LFS303

Building patient-centric virtualized trials

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AWS re:Invent

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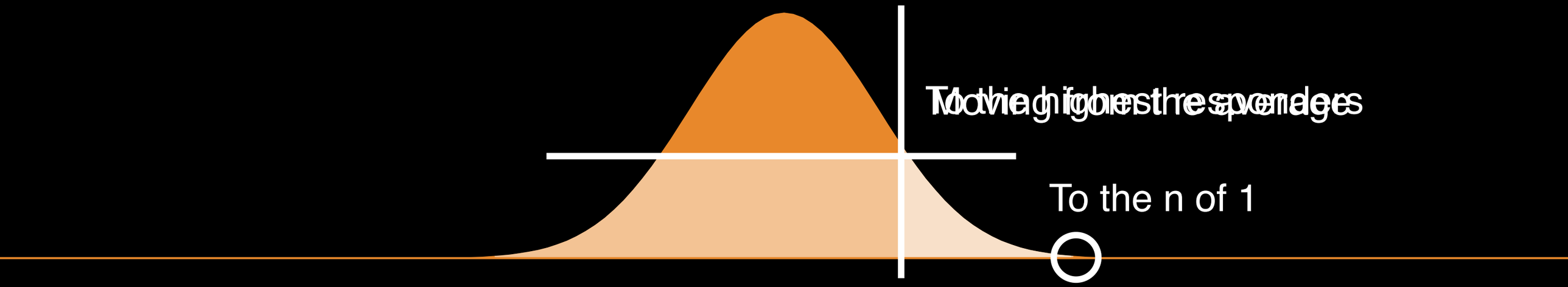
AWS cloud-enabling precision medicine



Human Beings OS =

Multi-omics + Clinical data +
Cellular activity + Exogenous
(Social+ Behavioral + Digital)

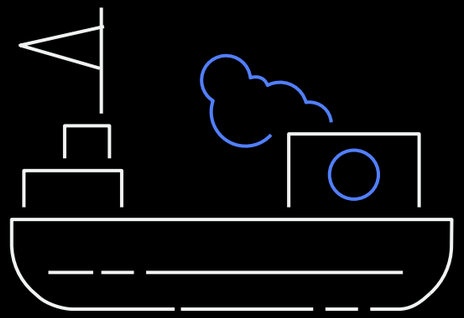
Therapies =

Patches in the code

BioPharma =

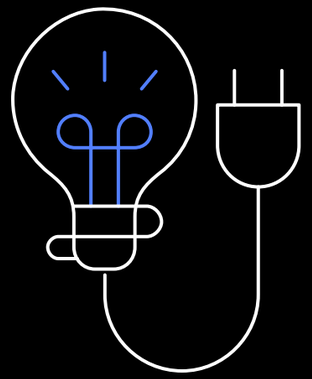
Data and technology companies

Fourth industrial revolution—



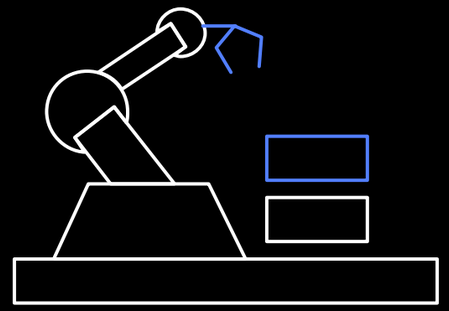
First industrial revolution

WATER & STEAM



Second industrial revolution

ELECTRICITY



Third industrial revolution

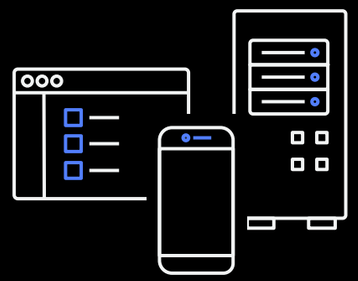
AUTOMATION

Fourth industrial revolution

CYBER-PHYSICAL SYSTEMS

A critical enabler: Amazon Kinesis Data Firehose

How it works



Input

Capture and send data to Amazon Kinesis Data Firehose

Amazon Kinesis Data Firehose

Prepares and loads the data continuously to the destinations you choose

- Amazon S3
- Amazon Redshift
- Amazon Elasticsearch Service
- Splunk

Durably store the data for analytics

Output

Analyze streaming data using analytics tools

BIG DATA & MACHINE LEARNING

Alessio Signorini

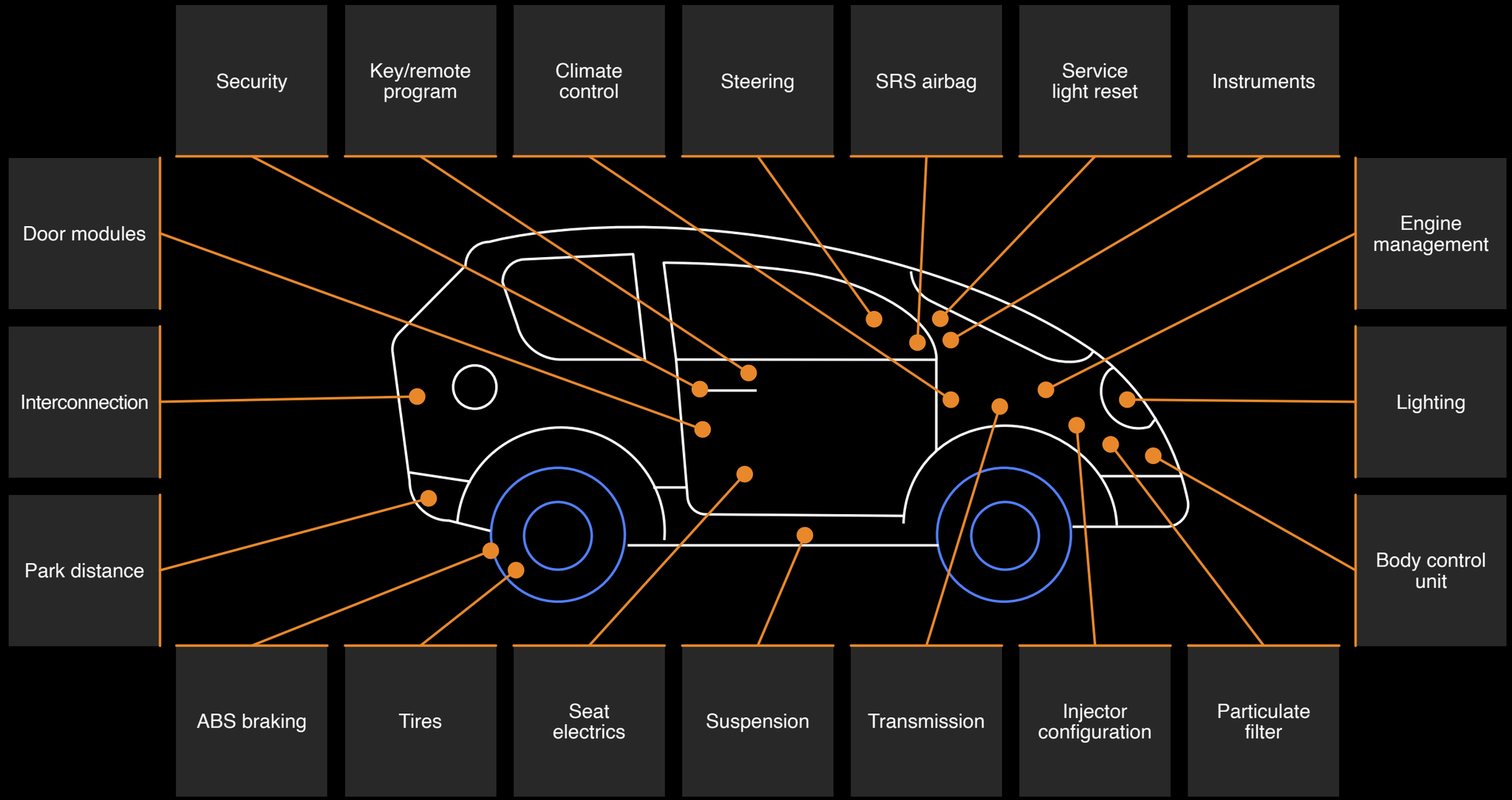
Christine Lemke

Luca Foschini

Mikki Nasch

Measure health

Our cars have dozens of sensors

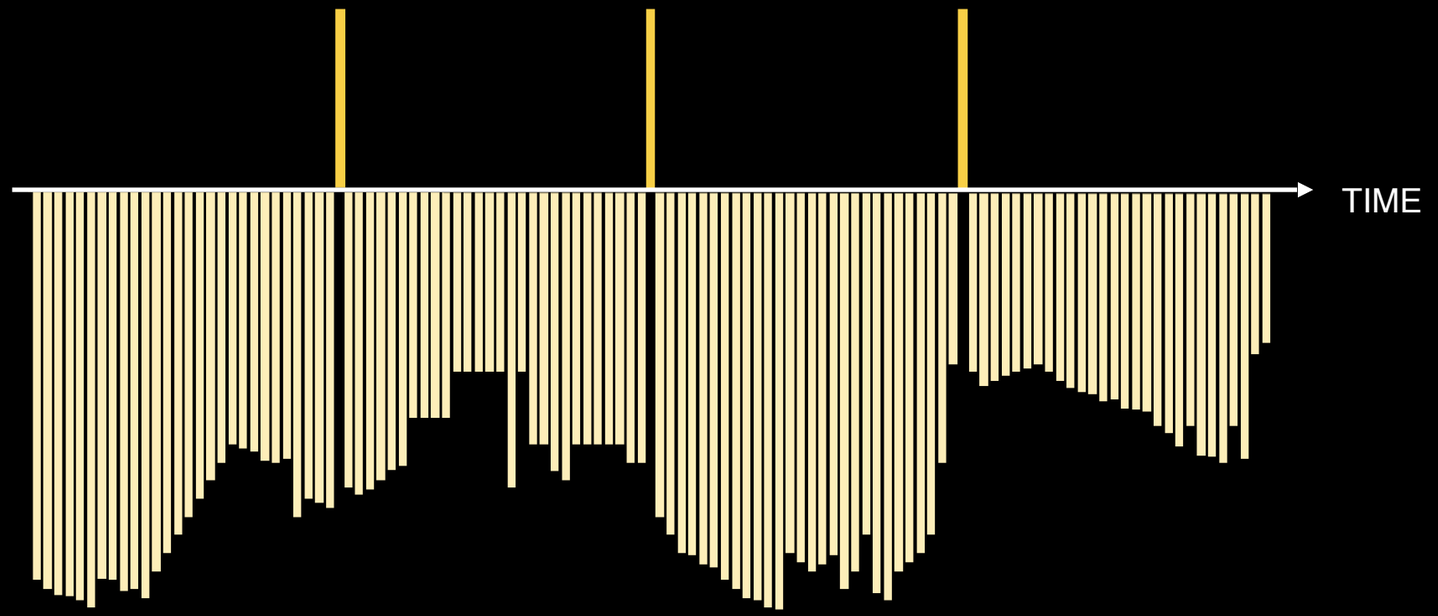


MEASURE HEALTH

HEALTHCARE HAS HISTORICALLY BEEN LIMITED TO VISIBLE-TO-THE-SYSTEM DATA SETS

VISIBLE DATA
Collected episodically in clinical settings

INVISIBLE DATA
Collected passively and continuously in everyday life

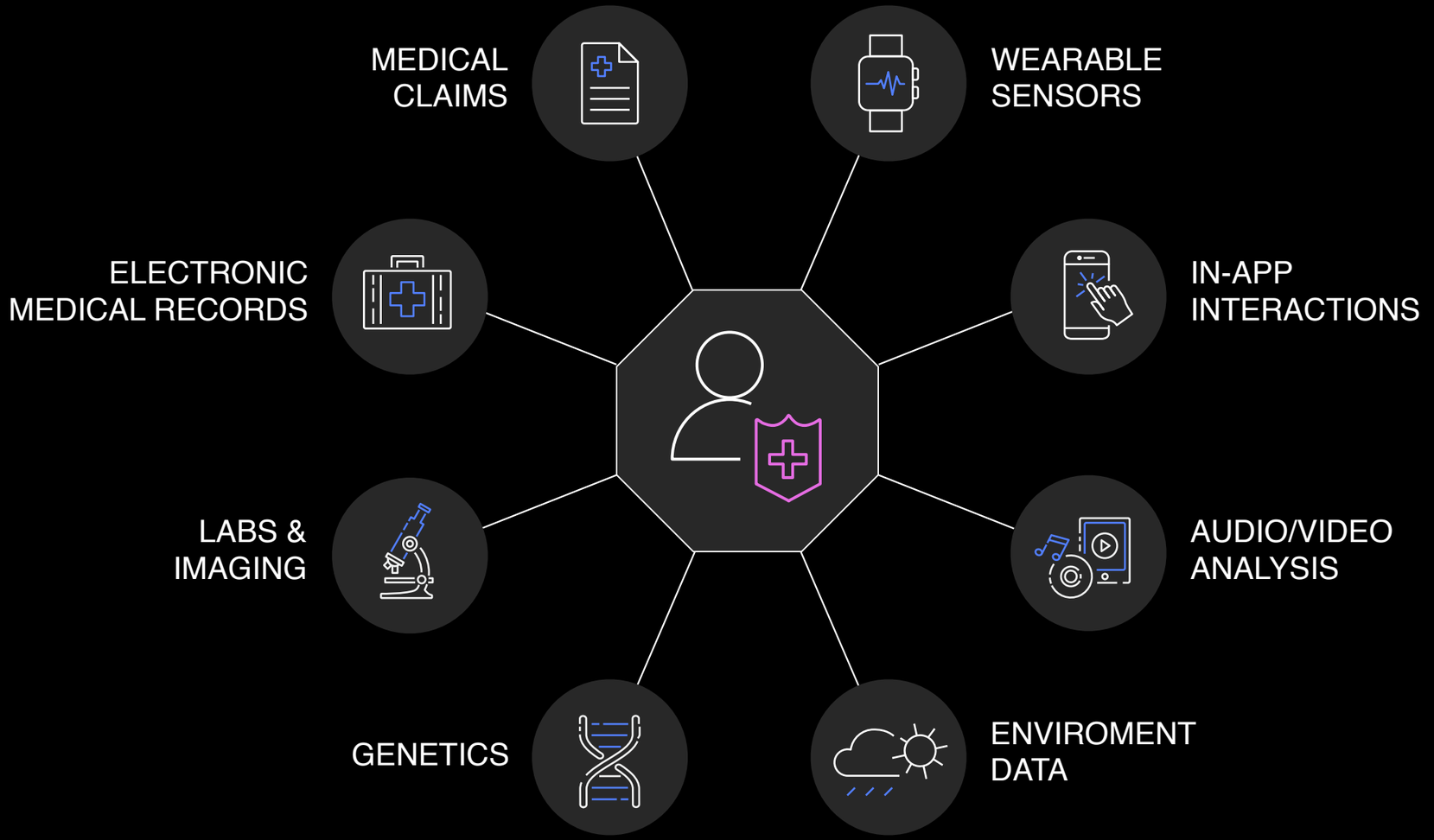


Measure health

Massive leap in efficiency of data collection and richness

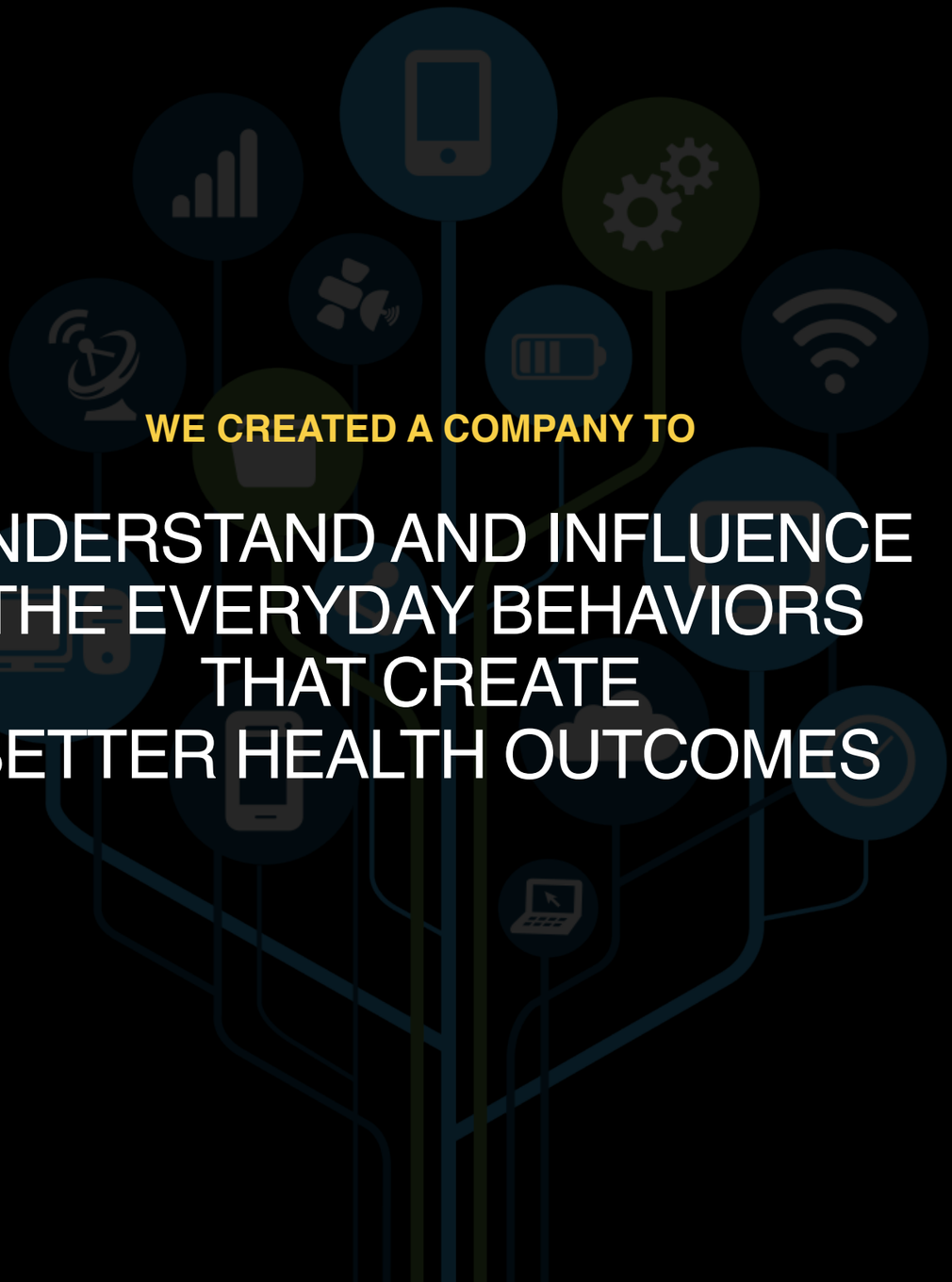
VISIBLE

Active
Episodic
In-clinic
Subjective
Insensitive



INVISIBLE

Passive
Continuous
Remote
Objective
Sensitive

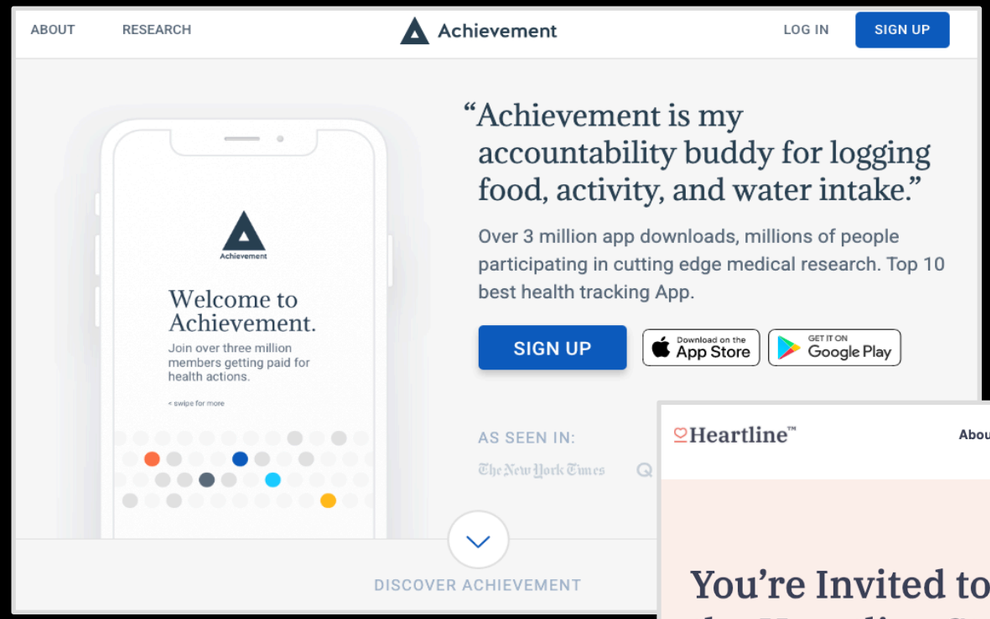


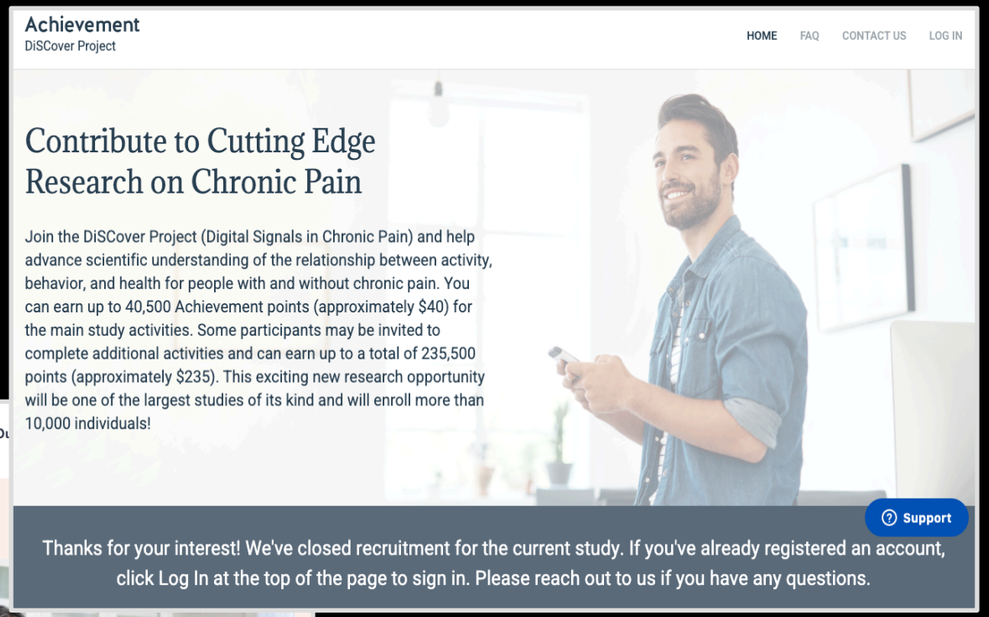
WE CREATED A COMPANY TO

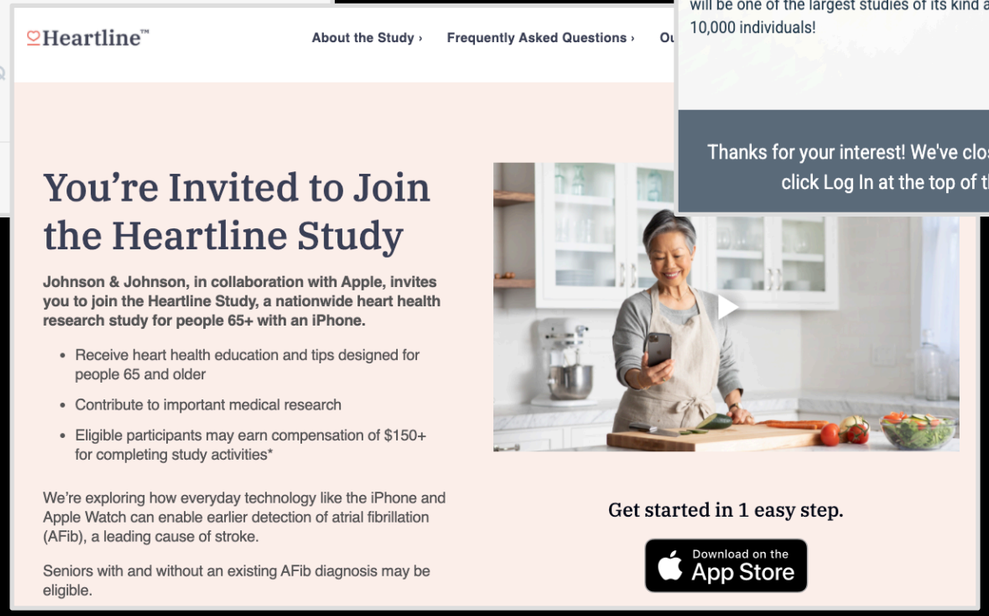
UNDERSTAND AND INFLUENCE THE EVERYDAY BEHAVIORS THAT CREATE BETTER HEALTH OUTCOMES

HEALTH STUDIES

IN PARTNERSHIP WITH THE MOST INNOVATIVE HEALTHCARE ORGANIZATIONS







A DIGITAL STUDY

Participant learns about study & does online screening questions

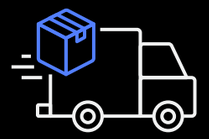
Electronic medical record request approval

Informed consent form & approval to share digital device information

Connected digital devices

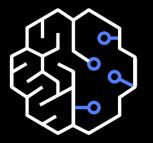
One-click survey on health

Lab kit sent to home



Results and data to Evidation

Data validation & analysis



Study end & report to participants

HIGHLY REGULATED SECTOR

OUR SYSTEMS AND PROCESSES MUST COMPLY WITH SEVERAL POLICIES

- Health Insurance Portability and Accountability Act (HIPAA)
- Code of Federal Regulation Title 21 (21 CFR Part-11)
- General Data Protection Regulation (GDPR)
- California Consumer Privacy Act (CCPA)
- Personal Data Protection Act (PDPA)
- Foreign Governments’ Policies
- Healthcare companies’ internal policies

STUDY PLATFORM CHALLENGES

WE NEED TO MAINTAIN SEVERAL INSTANCES OF THE PLATFORM ACROSS THE WORLD

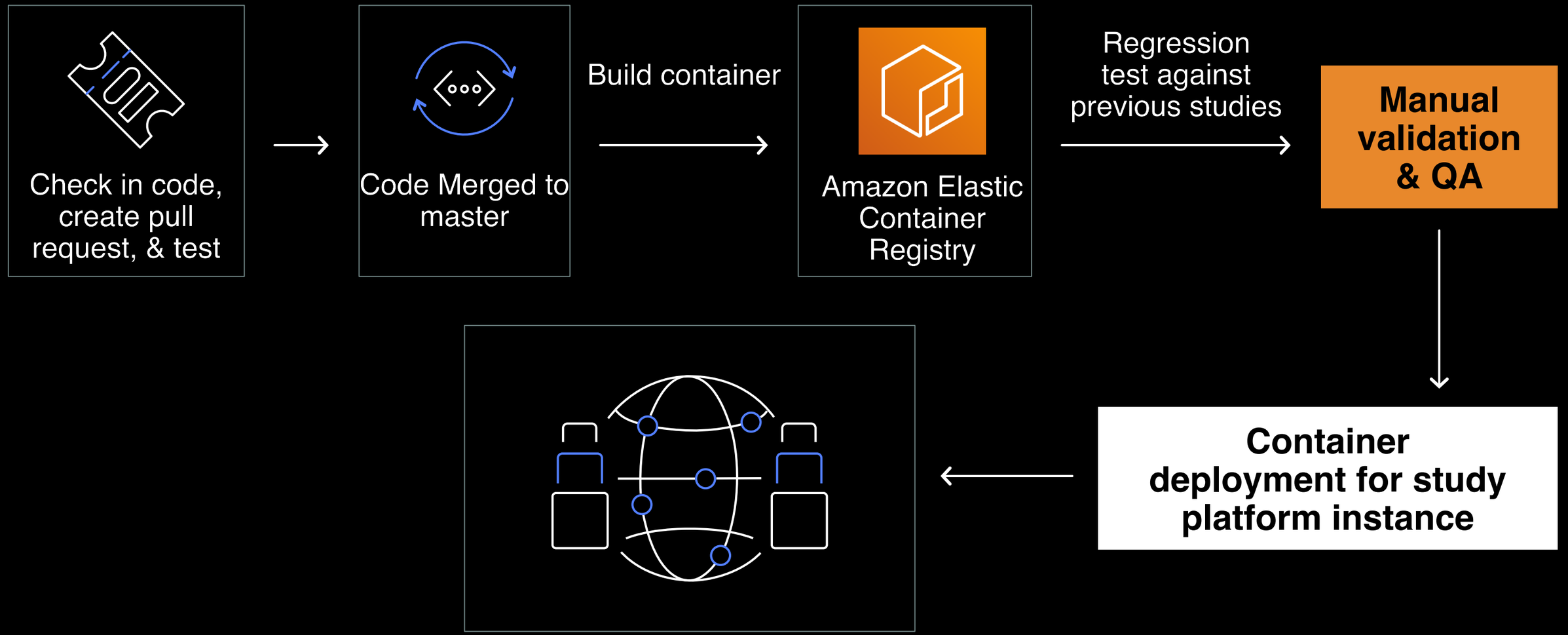
- Data Separation and Reliability
  - are requirements, together with auditability
- Strict validation and compliance
  - can’t “go fast and break things”, most changes require several approvals
- Very long-lived releases
  - often several years, while patching vulnerabilities
- Bi-modal traffic patterns
  - relatively low in general, but with high peaks
- High Availability is a must
  - being offline can influence results

CONTAINERS ARE THE PERFECT SOLUTION

AMAZON ECS TO THE RESCUE

- Containers offer Increased Portability
- No servers to maintain, OS to upgrade, etc
- We can focus on our application
- Amazon ECS takes care of Orchestration
- Load Balancing and Auto-scaling
- Updates and Deployments are easier and predictable
- Secret Management & Service Discovery
- Server-less with AWS Fargate

DEVELOPMENT & DEPLOYMENT PIPELINE

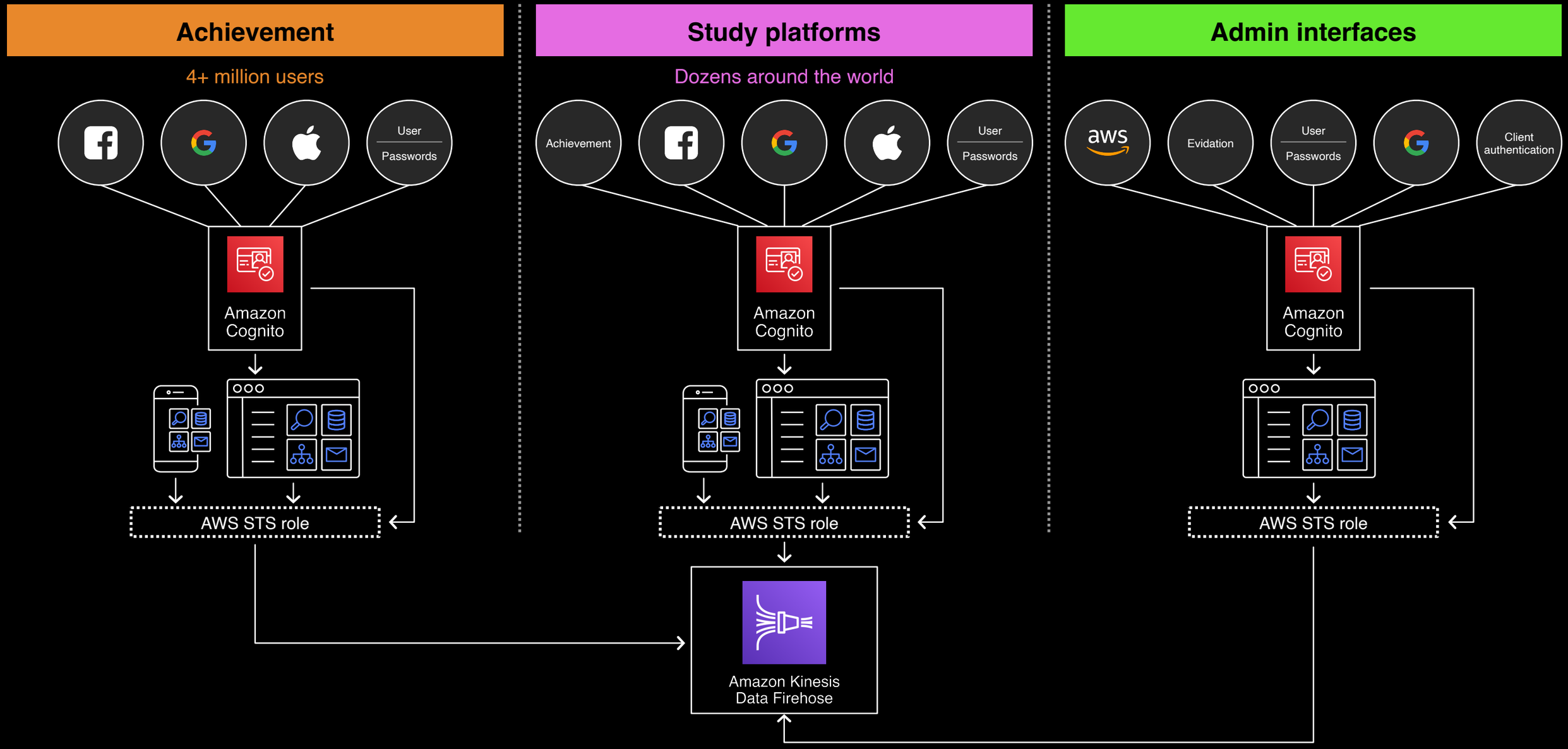


PARTICIPANT LOGIN AND AUTHENTICATION

AWS COGNITO ALLOWS US TO SECURELY AUTHENTICATE USERS ACROSS THE GLOBE

- Millions of Participants all over the world
  - scalability and reliability are no longer a concern
- Social Logins
  - Facebook, Google and Apple Sign In are a must these days, what about tomorrow?
- Enterprise Identity Federation & SAML/OpenID Standards
  - allow partners to login with their own credentials into admin UIs
- Access Control to AWS Resources
  - our apps can send data directly to Kinesis Firehose for authorized users
- Easy to Integrate
  - Amplify was easy to integrate in our ReactNative, iOS and Android apps

PARTICIPANT LOGIN & AUTHENTICATION



CHALLENGES OF DATA INGEST AT SCALE

TRANSFERRING DATA FROM WEARABLES AND APPS TO OUR INFRASTRUCTURE

- Events from Millions of Apps and Portals
  - most activity have to be tracked, apps can be several versions behind
- HealthKit, SensorKit, SamsungHealth, etc
  - mobile devices produce lots of interesting health data to be captured passively
- Fitness Devices
  - wearables fitness devices generate activities and updates every day
- High-Resolution Data
  - some devices have dozens of sensors running at 100Hz (that’s 100M datapoints/day!)
- High Availability and Reliability
  - losing data puts the study at risk

KINESIS FIREHOSE MADE DATA INGEST EASIER

USING A QUEUE THAT DUMPS TO S3 SIMPLIFIED THE TASK

- Uptime is 99.9%
- Automated Elastic Scaling
- Data is automatically bundled and archived to S3
- Stream identifier is stable, destination can be redirected if needed
- Point-to-Point Encryption without certificate management
- Automatic Encryption at rest via KMS
- Authorization to write granted via IAM roles or Cognito

KINESIS FIREHOSE MADE DATA INGEST EASIER

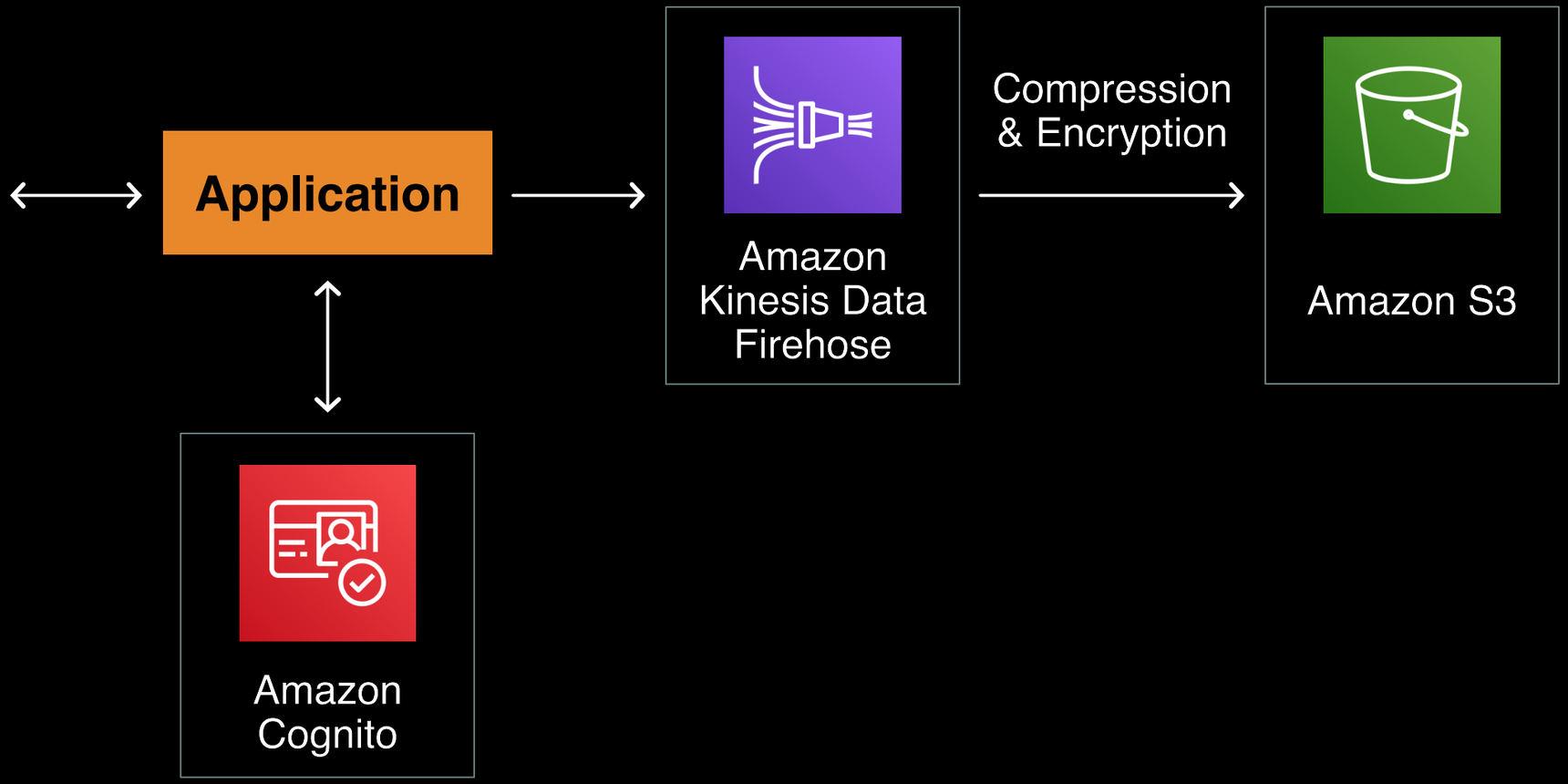
Data sources - HealthKit, SensorKit, SamsungHealth

Labs

Fitness devices

Internal computed data

Etc.



REAL LIFE OUTCOMES

RIGOROUS SCIENCE, BIG DATA, MEANINGFUL IMPACT

- Singapore’s National Population Health Program
  - rewarding healthy activities to improve health outcomes at scale
- Detect early Warning Signs of COVID-19
  - analyzing behavior, sleep and activity patterns to measure health status
- Reduce Stroke Risk
  - identify Atrial Fibrillation (AFib) via sensors analysis
- Improve Diabetes-related Outcomes
  - reduced Hemoglobin A1c, total cholesterol and improve medication adherence
- Monitor Alzheimer’s Disease
  - monitor sleep and behavior to measure cognitive decline

TAKEAWAYS

WE WANT TO IMPROVE HEALTH OUTCOMES, IF YOU TOO, HERE ARE SOME ADVICES

- Don’t build your own Study Platform
  - it’s tough, has to be secure but traceable, complex to maintain and upgrade
- You will get audited a lot. A. LOT.
  - lots of regulations to follow, and every partner/country has different standards
- Be grateful for the Cloud
  - not having to worry about cooling, fire, failures, security, etc, world-wide, is huge
- Ship with Containers
  - forget the ugly metal boxes, they actually can make your life easier
- Move slow and do things well
  - you can break things…in staging, be methodical and intentional, do lots of code reviews

Thank you!

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