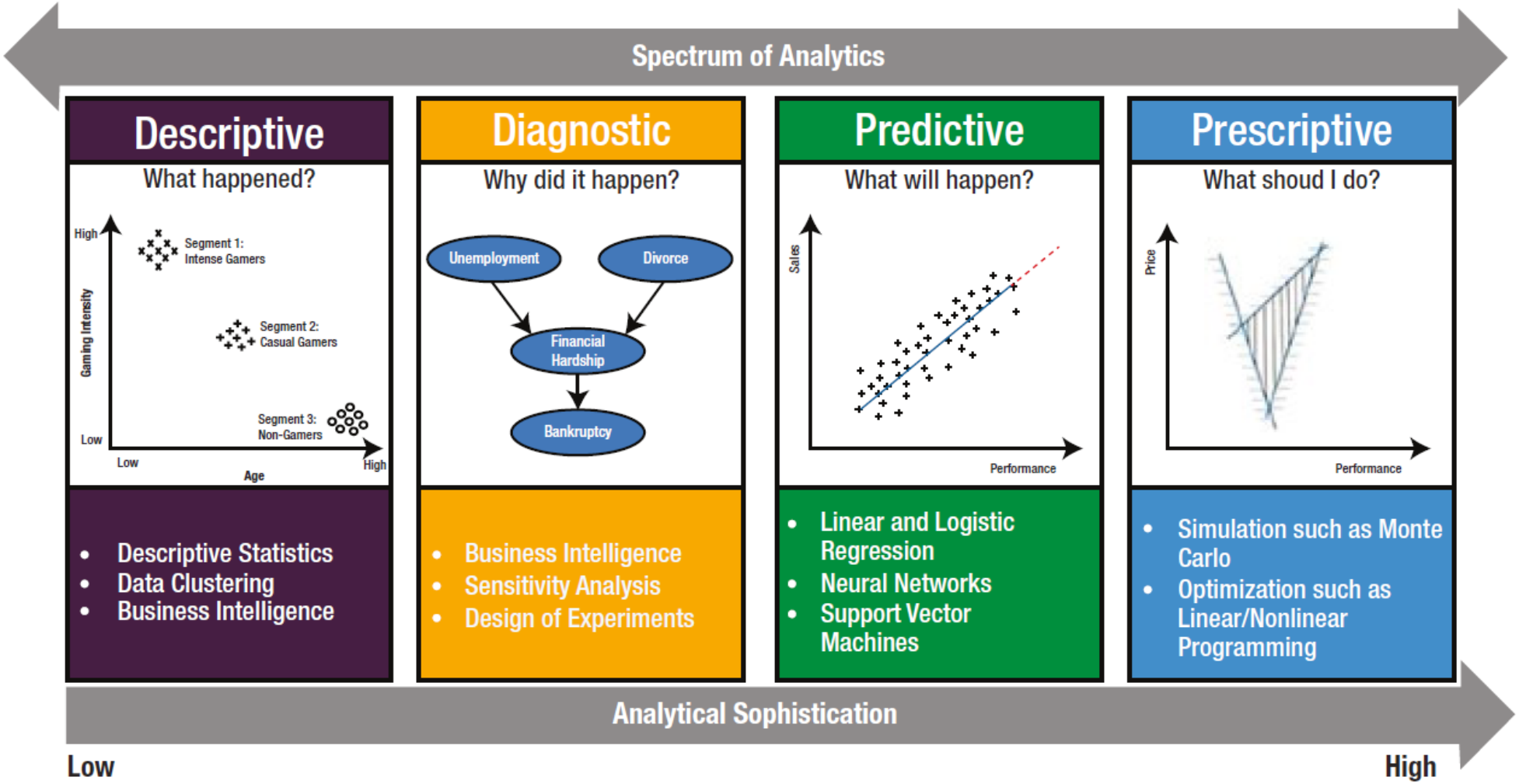
Big Data Analytic Platforms



Big Data Analytic Platforms



Big Data Analytic Platforms
How do we use them for Analysis?



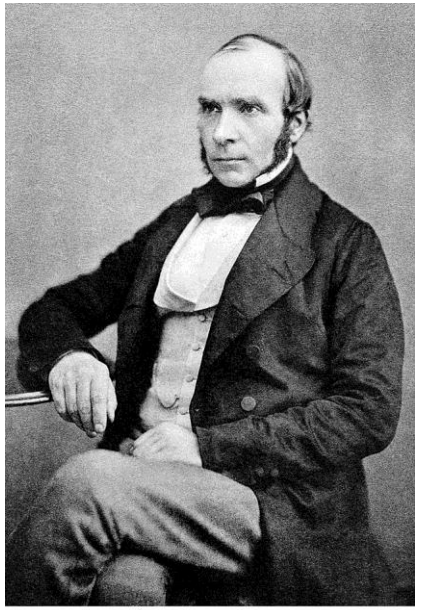
GIS – A Brief Review

As we all know, location matters…

GIS – A Brief Review

and everything happens somewhere…
and at a specific time…

Dr. John Snow



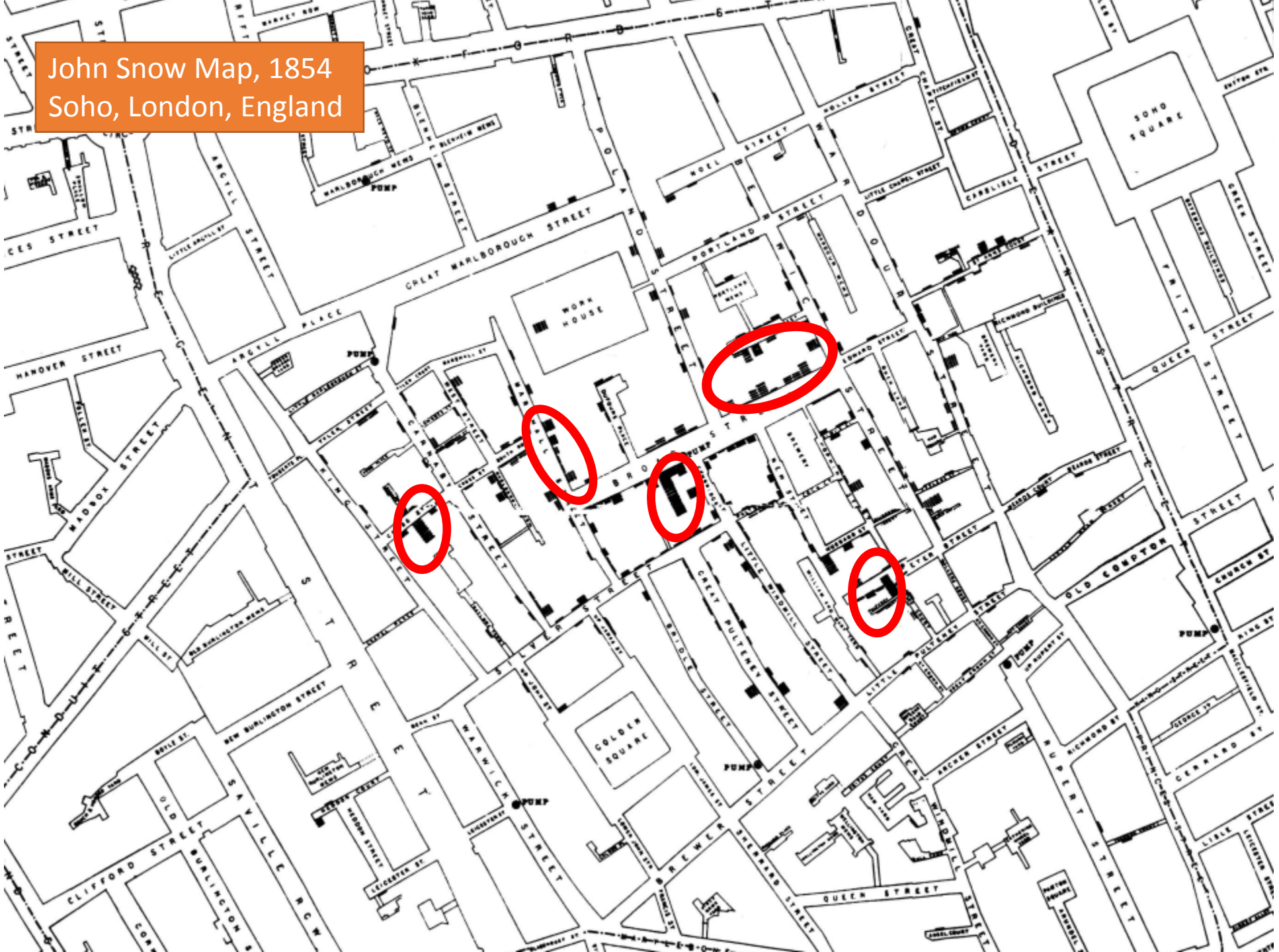
Dr. Snow is frequently referred to as the 'father of public health.' In 1854 a cholera epidemic raged across Europe. The onset of the disease is sudden and death can result in as little as a week. In London, one devastating outbreak claimed the lives of more than 500 people in just ten days. The search for the cure and the cause was furious and fruitless.

Dr. Snow had observed cholera first-hand in 1831 as an apprentice surgeon, but it was only 17 years later, in 1848-1849, that he developed a new theory for the mechanism of cholera transmission. Contrary to the prevailing belief, Snow argued that cholera was a disease of the gut and that the causal agent must enter through the mouth and then multiply within the gut of the sufferer, subsequently spreading to others. Dr. Snow reasoned that broad transmission of cholera had to be due to contaminated drinking water.

In September 1854, when Dr. Snow was called on to examine the causes of the cholera epidemic, he turned immediately to the water supply. His previous research suggested that the localized nature of the outbreak would mean that the cause had to be a contaminated pump or well, rather than a problem with the general water supply. He discovered that while there were five water pumps in the neighborhood, most of the deaths took place near the pump on Broad Street. Upon further investigation he discovered that among the deaths of people situated farther from the Broad Street pump, half of the deceased preferred the water from the Broad Street pump to their nearer pump, and another third attended school near the ill-fated pump. Upon presentation of his findings to community leaders, the handle of the Broad Street pump was removed, and the epidemic quickly abated. Further investigation of the well discovered that a sewer pipe underground was leaking raw sewage into the drinking water of the Broad Street pump.

Dr. Snow realized that a spot map illustrating the location of the deaths in the Broad Street cholera outbreak would be a useful addition to his report. Snow's famous map was first exhibited at a meeting of the Epidemiological Society of London in December 1854.


John Snow Map, 1854
Soho, London, England
Regent Street
Piccadilly Circus
GREAT MARLBOROUGH STREET
ARGYLL PLACE
ARGYLL STREET
POLAND STREET
BROAD STREET
PUMP
WORK HOUSE
GOLDEN SQUARE
SOHO SQUARE
CARLISLE STREET
QUEEN STREET
OLD COMPTON
CLIFFORD STREET
SAVILLE ROW
NEW BURLINGTON STREET
HANOVER STREET
MADDOX STREET


John Snow Map, 1854
Soho, London, England
GREAT MARLBOROUGH STREET
PORTLAND STREET
BROAD STREET
WORK HOUSE
PUMP
ARGYLL PLACE
ARGYLL STREET
HANOVER STREET
MADDOX STREET
REGENT STREET
NEW BURLINGTON STREET
CLIFFORD STREET
SAVILLE ROW
GOLDEN SQUARE
SARWICK STREET
LEICESTER ST
GREAT PULTENEY STREET
LITTLE PULTENEY STREET
QUEEN STREET
NOEL STREET
LITTLE CHAPEL STREET
CARLISLE STREET
SOHO SQUARE
OLD COMPTON
QUEEN STREET
ARCHER STREET
GERRARD ST
CHURCH ST


John Snow Map, 1854
Soho, London, England
GREAT MARLBOROUGH STREET
ARGYLL PLACE
PORTLAND STREET
BROAD STREET
WORK HOUSE
SOHO SQUARE
GOLDEN SQUARE
SAVILLE ROW
REGENT STREET
OLD COMPTON
QUEEN STREET
CLIFFORD STREET
NEW BURLINGTON STREET
HANOVER STREET
MADDOX STREET
PUMP


John Snow Map, 1854
Soho, London, England
Water Pump
Location and Number of Deaths
BROAD STREET
PUMP
DUFOURS PLACE
BERWICK STREET
EDWARD STREET
DUCK LANE
BREWERY
NEW STREET
HUSBAND ST
LITTLE WINDMILL
GREAT PULT
PETER
COURT


John Snow Map, 1854
Soho, London, England
GREAT MARLBOROUGH STREET
ARGYLL PLACE
ARGYLL STREET
PORTLAND STREET
WORK HOUSE
BROAD STREET
HANOVER STREET
MADDOX STREET
REGENT STREET
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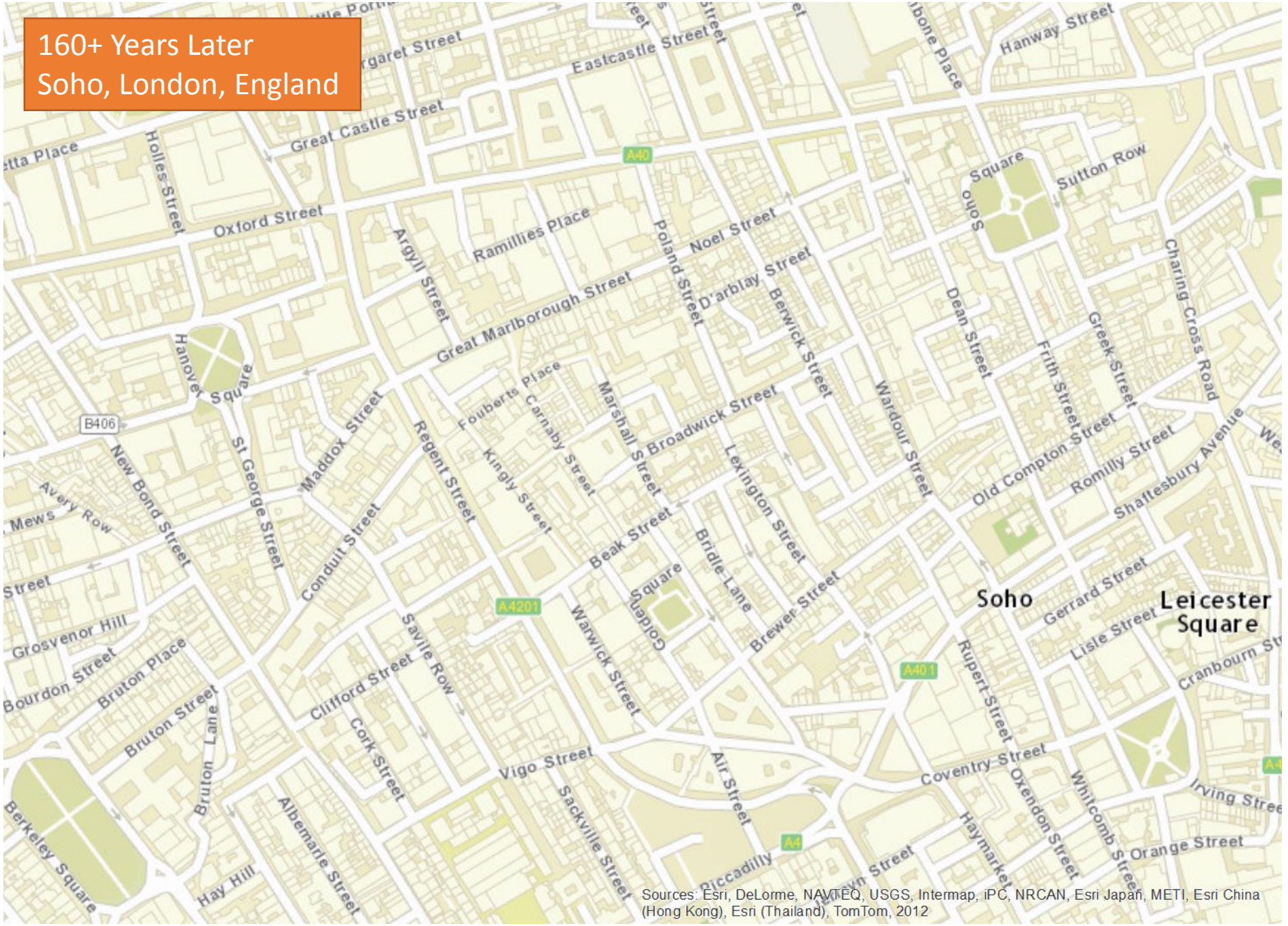
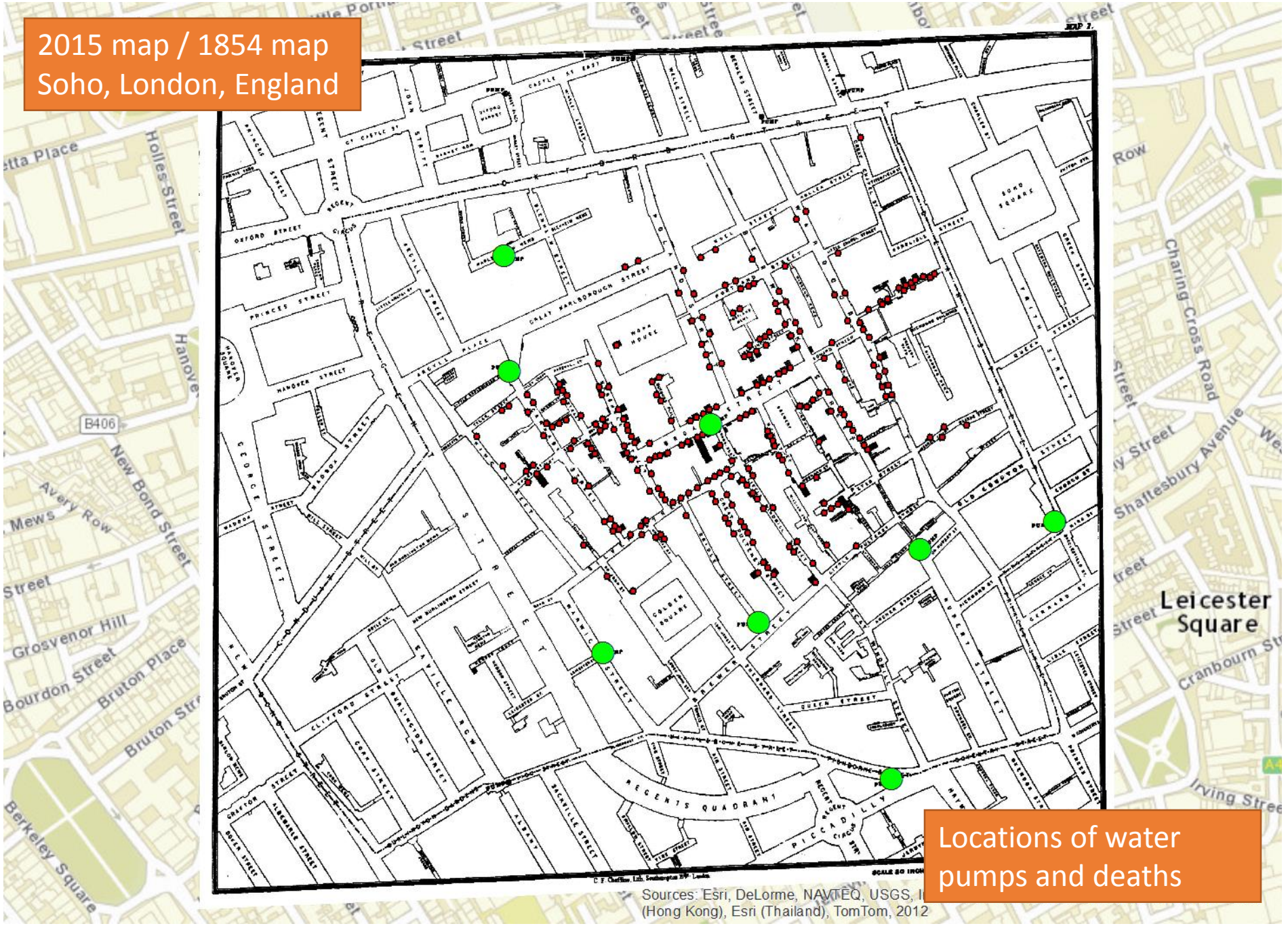
OLD COMPTON STREET
SOHO SQUARE
PUMP



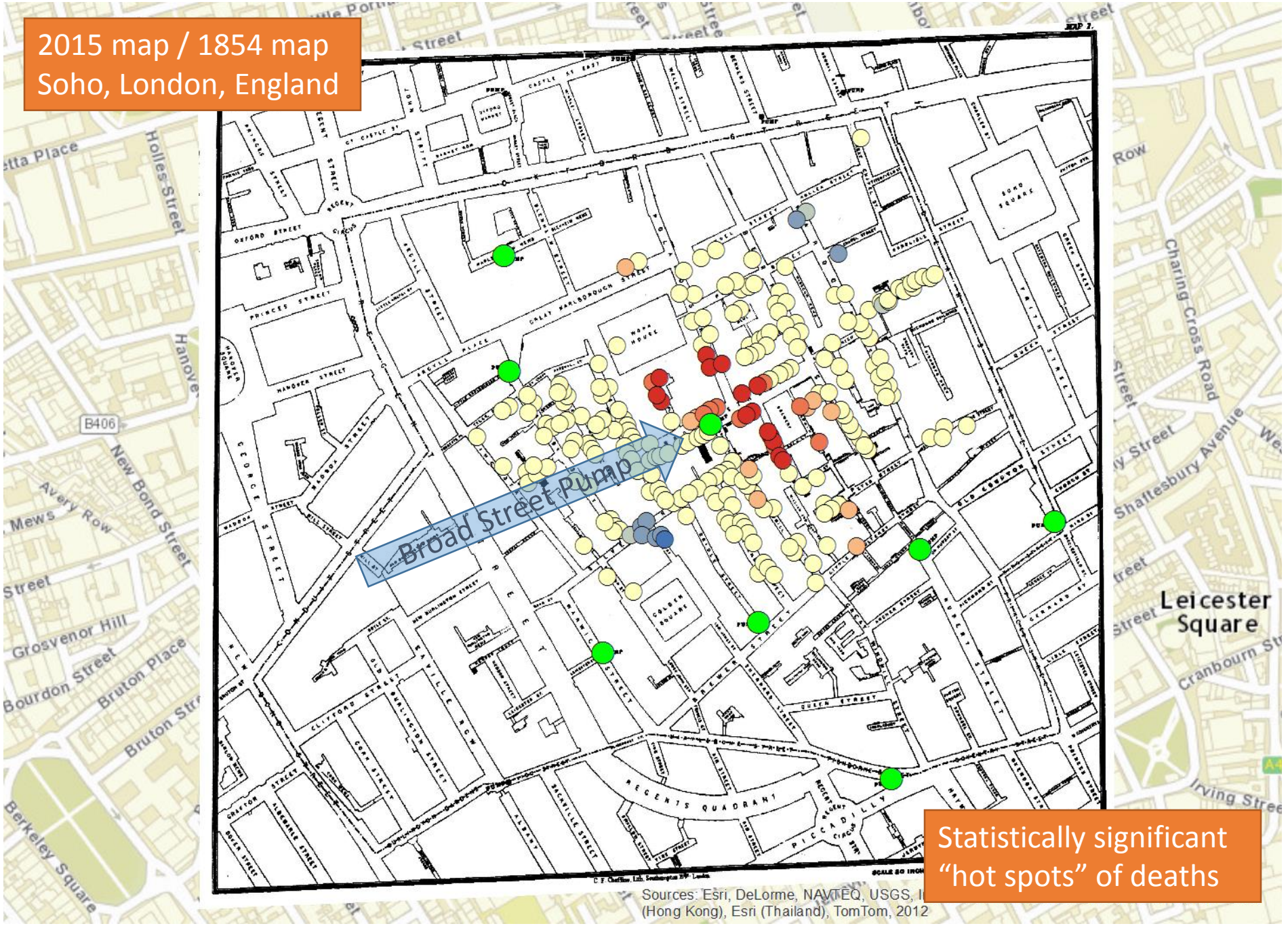
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2012

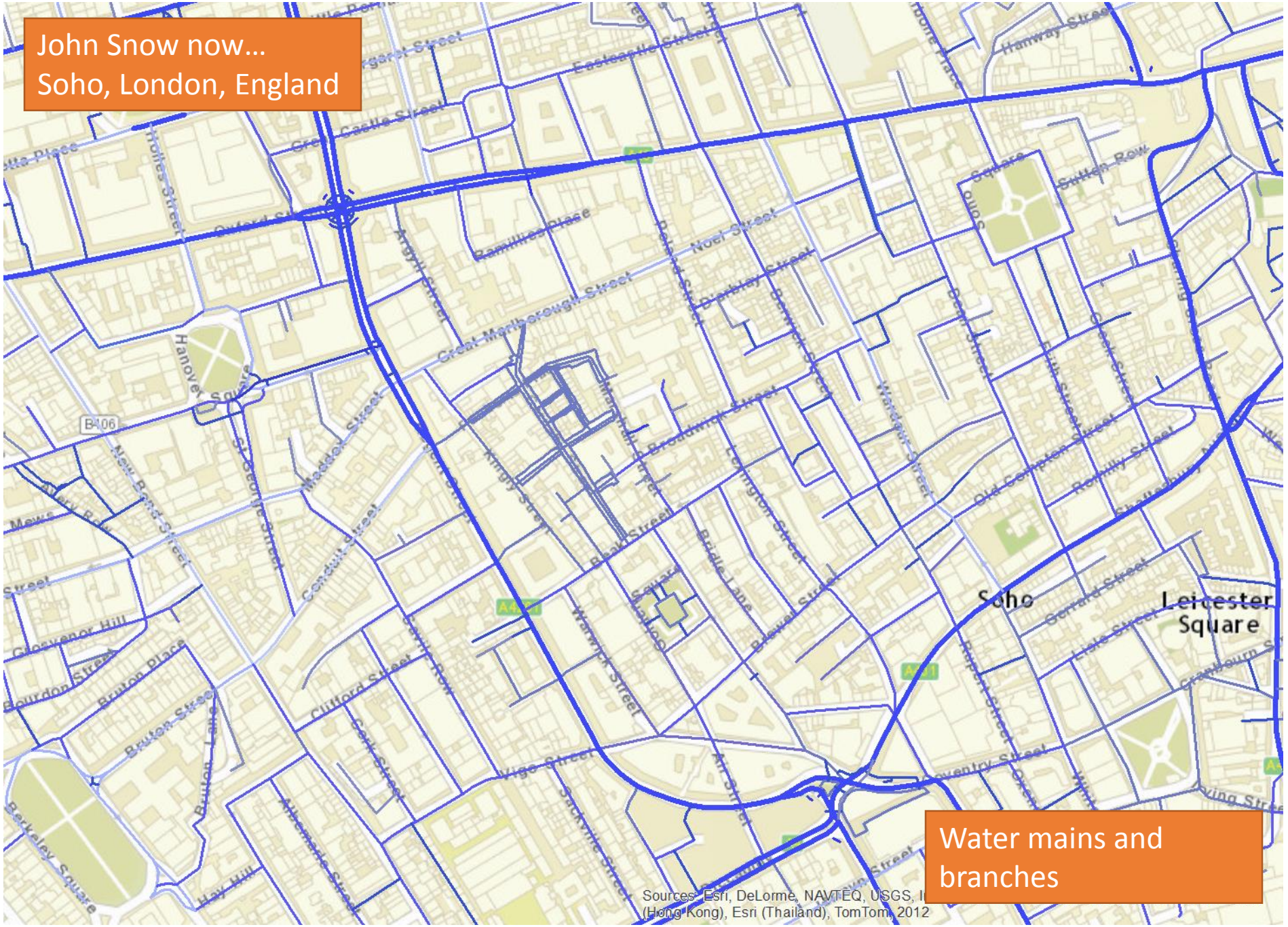

2015 map / 1854 map
Soho, London, England
Georeferenced image of the 1854 map
Sources: Esri, DeLorme, NAVTEQ, USGS, I
(Hong Kong), Esri (Thailand), TomTom, 2012
Holles Street
B406
New Bond Street
Avery Row
Grosvenor Hill
Bourdon Street
Bruton Place
Berkeley Square
Charing Cross Road
Shaftesbury Avenue
Leicester Square
Cranbourn St
Irving Stree
OXFORD STREET
REGENT STREET
PRINCES STREET
GREAT MARLBOROUGH STREET
HANOVER STREET
GEORGE STREET
ARGYLL PLACE
BROAD STREET
POLAND STREET
PORTLAND STREET
BERNERS STREET
WARDOUR STREET
NEW BURLINGTON STREET
CLIFFORD STREET
SAVILLE ROW
REGENT'S QUADRANT
PICCADILLY
GRAFTON STREET
BOND STREET
CHARLES ST
SOHO SQUARE
GOLDEN SQUARE
OLD COMPTON
WORK HOUSE

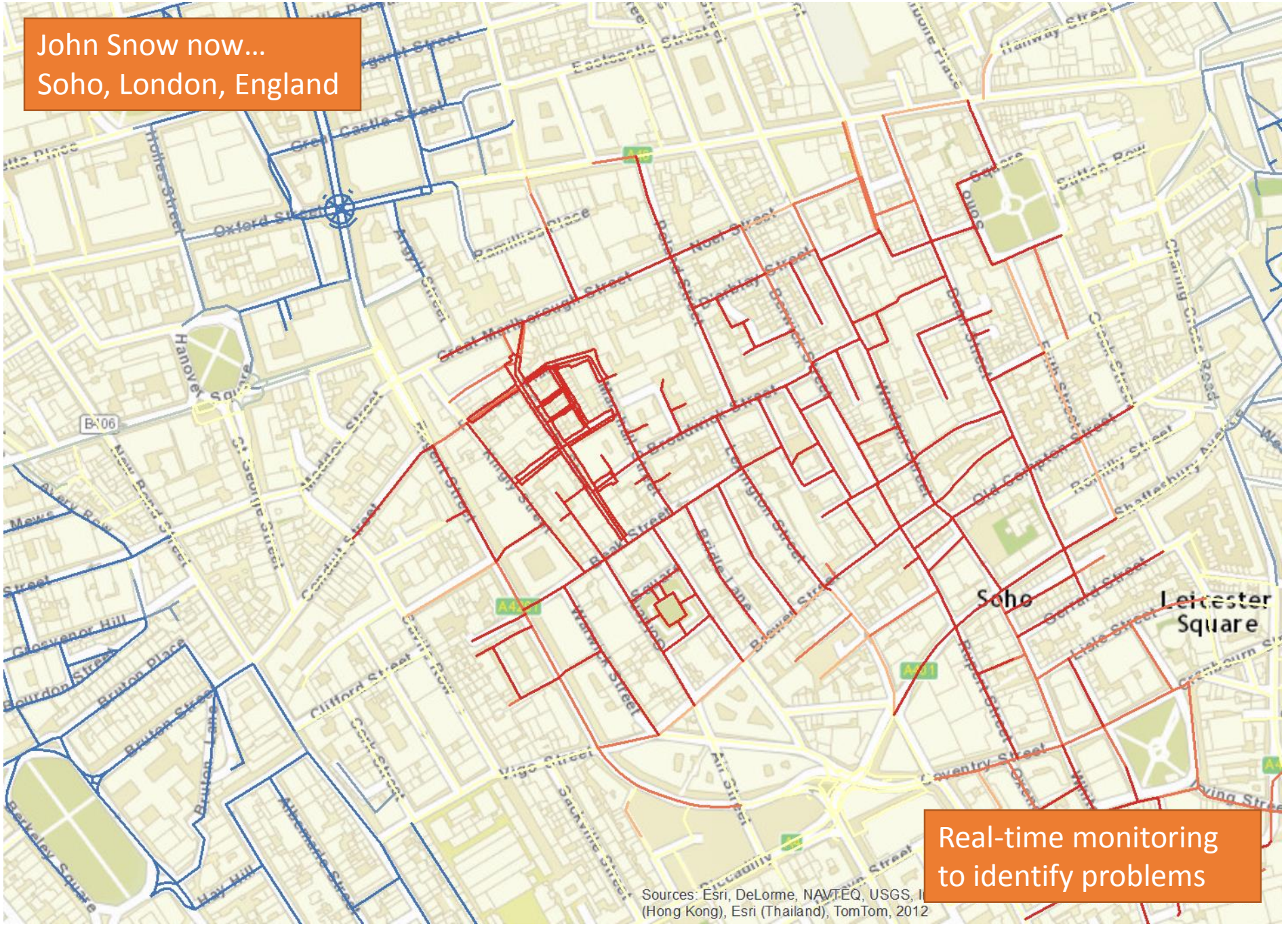

2015 map / 1854 map
Soho, London, England
Locations of water pumps and deaths
Sources: Esri, DeLorme, NAVTEQ, USGS,
(Hong Kong), Esri (Thailand), TomTom, 2012
Leicester Square
Holles Street
New Bond Street
Grosvenor Hill
Bourdon Street
Bruton Place
Berkeley Square
Charing Cross Road
Shaftesbury Avenue
Cranbourn St
Irving Stree
B406
OXFORD STREET
GREAT MARLBOROUGH STREET
REGENT STREET
REGENT'S QUADRANT
PICCADILLY
GEORGE STREET
HANOVER STREET
PRINCES STREET
ARGYLL PLACE
GOLDEN SQUARE
SOHO SQUARE
WORK HOUSE
BROAD STREET

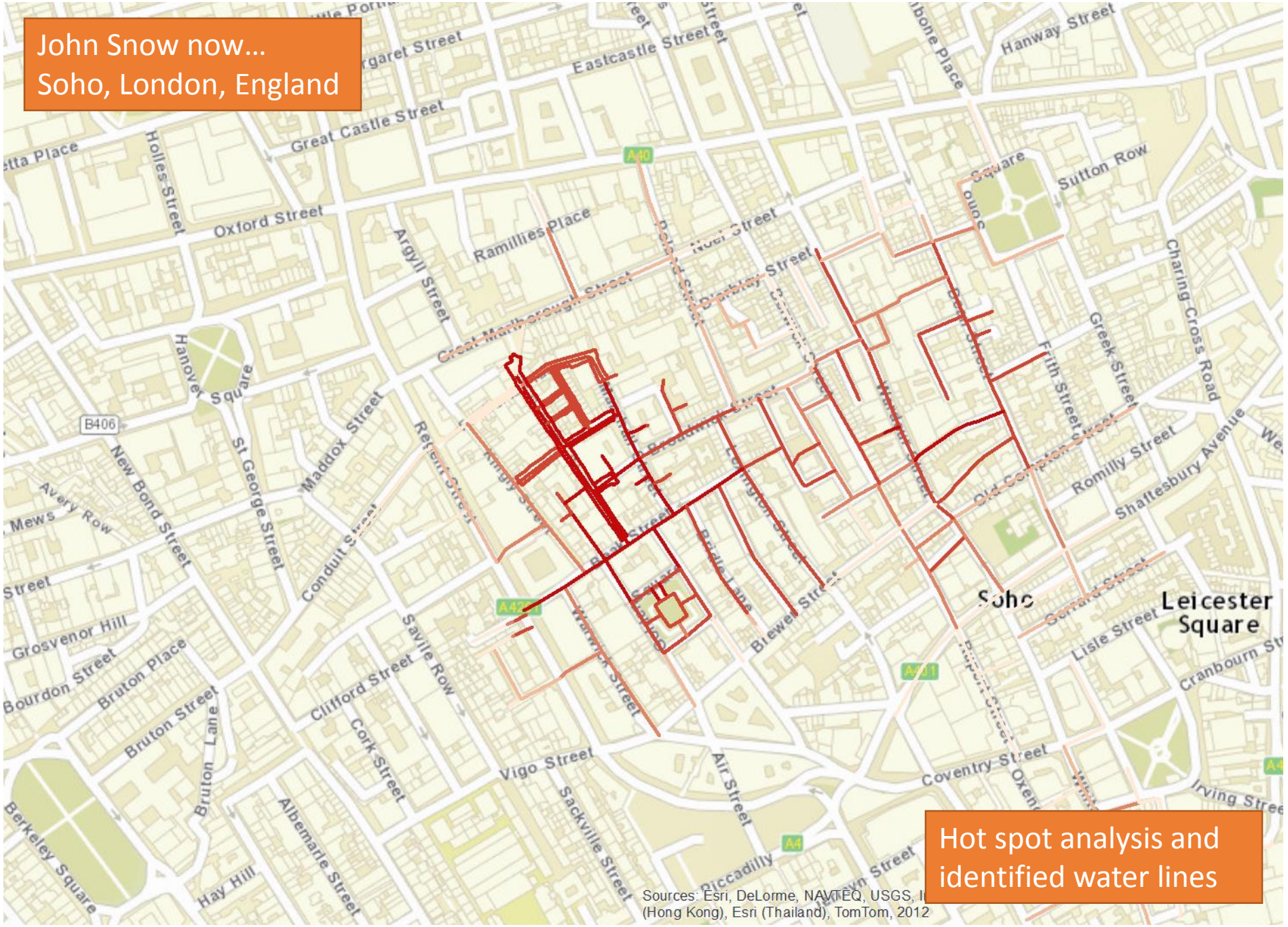
2015 map / 1854 map
Soho, London, England

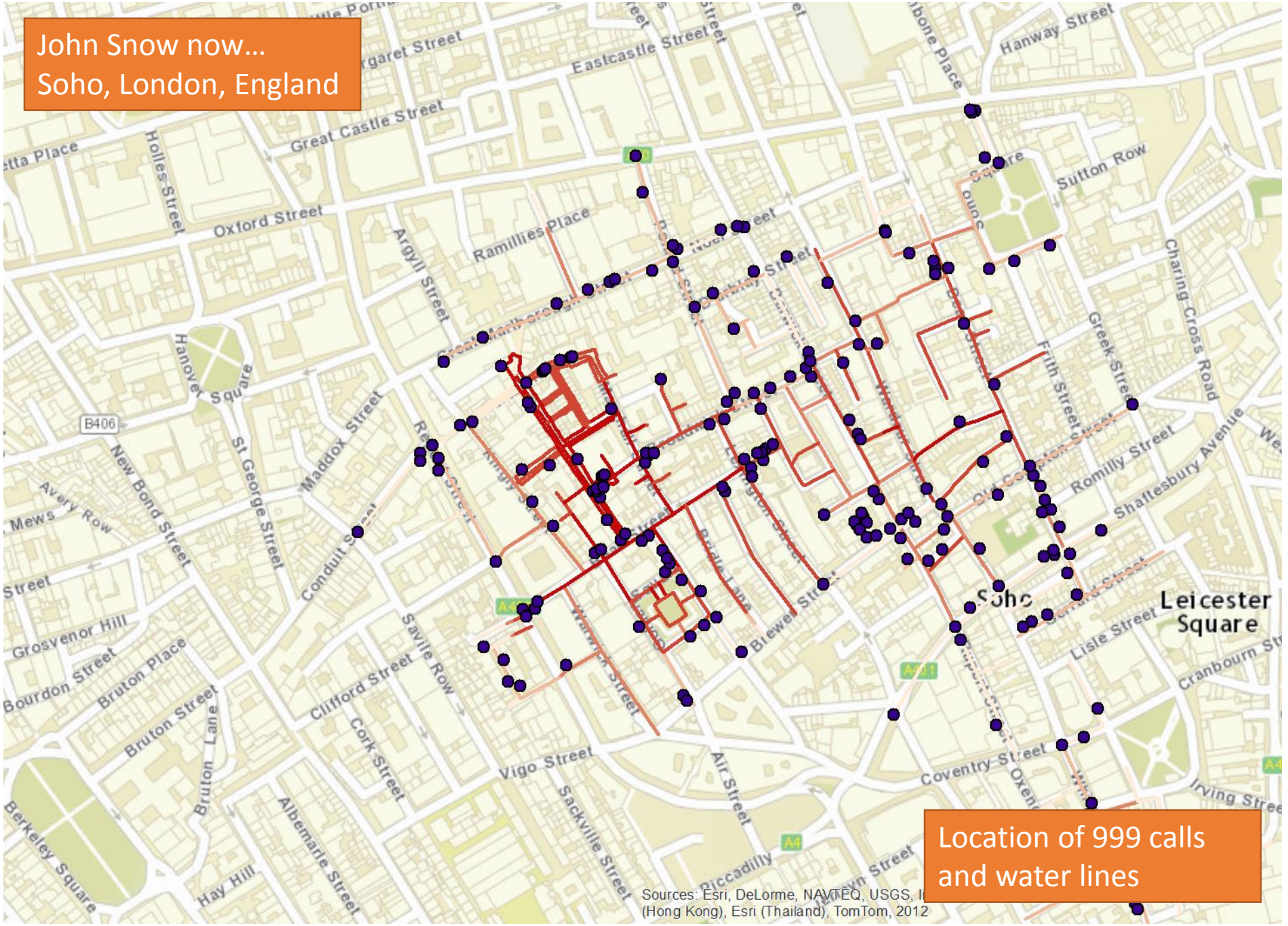
Density of location of deaths

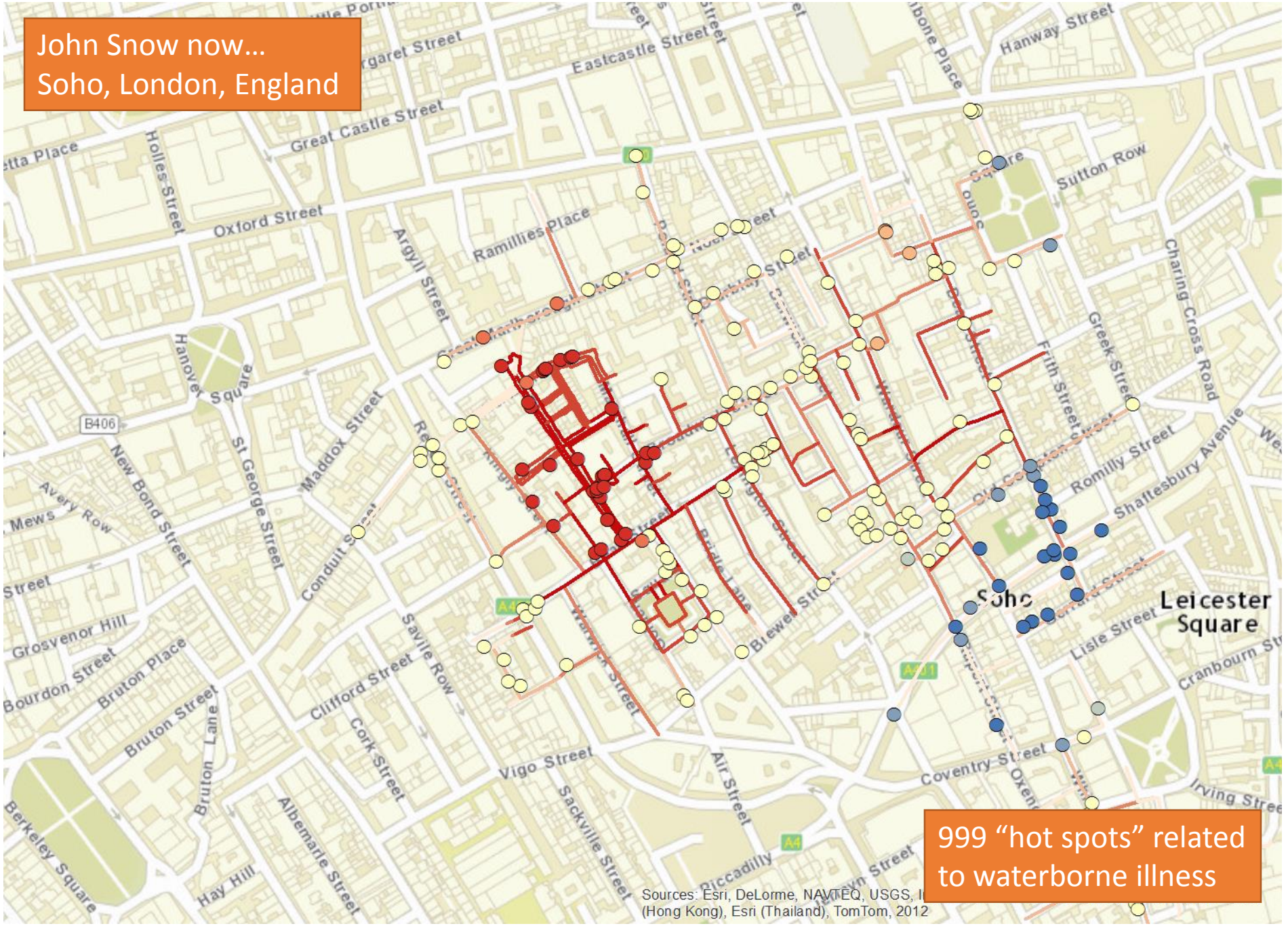

2015 map / 1854 map
Soho, London, England
Broad Street Pump
Statistically significant
“hot spots” of deaths
Leicester
Square
Sources: Esri, DeLorme, NAVTEQ, USGS,
(Hong Kong), Esri (Thailand), TomTom, 2012


John Snow now…
Soho, London, England
Water mains and branches
Soho
Leicester Square
Sources: Esri, DeLorme, NAVTEQ, USGS, I
(Hong Kong), Esri (Thailand), TomTom, 2012


John Snow now…
Soho, London, England
Soho
Leicester Square
Real-time monitoring to identify problems
Sources: Esri, DeLorme, NAVTEQ, USGS, I
(Hong Kong), Esri (Thailand), TomTom, 2012


John Snow now…
Soho, London, England
Hot spot analysis and identified water lines
Soho
Leicester Square
Great Castle Street
Oxford Street
Regent Street
Piccadilly
Sources: Esri, DeLorme, NAVTEQ, USGS,
(Hong Kong), Esri (Thailand), TomTom, 2012


John Snow now…
Soho, London, England
Location of 999 calls and water lines
Great Castle Street
Oxford Street
Ramillies Place
Argyll Street
Hanover Square
Maddox Street
New Bond Street
St George Street
Conduit Street
Regent Street
Brewer Street
Warwick Street
Clifford Street
Savile Row
Cork Street
Vigo Street
Air Street
Sackville Street
Piccadilly
Bruton Place
Bruton Street
Bruton Lane
Berkeley Square
Hay Hill
Albemarle Street
Grosvenor Hill
Bourdon Street
Avery Row
Mews
Street
B406
Eastcastle Street
Hanway Street
Sutton Row
Charing Cross Road
Greek Street
Frith Street
Romilly Street
Shaftesbury Avenue
Soho
Leicester Square
Lisle Street
Cranbourn Street
Coventry Street
Irving Street
Sources: Esri, DeLorme, NAVTEQ, USGS, I
(Hong Kong), Esri (Thailand), TomTom, 2012


John Snow now…
Soho, London, England
Great Castle Street
Oxford Street
Ramillies Place
Argyll Street
Hanover Square
B406
New Bond Street
St George Street
Maddox Street
Conduit Street
Regent Street
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Hanway Street
Sutton Row
Charing Cross Road
Greek Street
Frith Street
Romilly Street
Shaftesbury Avenue
Soho
Leicester Square
Lisle Street
Coventry Street
Irving Street
Cranbourn Street
Sources: Esri, DeLorme, NAVTEQ, USGS, I
(Hong Kong), Esri (Thailand), TomTom, 2012
999 “hot spots” related to waterborne illness

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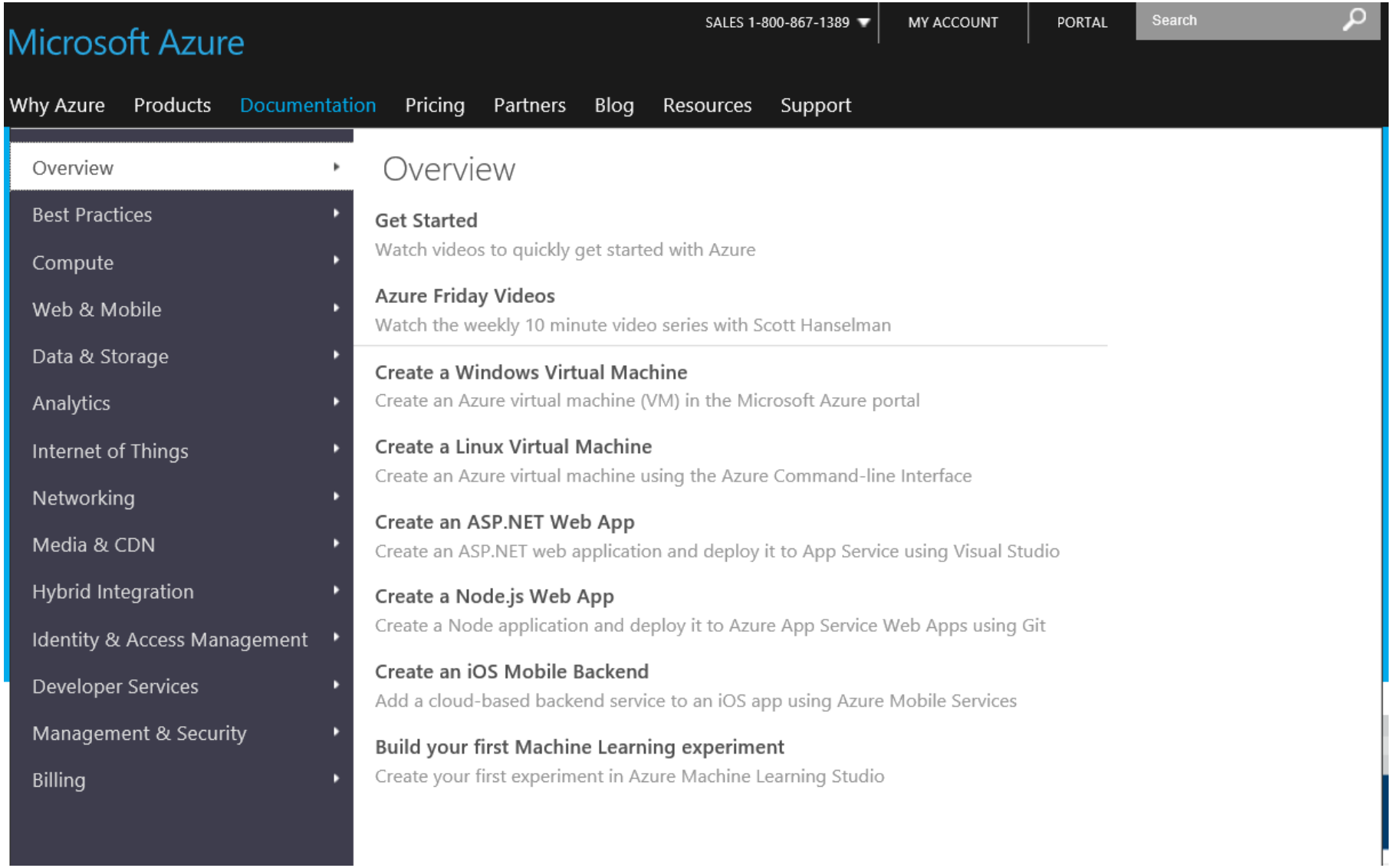
A brief detour…



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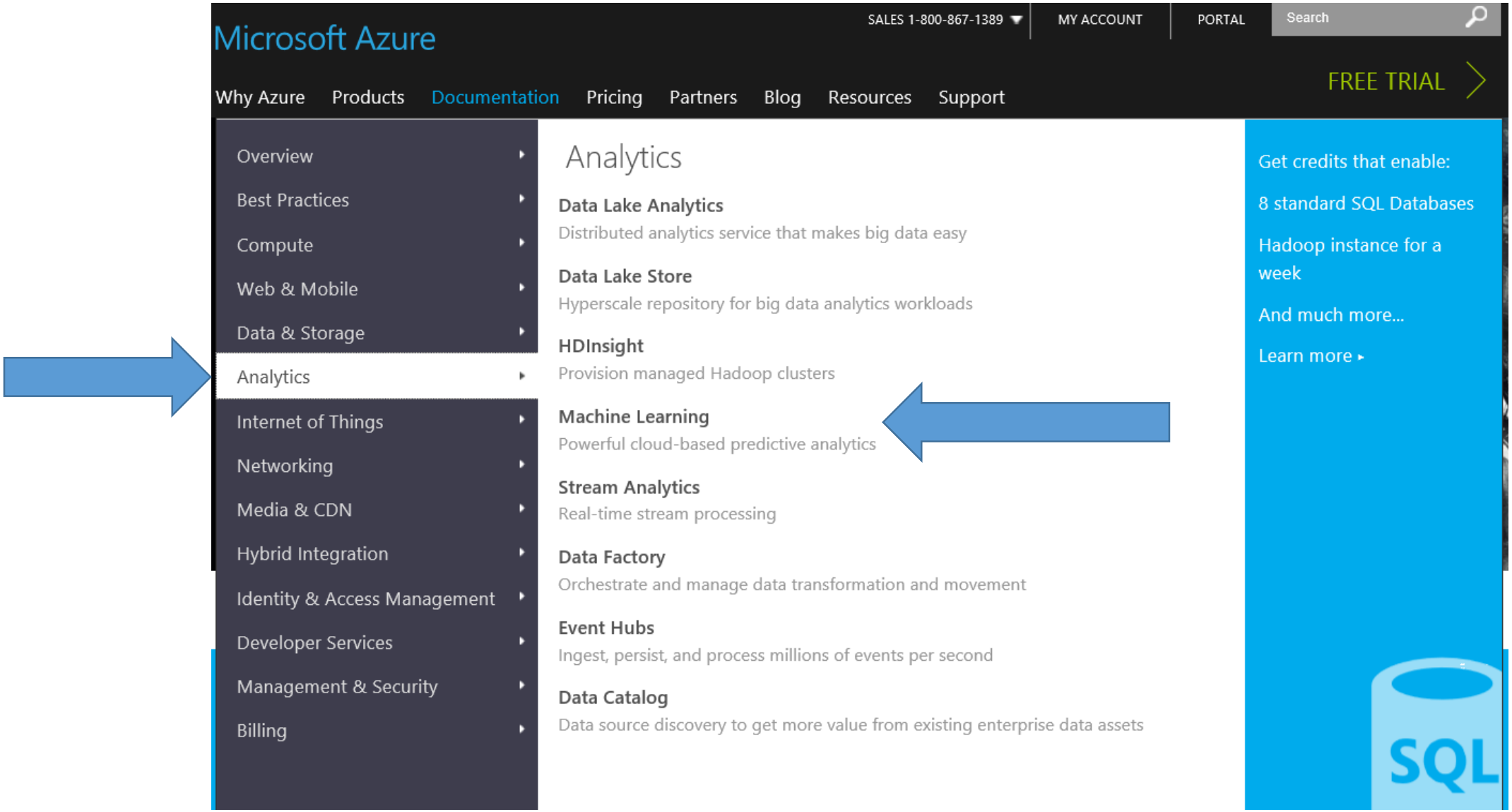

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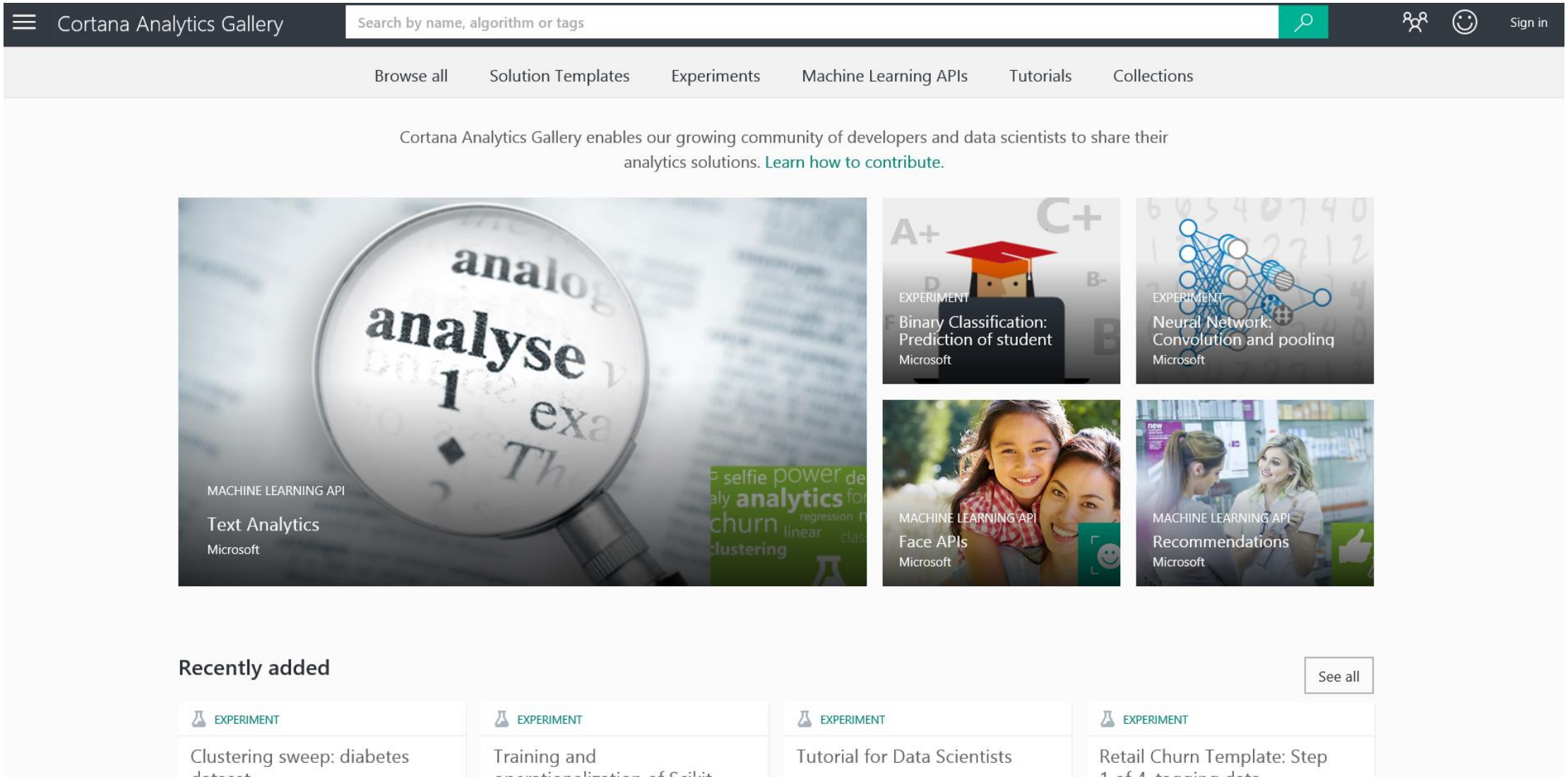

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- TechReady
- Learning with counts
- Modify Count Table Parameters
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ALGORITHMS USED
- Two-Class Logistic Regression
- Multiclass Decision Forest
- Boosted Decision Tree Regression

We've found 11 results for **nyc**

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NYC Taxi - Multiclass

This experiment demonstrates the multiclass classification task with NYC Taxi dataset
Multiclass Decision Forest
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EXPERIMENT
NYC Taxi - Regression

This experiment demonstrates the regression task with NYC Taxi dataset
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NYC Taxi - Binary Classification

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NYC Taxi - Regression

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EXPERIMENT
NYC Taxi - Binary Classification

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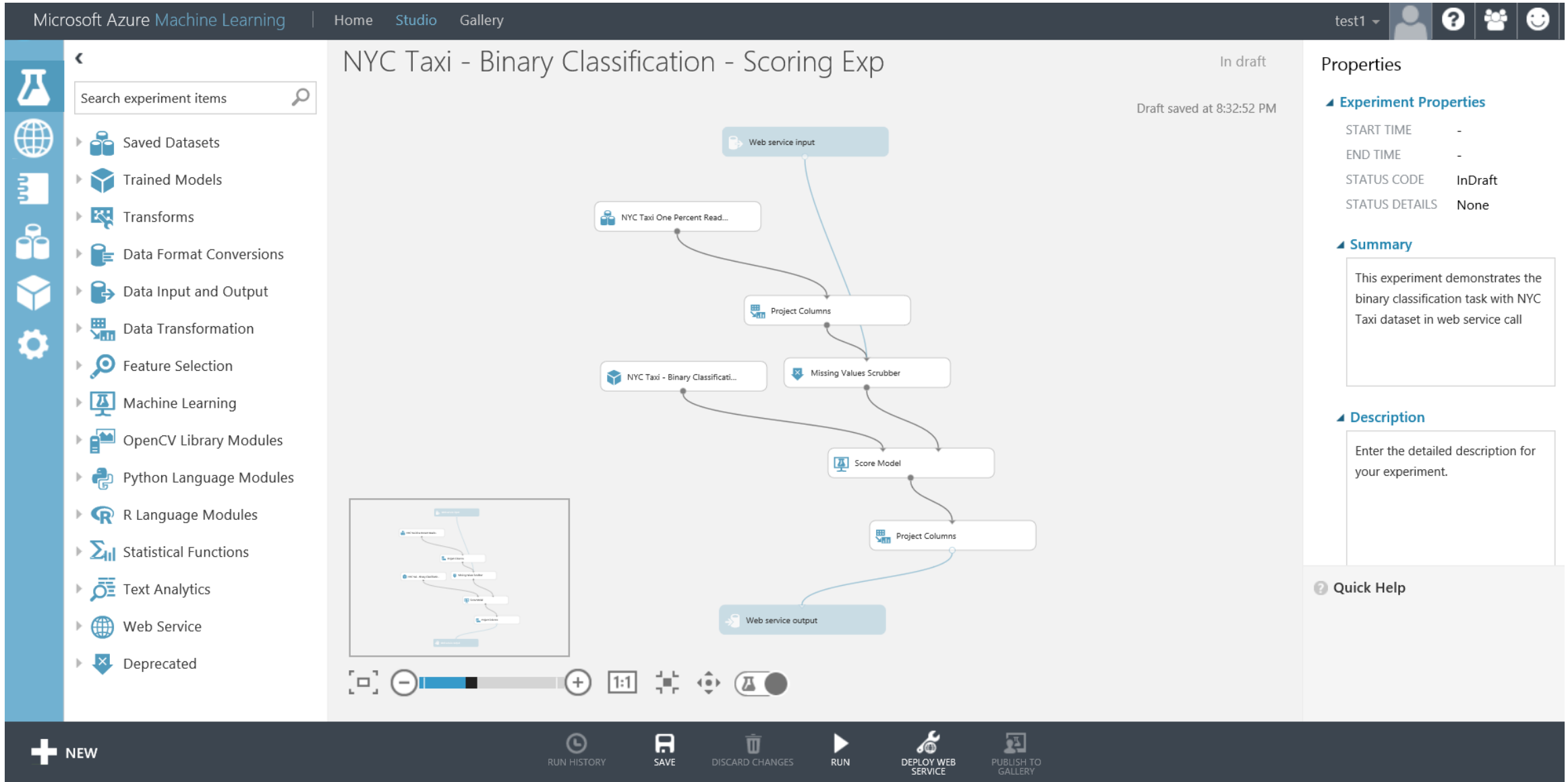

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NYC Taxi Data - consists of **over 173 million** taxi rides in the year 2013

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NYC Taxi Data - includes driver details, pickup and drop-off locations, time of day, trip locations (longitude-latitude), cab fare and tip amounts. An analysis of the data shows that:

- Almost 50% of the trips **did not** result in a tip,
- The median tip on **Friday and Saturday nights was typically the highest**, and
- The **largest tips** came from taxis **going from Manhattan to Queens**.

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NYC Taxi Data

Was a tip paid for the trip? (Binary Classification)

What was the tip amount range? (Multiclass Classification)

What was the tip amount? (Regression)

Microsoft Azure Machine Learning: Algorithm Cheat Sheet

This cheat sheet helps you choose the best Azure Machine Learning Studio algorithm for your predictive analytics solution. Your decision is driven by both the nature of your data and the question you're trying to answer.

START

Finding unusual data points

Discovering structure

Predicting categories

Predicting values

Three or more

Two

ANOMALY DETECTION

- **One-class SVM** — >100 features, aggressive boundary
- **PCA-based anomaly detection** — Fast training

CLUSTERING

- **K-means**

MULTI-CLASS CLASSIFICATION

- Fast training, linear model — **Multiclass logistic regression**
- Accuracy, long training times — **Multiclass neural network**
- Accuracy, fast training — **Multiclass decision forest**
- Accuracy, small memory footprint — **Multiclass decision jungle**
- Depends on the two-class classifier, see notes below — **One-v-all multiclass**

REGRESSION

- **Ordinal regression** — Data in rank ordered categories
- **Poisson regression** — Predicting event counts
- **Fast forest quantile regression** — Predicting a distribution
- **Linear regression** — Fast training, linear model
- **Bayesian linear regression** — Linear model, small data sets
- **Neural network regression** — Accuracy, long training time
- **Decision forest regression** — Accuracy, fast training
- **Boosted decision tree regression** — Accuracy, fast training, large memory footprint

TWO-CLASS CLASSIFICATION

- **Two-class SVM** — >100 features, linear model
- **Two-class averaged perceptron** — Fast training, linear model
- **Two-class logistic regression** — Fast training, linear model
- **Two-class Bayes point machine** — Fast training, linear model

- Accuracy, fast training — **Two-class decision forest**
- Accuracy, fast training, large memory footprint — **Two-class boosted decision tree**
- Accuracy, small memory footprint — **Two-class decision jungle**
- >100 features — **Two-class locally deep SVM**
- Accuracy, long training times — **Two-class neural network**

Created by the Azure Machine Learning Team Email: AzurePoster@microsoft.com

Download this poster: http://aka.ms/MLCheatSheet

Microsoft

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Uber data, NYC Taxi data, and Weather data

“What if I were Uber?”

“How would we use this Spatial-Temporal Data?”

- Real-time data - Uber and Weather data
- Historic data - Uber, NYC Taxi, and Weather data

Spatial Big Data and Analytics

Uber data, NYC Taxi data, and Weather data

“What if I were an Uber driver?”

“How would I use this Spatial-Temporal Data?”

- Where should I be for the most number of pick-ups?
- Where is the best place for the highest tip?
- What’s the weather for the highest tip?

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NYC Taxi Data – 48 hour period – 30 and 31 December 2013

Emerging Hot Spot Analysis

Space-Time Cube Analysis

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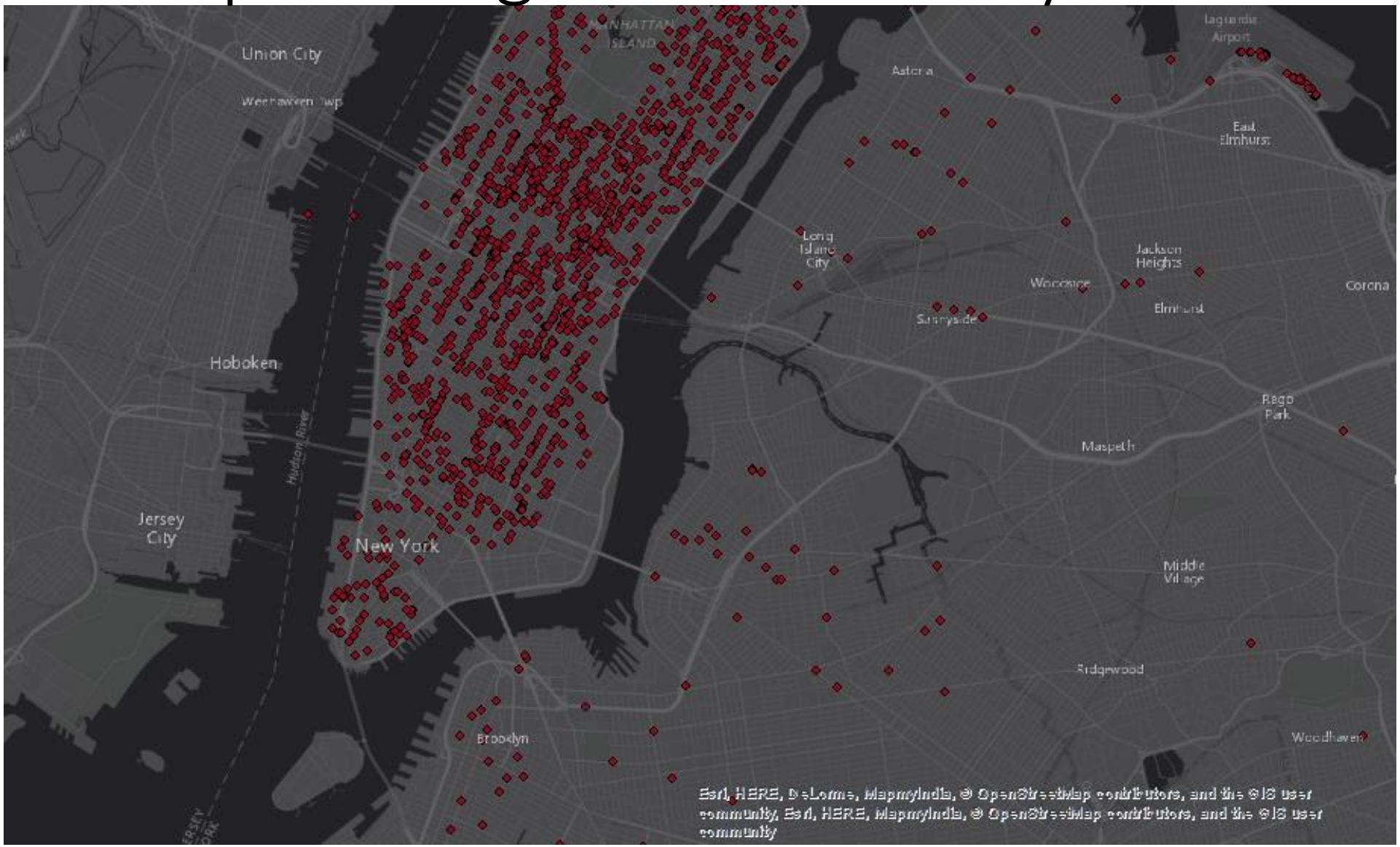

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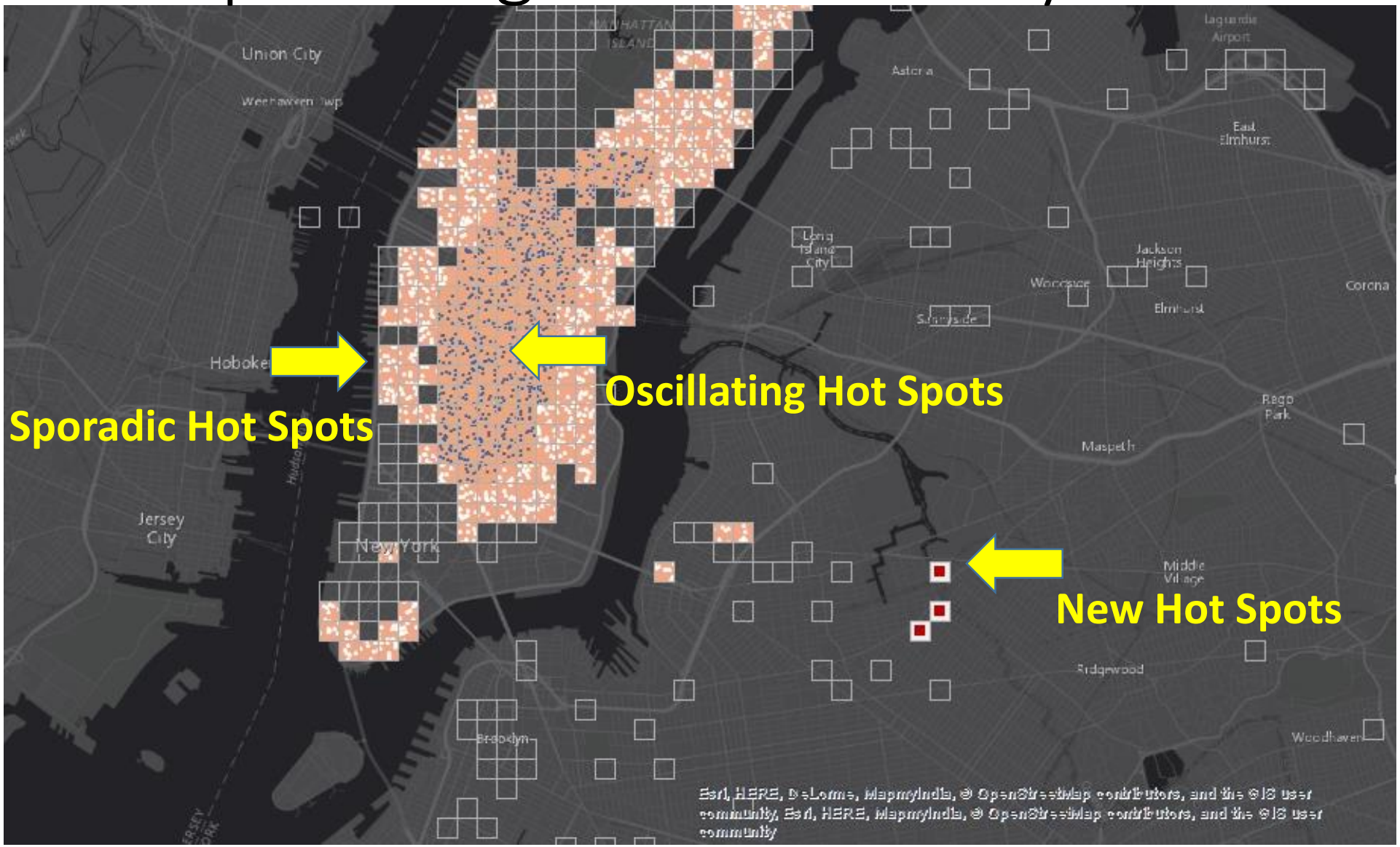

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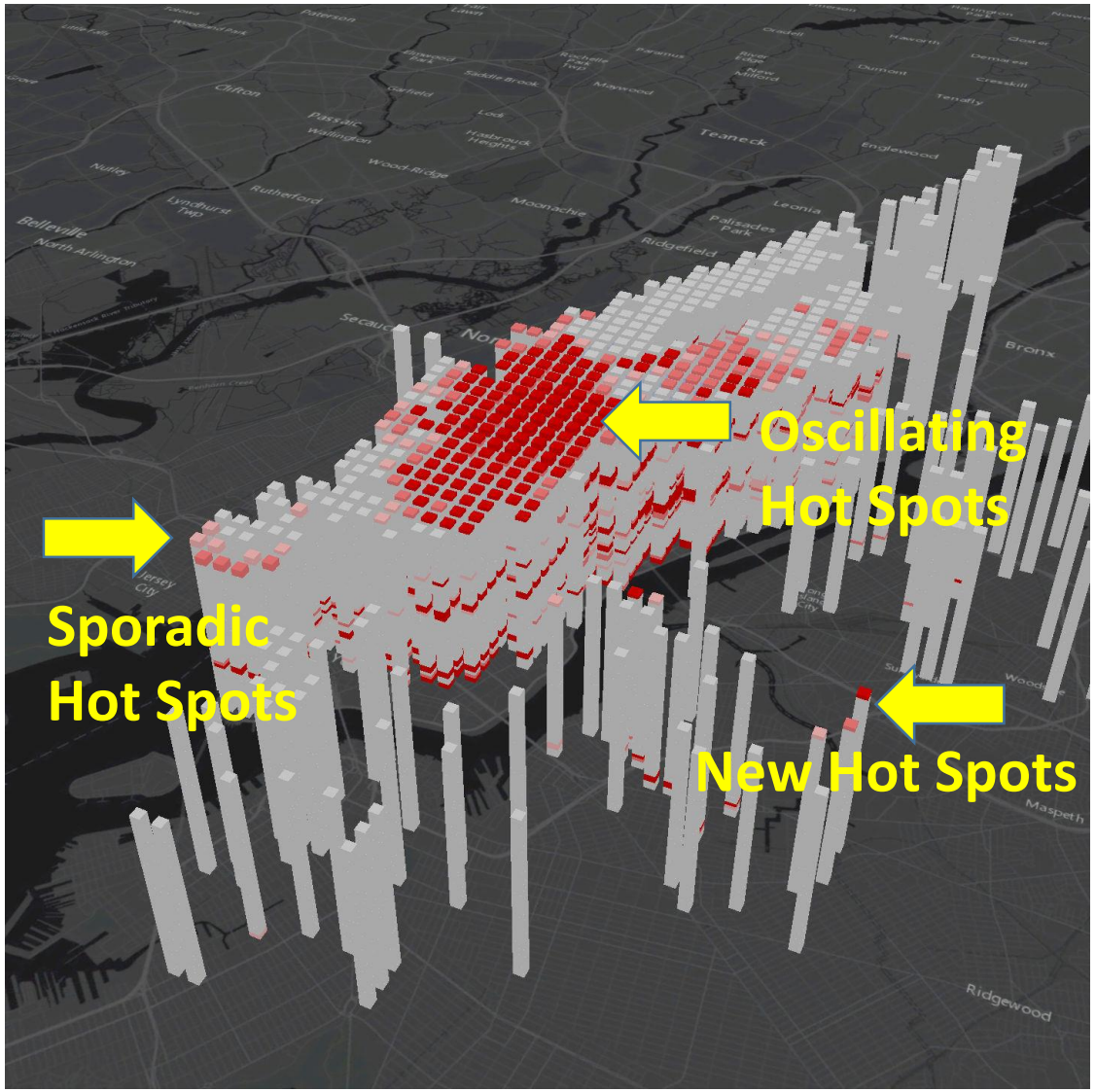

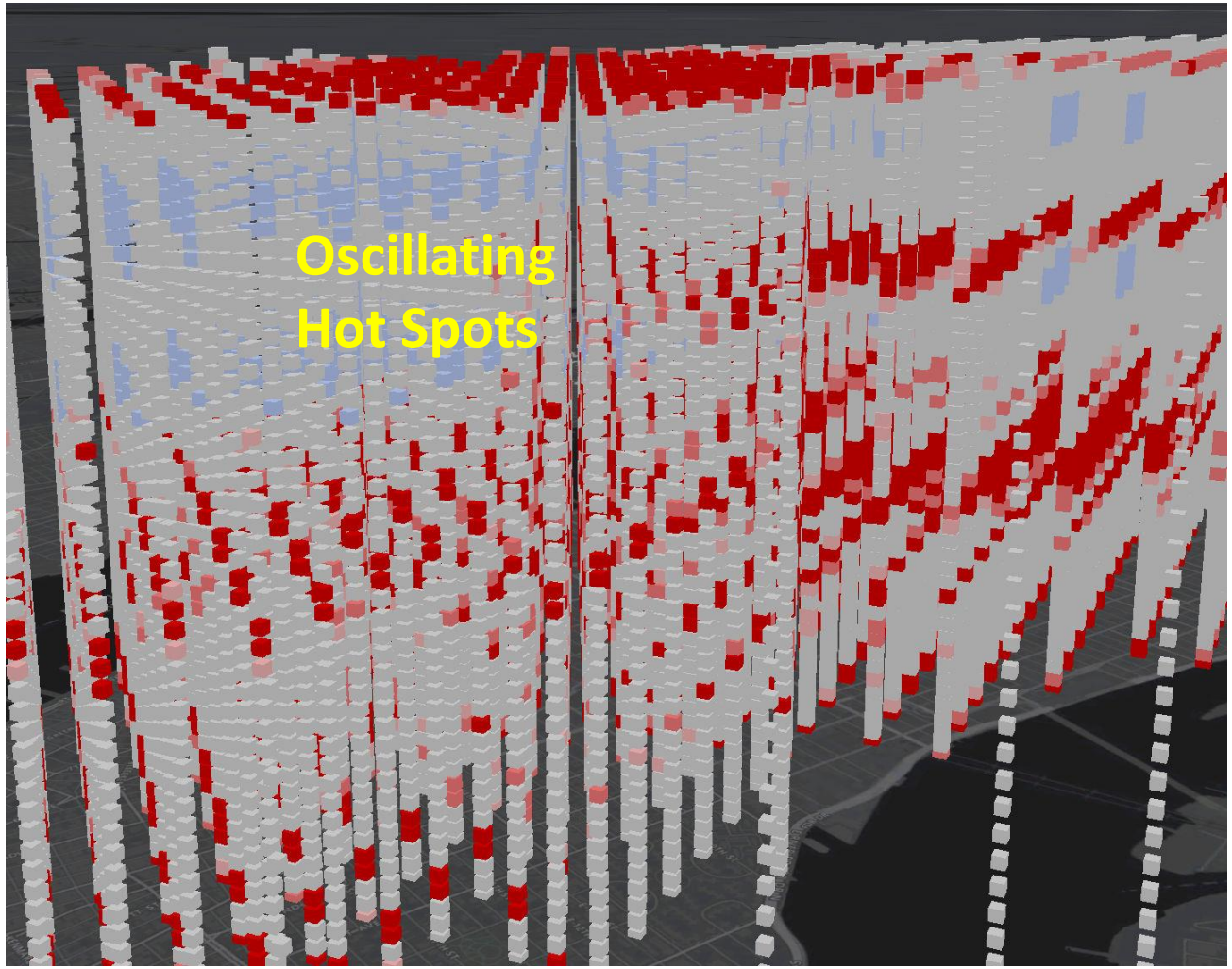

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How do we / will we use them for spatial-temporal:

analysis?
data mining?
machine learning?
knowledge discovery?
visualization?
…

Spatial Big Data and Analytics

What are / will be the workflows?

How will data move through these platforms?

data > non-spatial analysis > spatial analysis
data > spatial analysis > non-spatial analysis > spatial analysis

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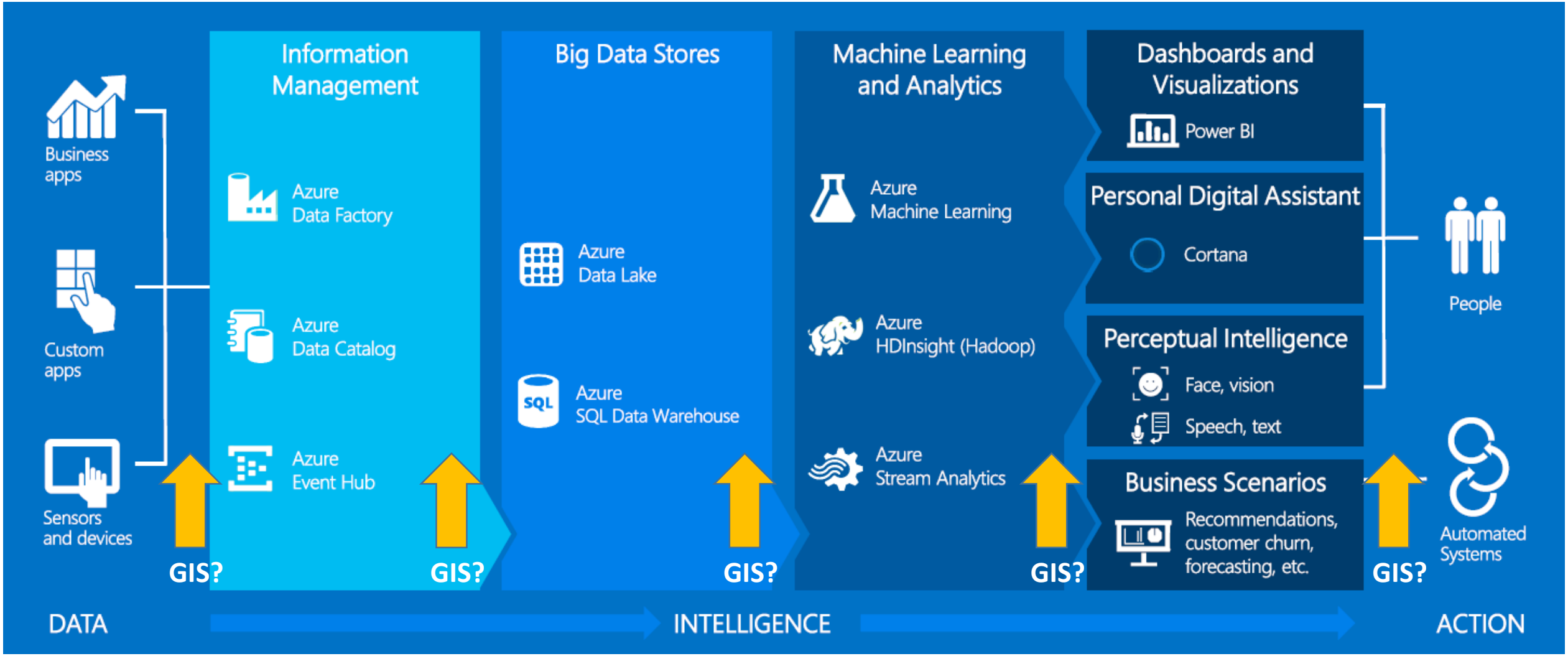

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What will the future look like?