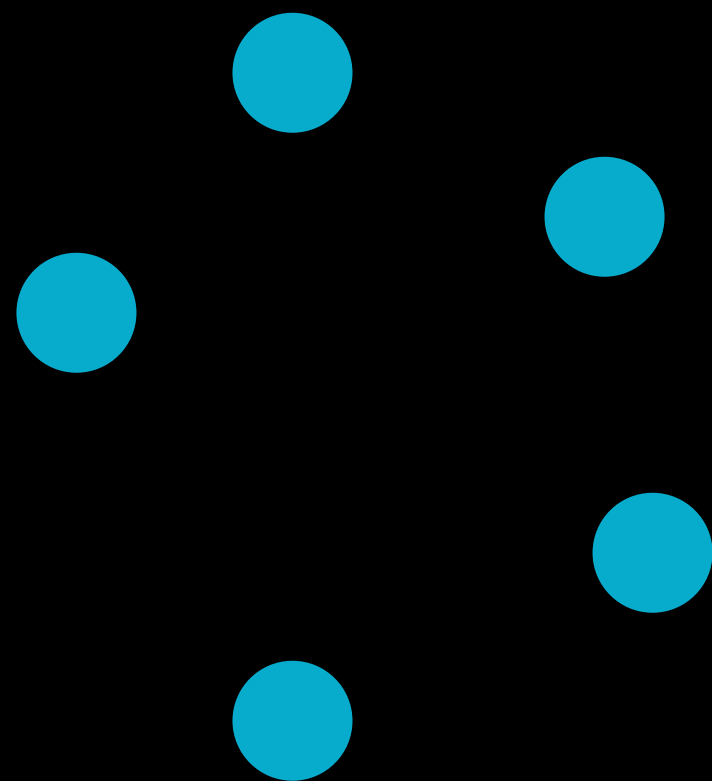# Design + systems:
An overview

Hugh Dubberly

We are in the midst of **a fundamental shift** in how we view the world — how we explain it — and how we operate in it.
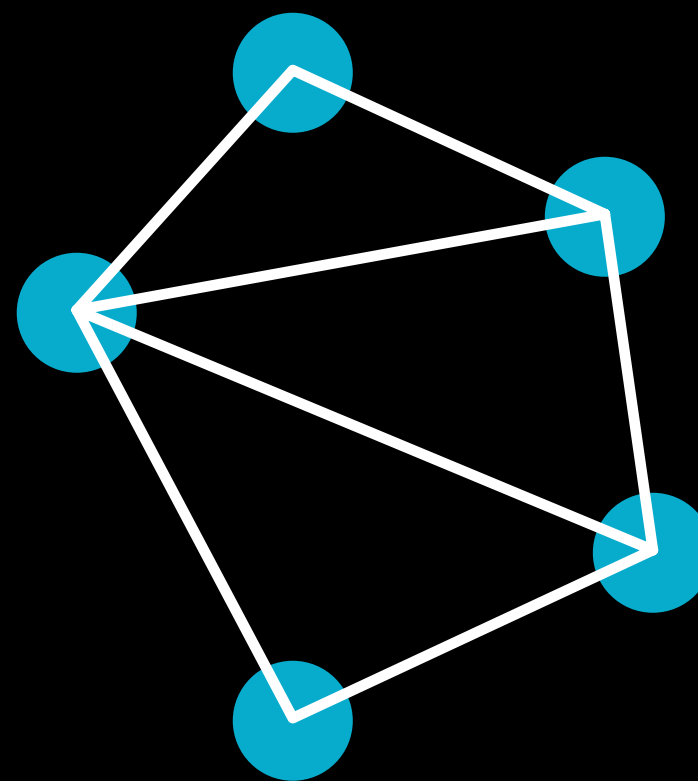
from

Nodes, Nouns, Objects, Things

to

Links, Verbs, Relations, Systems

from
Mechanical,
clockwork models

to
Biological,
living systems models

from

Industrial age
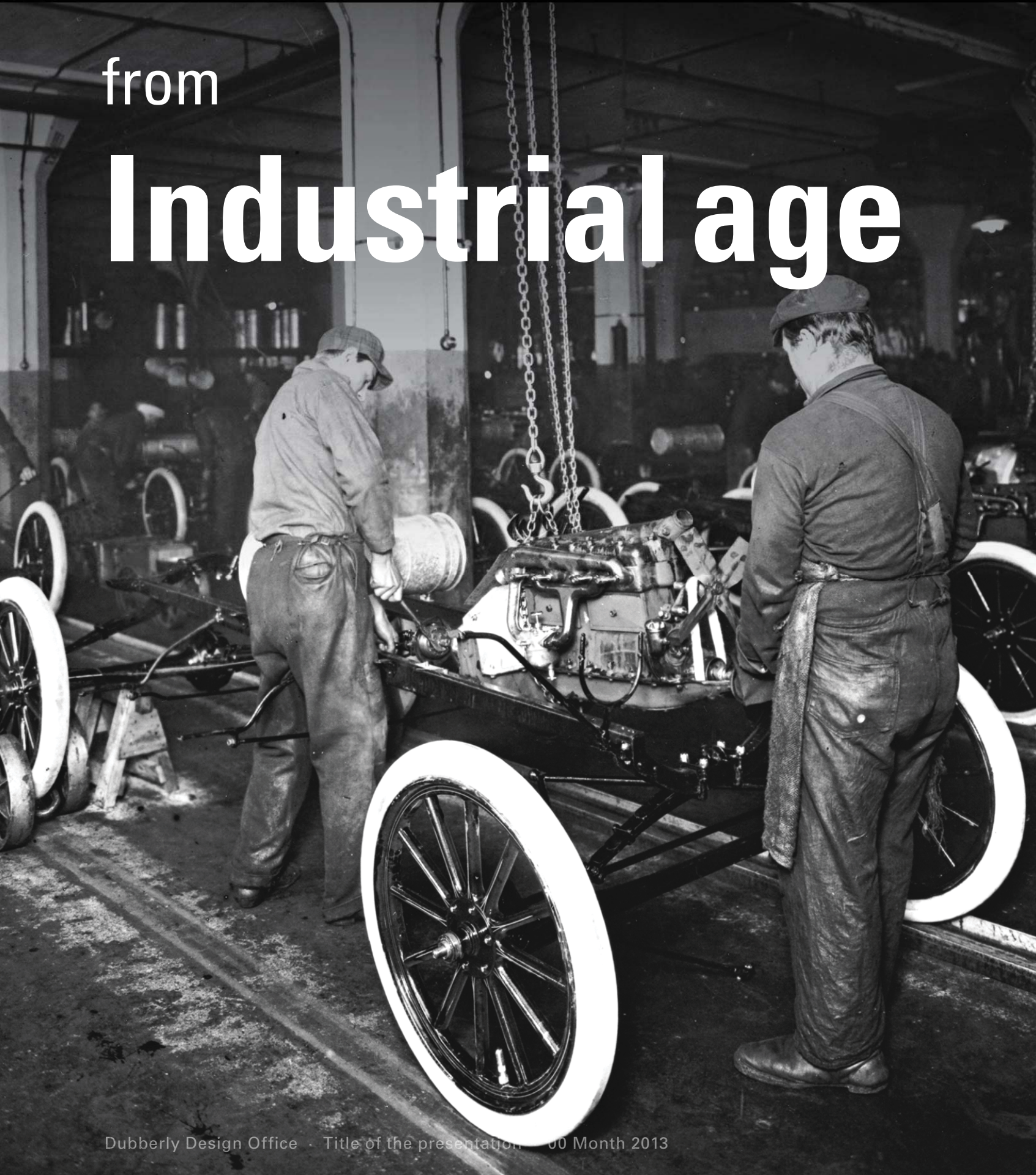
to

Information age
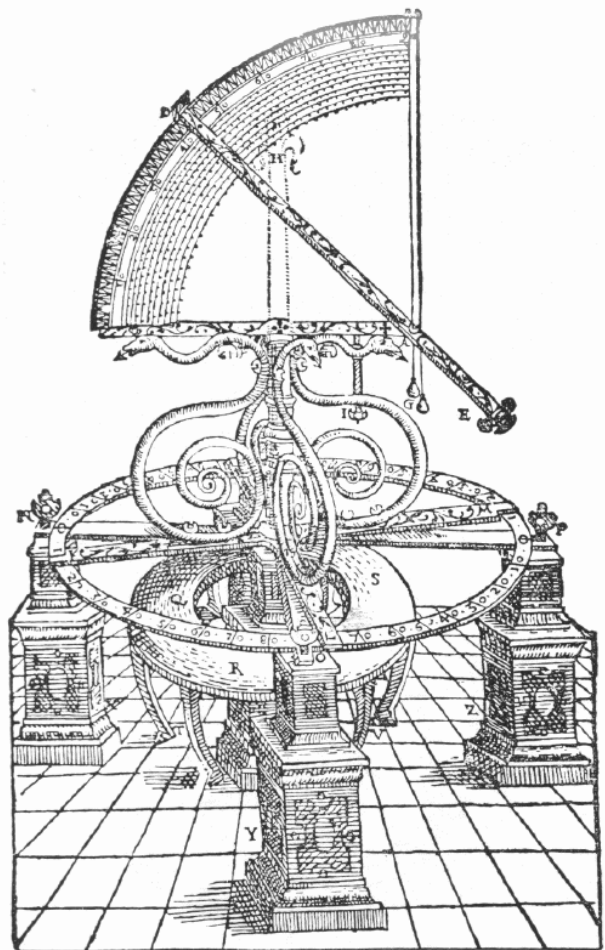
from

Infrequent sampling + scarce data

to

Measuring everything, all-the-time

from

Customer mailing list as an afterthought
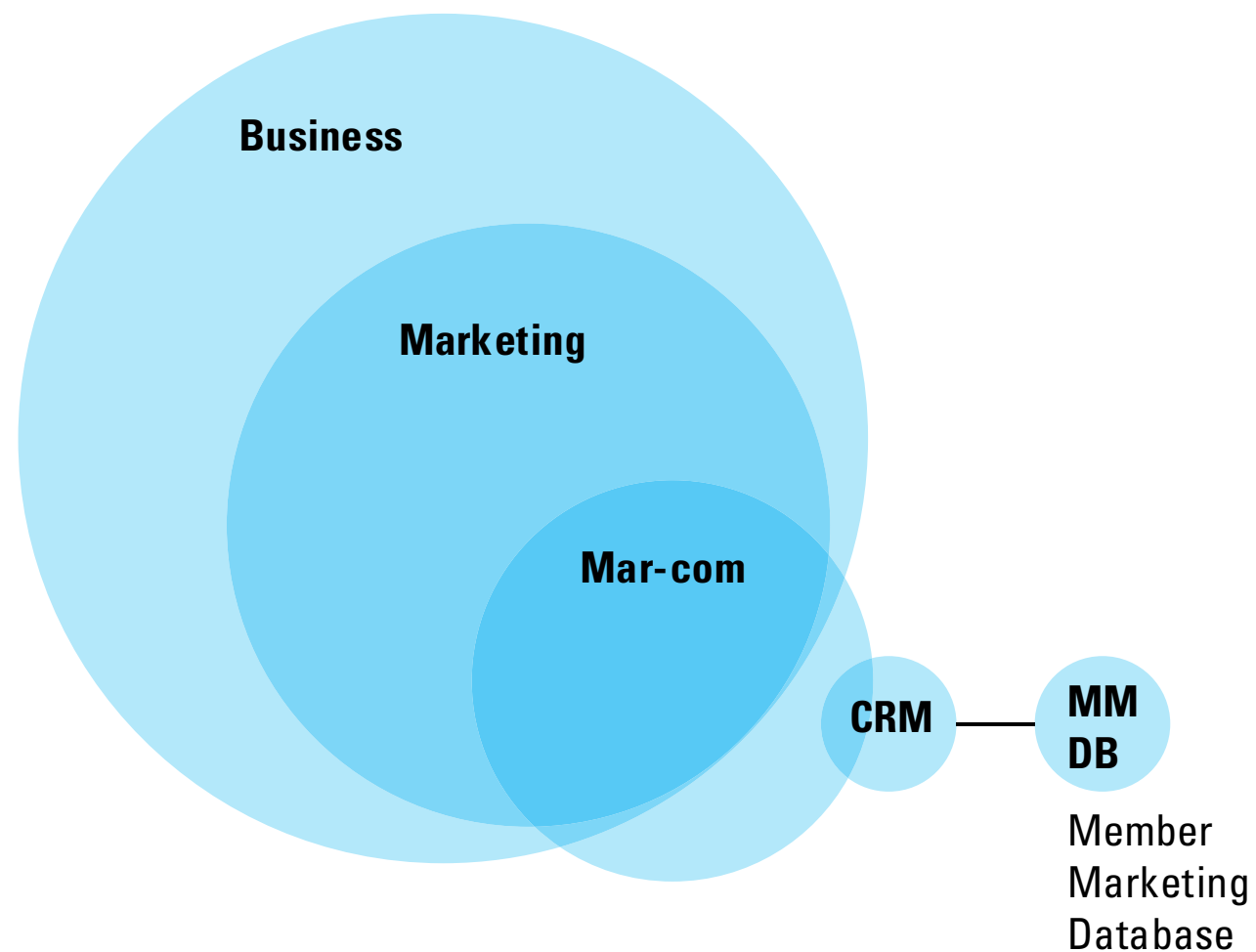
to

User profiles as core to the business

Business

Marketing

Mar-com

CRM

MM DB

Member Marketing Database

New products + services built on the MMDB.

Business

MM DB

CRM

Mar-com

Marketing
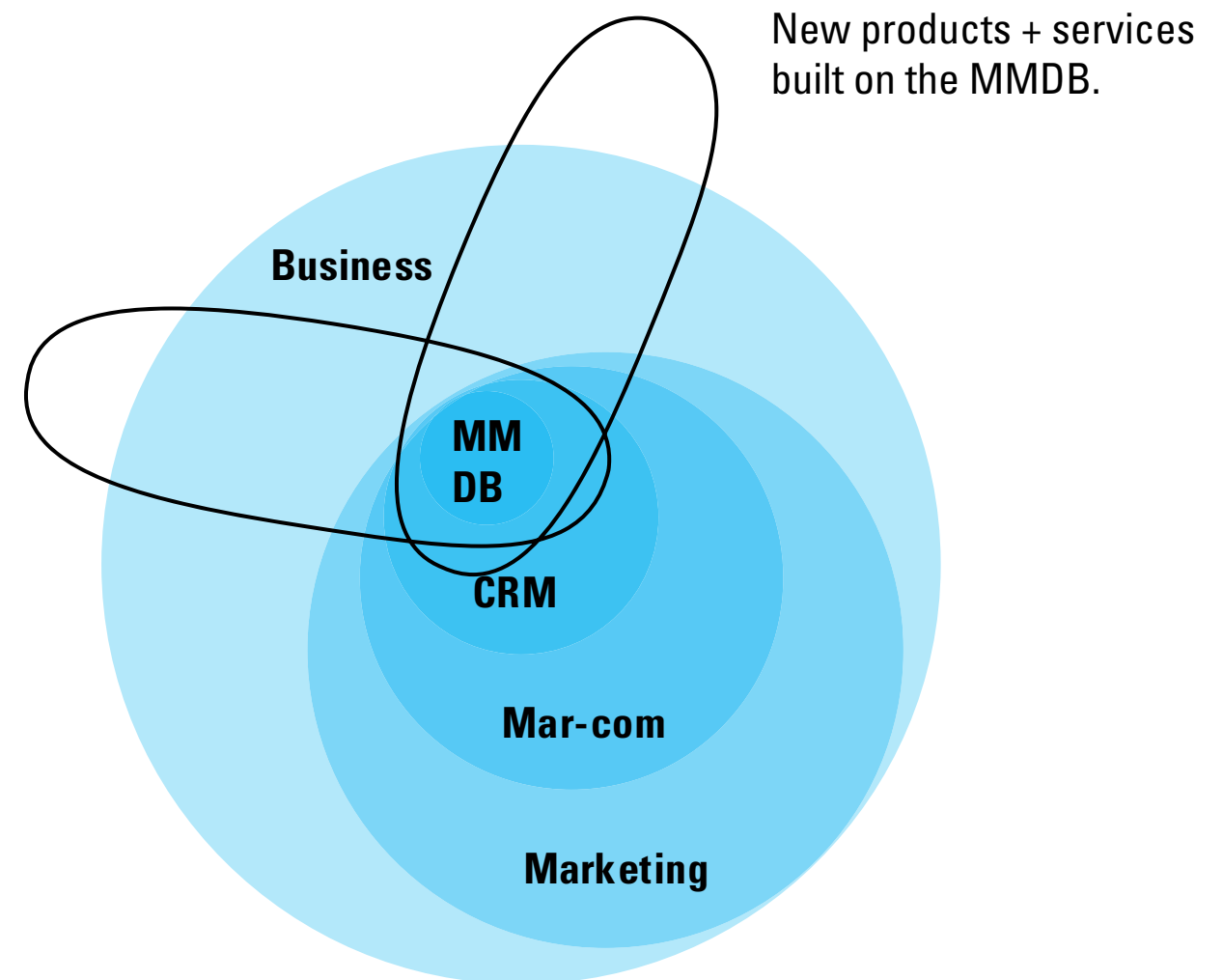
What the data enable is relevance, personalization at global scale — design of systems that adapt to each individual.

Relevance

The right resources
in the right amounts
at the right time
in the right place

=

Identity

for a person
or team
in their environment
during an activity

+

Context

to accomplish
the tasks at hand
without disruption
or loss of flow

The shift is reflected in the values* of these companies —
both their economic values and their cultural values.

Apple	$2.41 Trillion		AT&T	$197 Billion
amazon	$2.25 Trillion		BOEING	$125 Billion
Microsoft	$2.25 Trillion		ExxonMobil	$233 Billion
Google	$1.88 Trillion		GE	$110 Billion
facebook	$1.03 Trillion		Walmart	$403 Billion

* Market caps as of September 19, 2021

The shift entails

a new feedback system paradigm;

it values measuring + aggregating data;

monitoring + responding;

and predicting + pre-empting.

Smartphones are driving a revolution in sensors;
for example, the latest iPhone includes at least 20 sensors.

3 cameras in the back
Wide
Ultra-wide
3x

1 camera in the front
2 infrared cameras (for FaceID)
LiDAR
4 microphones

Touch screen with 'Haptic Touch'
Does not include Touch ID

Proximity sensor
Ambient light sensor

Radios
Cellular (5G + LTE x 4)
WiFi (x 2)
Bluetooth
NFC
iBeacon
GPS
Ultra Wideband (for AirTags, etc.)

2 internal moisture sensors
Barometer (for altitude)
Three-axis gyro
Three-axis accelerometers (motion)
Digital Compass (3-axis magnetometers)

IoT devices are also built around sensors,
for example, Nest offers a whole family of home monitoring devices.

Cameras

Smoke-CO Alarms

Doorbells

Speakers

Locks

Thermostats

Security Alarms

Bands, glasses, patches, etc. put sensors on you,
measuring your location, activity, health, and more.

Apple Watch
Movement (steps)
Exercise (calories burned)
Standing (time, frequency)
Sleeping (time, quality)
Hand washing (length)
Heart Rate (plus EKG, rhythm)
Blood oxygen
Blood glucose (rumored)

Blood pressure (Samsung
Galaxy Watch)

Body temperature (FitBit)

Disney Magic Band enables guests to
Unlock the door of their hotel room
Enter theme and water parks
Check in at FastPass+ entrances
Connect Disney PhotoPass images
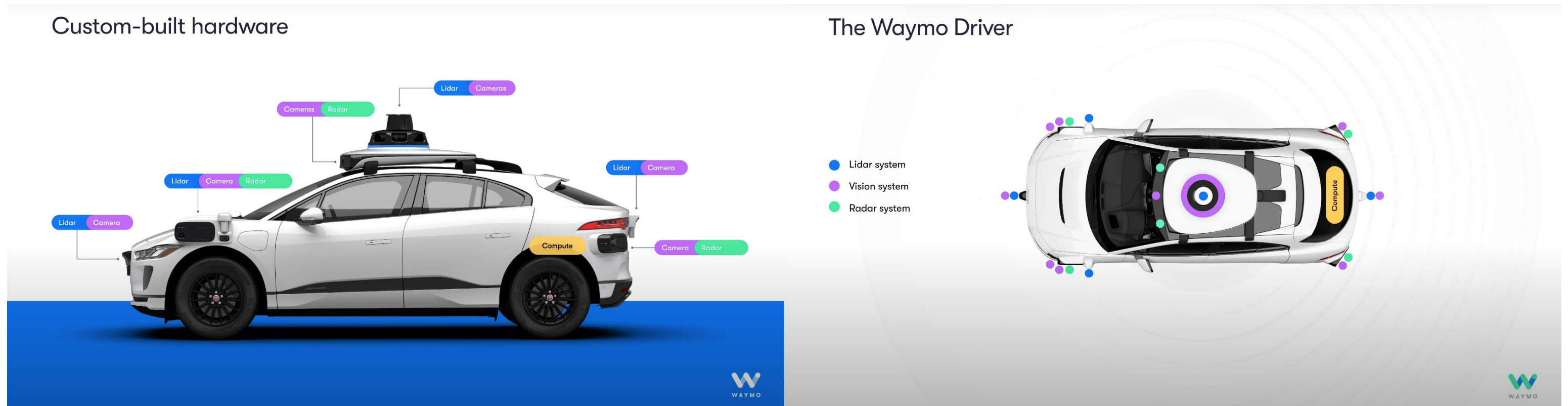to their account
Charge food and merchandise purchases

Facebook Ray-Ban Stories Smart Glasses
2 Cameras
3 Microphones
Touchpad
Bluetooth

The average new car has 80 to 100 sensors
self-driving cars come with way more.

Source: "Designing the Waymo Driver", https://www.youtube.com/watch?v=o8rCOKSDMcg

At the heart of these systems are 'digital twins' — virtual models of the system and its context.

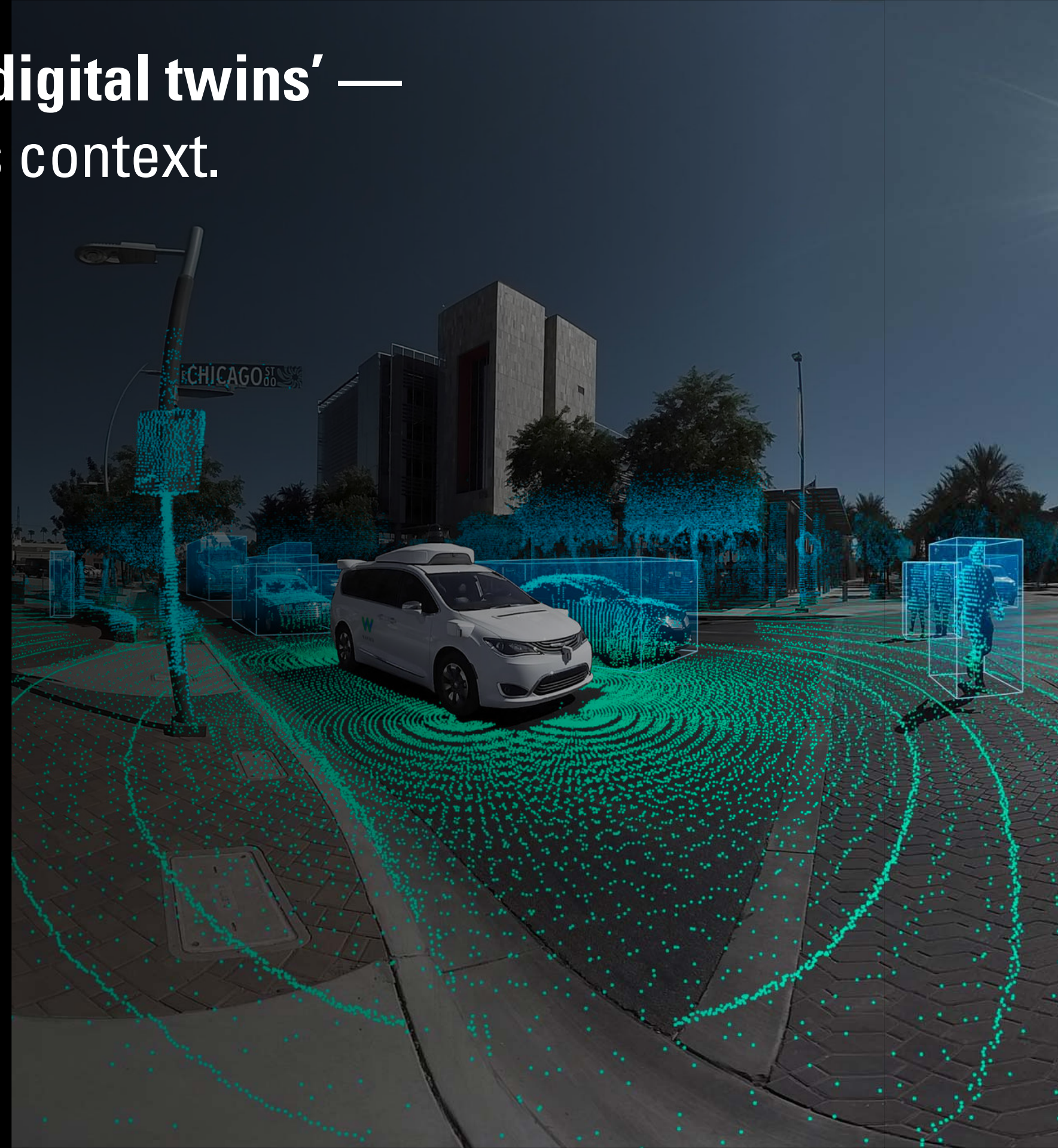The city road network, traffic, typical drive times

A current location, destination, route

Immediate surroundings, up to 1000 yards away,
including other cars, bikes, people, traffic lights —
plus the status of each and projected paths

The car itself — heading, speed, fuel, vital signs

The passengers

Source: https://xavier-barrade.squarespace.com/waymoexperience/

Digital twins exist all along a capability continuum or 'learning curve'.

Capability

Predicting
+
pre-empting

Monitoring
+
responding

Measuring
+
aggregating data

Time
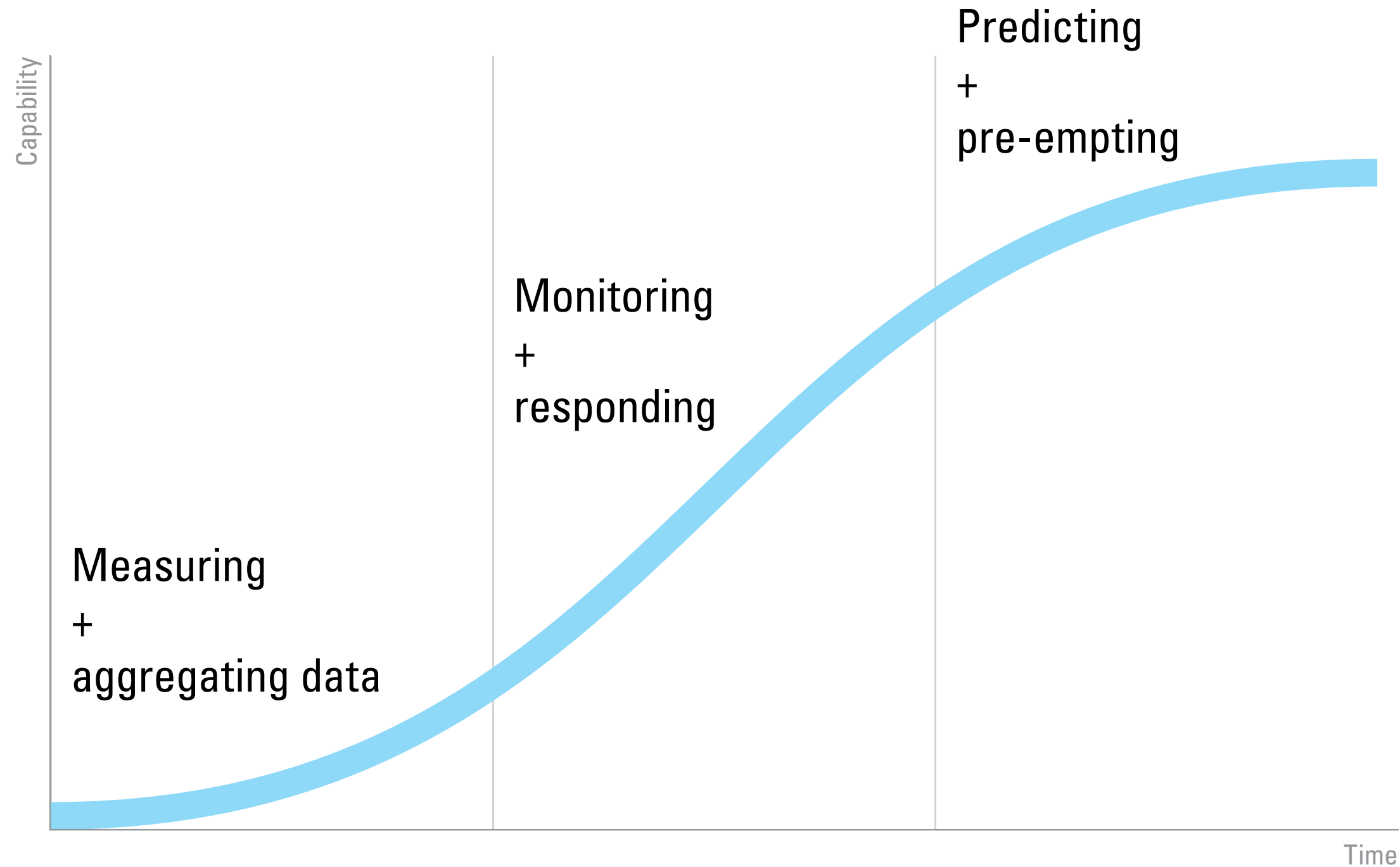
Deploy sensors and connect them to the cloud —
measure and aggregate data, continuously; and scale.
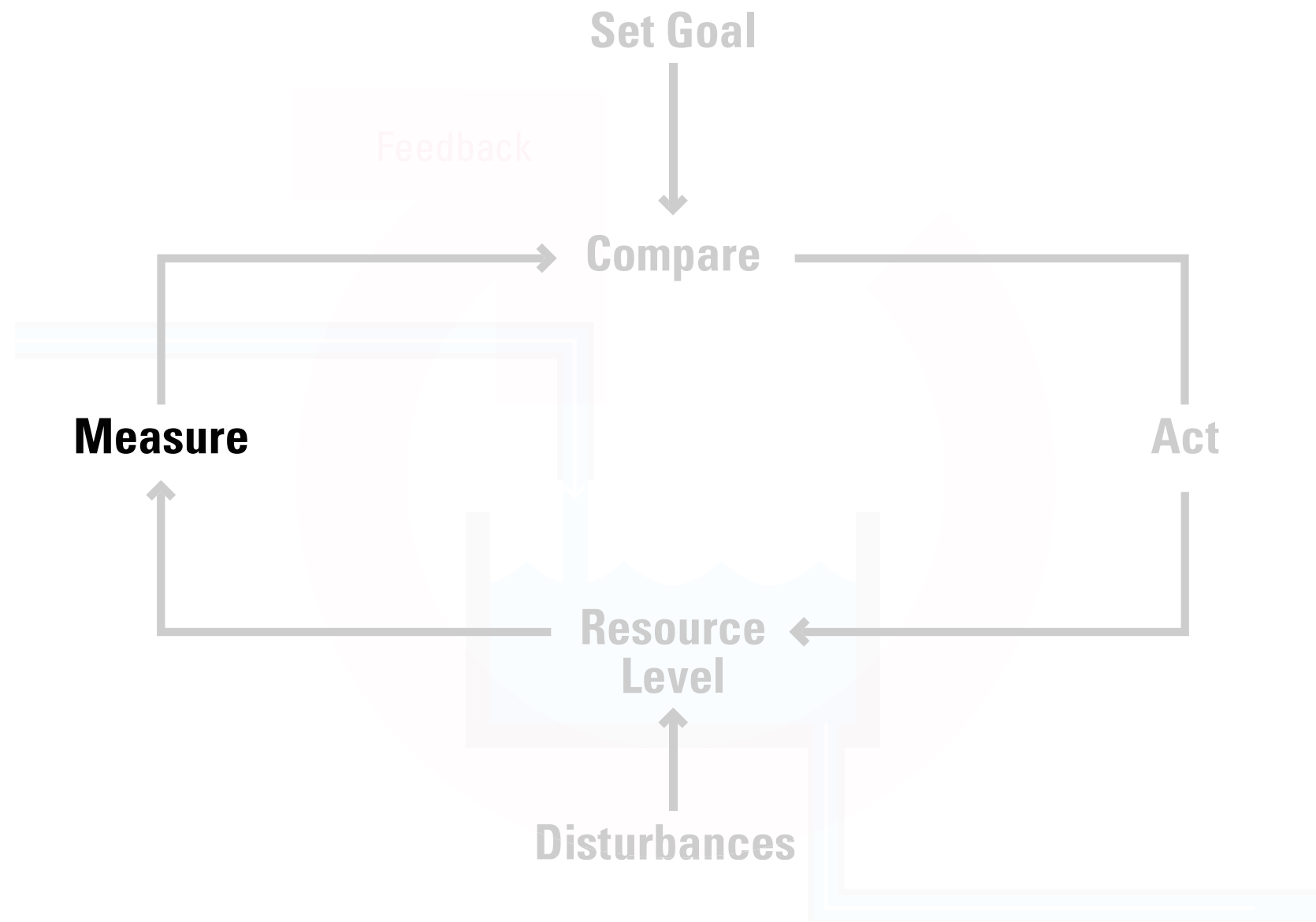
Monitor — compare current measurements to desired thresholds; report data, trends, and exceptions — via dashboards and alerts.

Set Goal

Compare

Measure

Act

Resource
Level

Disturbances
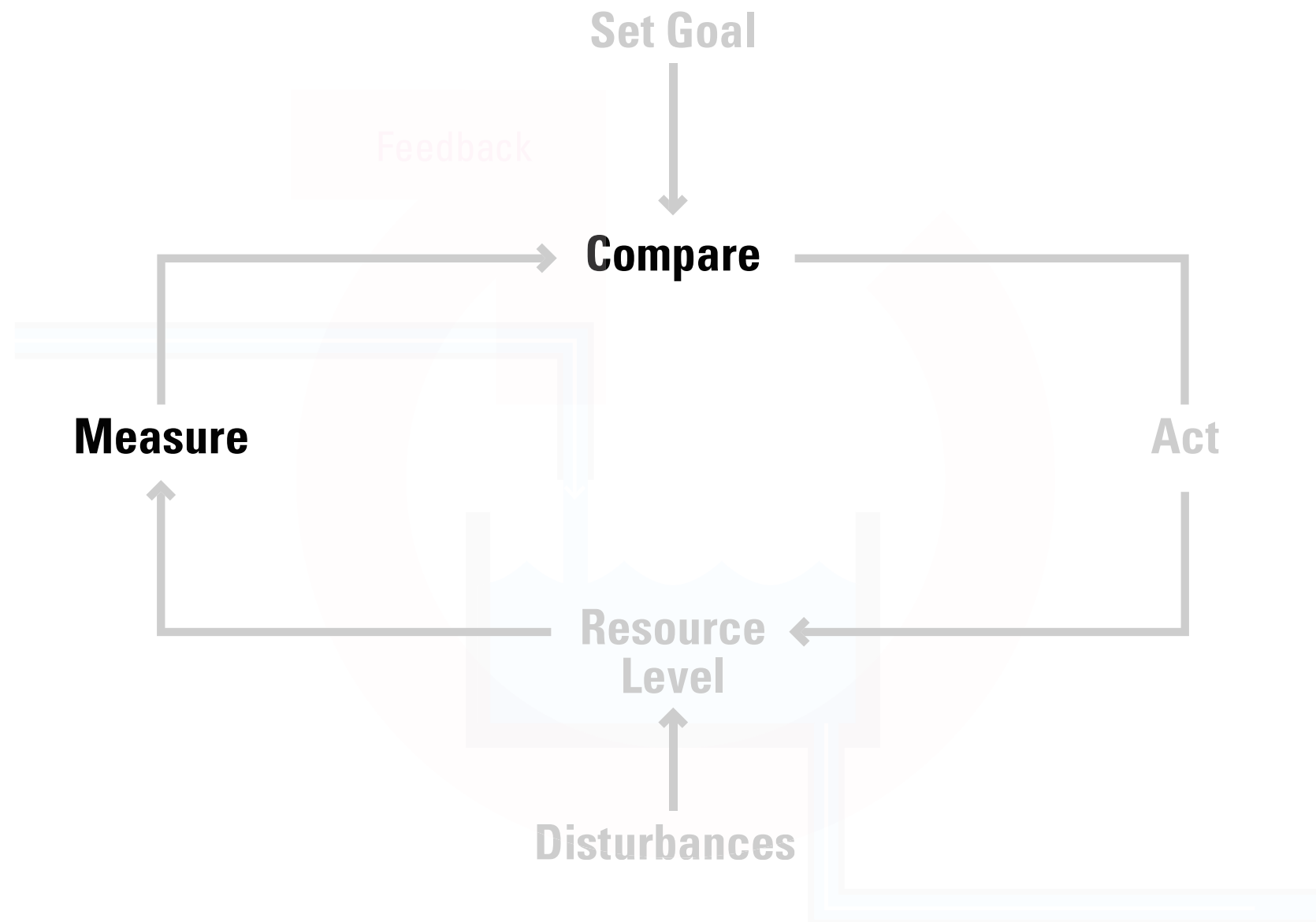
Respond automatically to exceptions, activating counter measures;
e.g., turn on the AC, close the blinds, administer insulin, stop the car.

Set Goal

Feedback

Compare

Measure

Act

Resource
Level

Disturbances

Step 4
Predicting + pre-empting requires models embedded in operations.

1. Gather histories
Sensors make a series of
point-in-time measurements.
As measurements accumulate,
an historical record emerges.

2. Derive models
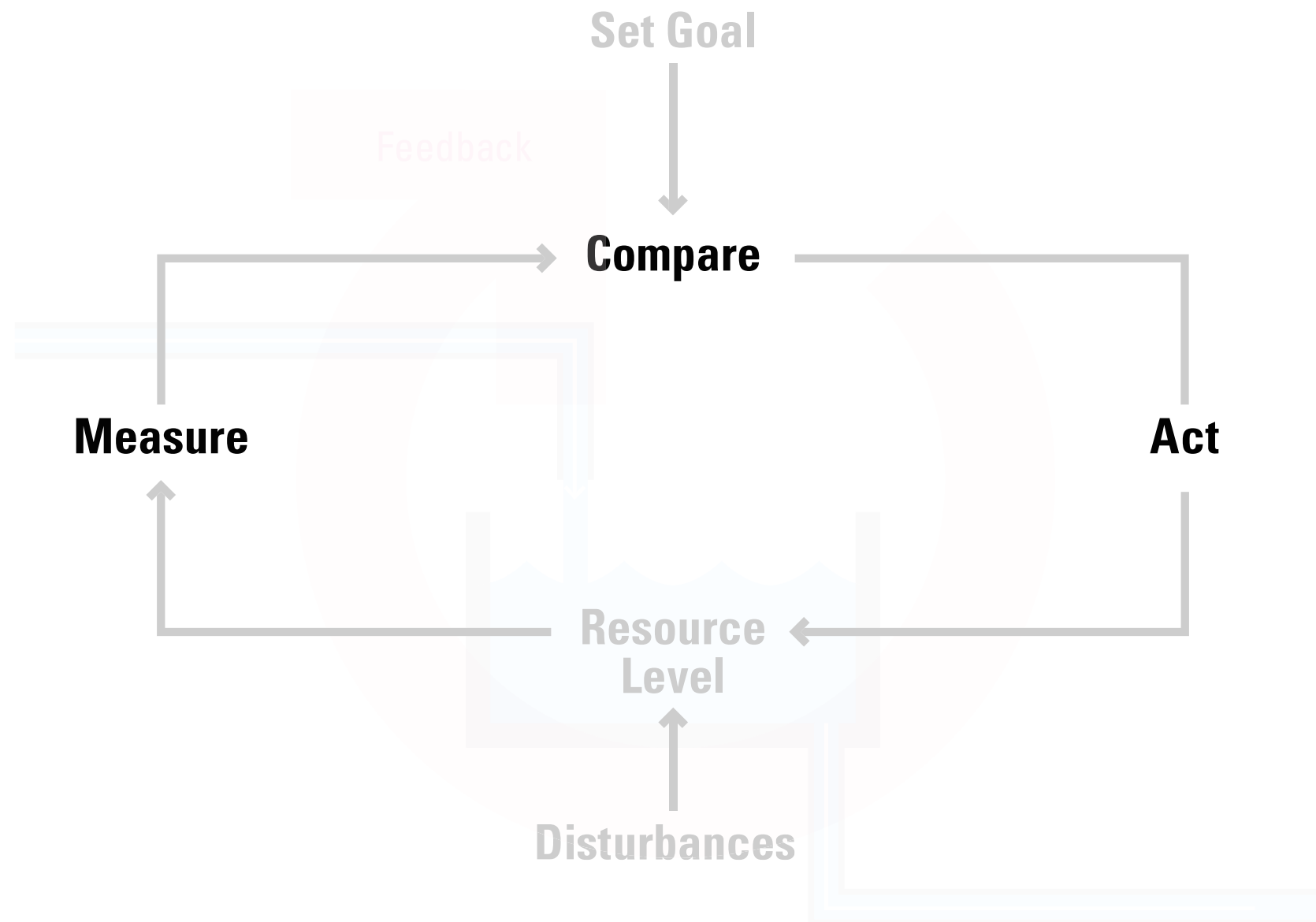Sufficient historical data enable analysts
to discover patterns and relationships—
these are codified in models.

3. Predict futures
Once trained, new measurements
are fed through the model
to predict the future—
enabling us to act today.

Measuring results of actions can improve models, in a learning cycle.
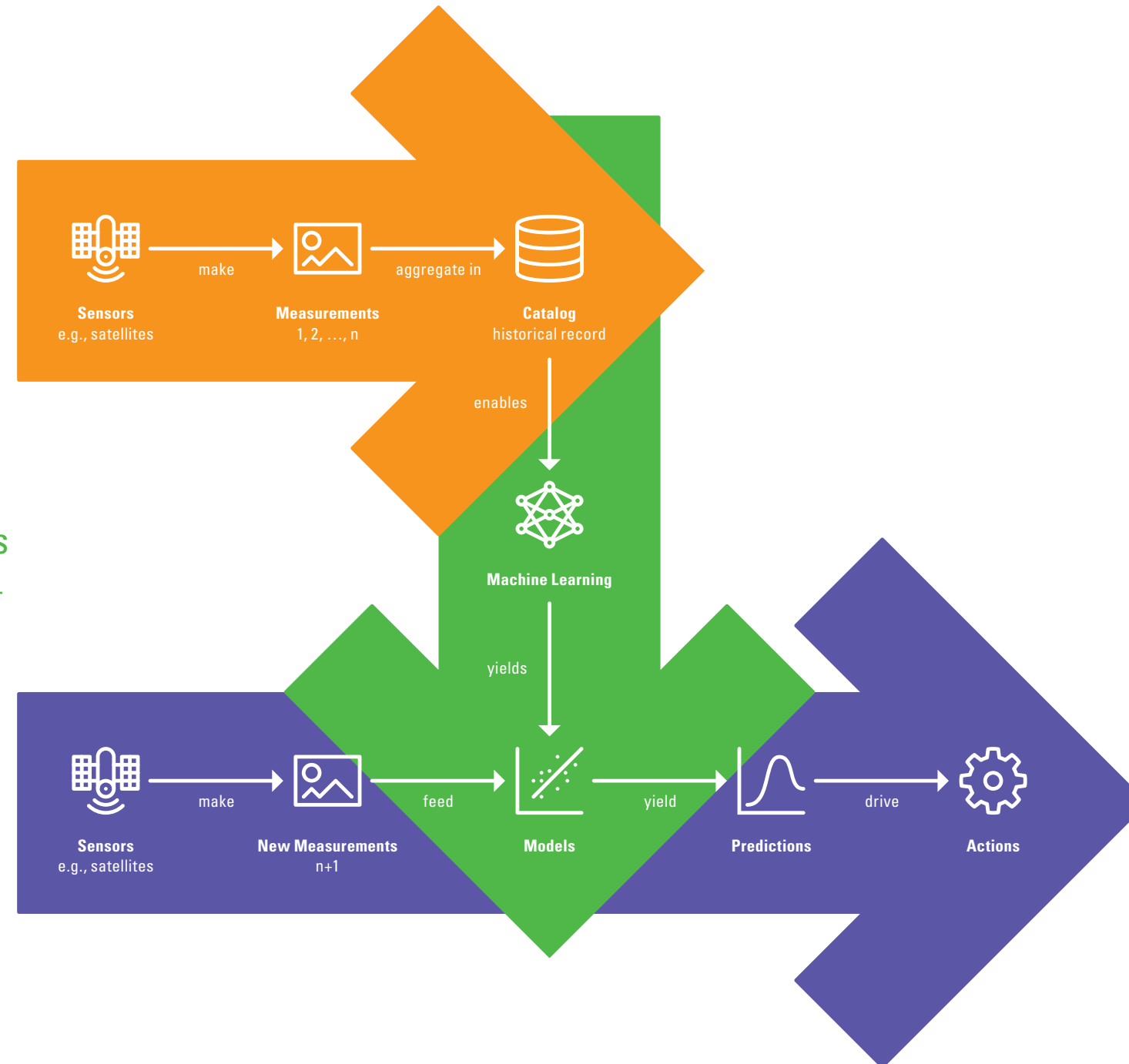
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4. Improve performance
Additional measurements,
including observation of results,
enable iteration—and "learning."

Sensors
e.g., satellites

make → Measurements
1, 2, ..., n

aggregate in → Catalog
historical record

measured and stored in

enables

Machine Learning

yields

Sensors
e.g., satellites

make → New Measurements
n+1

feed → Models

yield → Predictions

drive → Actions

drive → Results
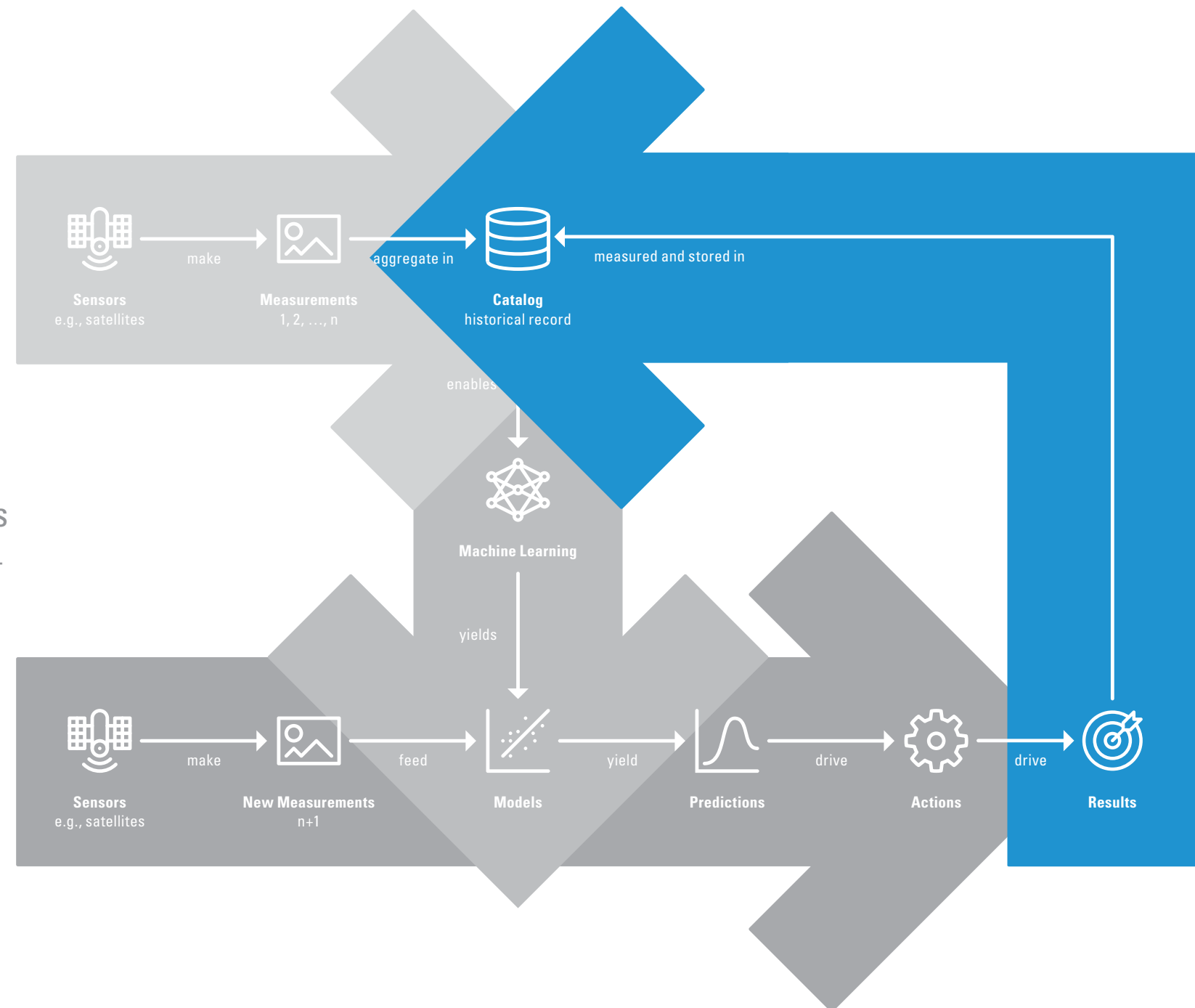
At the same time,
design is shifting, too —
what we design,
how we design,
and who designs.

From making
Simple physical artifacts
— objects

To maintaining
Complex adaptive systems
— ecologies

Product Design

Human Factors

Interaction Design

Service Design

Focus Groups

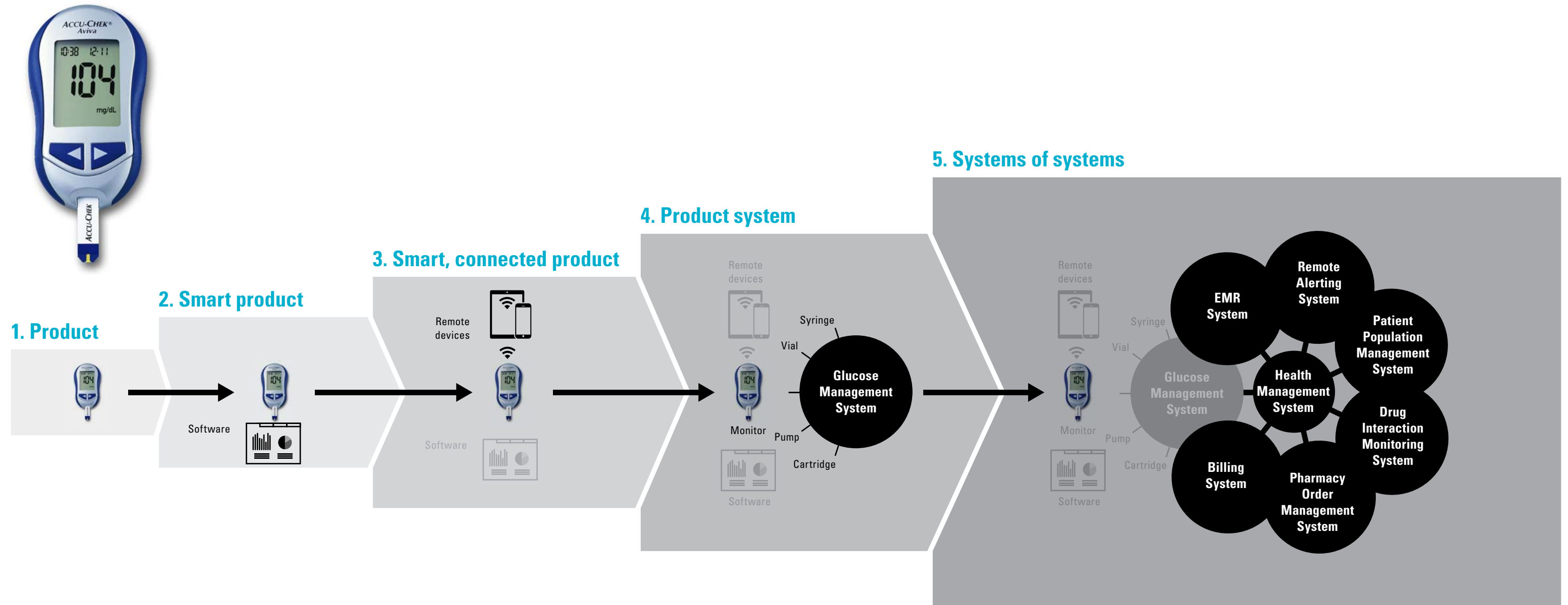Usability Studies

Data-driven Design

Model-driven Design

Harvard Business School Professor Michael Porter has written about "how smart, connected products are ... redefining industry boundaries."

1. Product

2. Smart product

3. Smart, connected product

4. Product system

5. Systems of systems
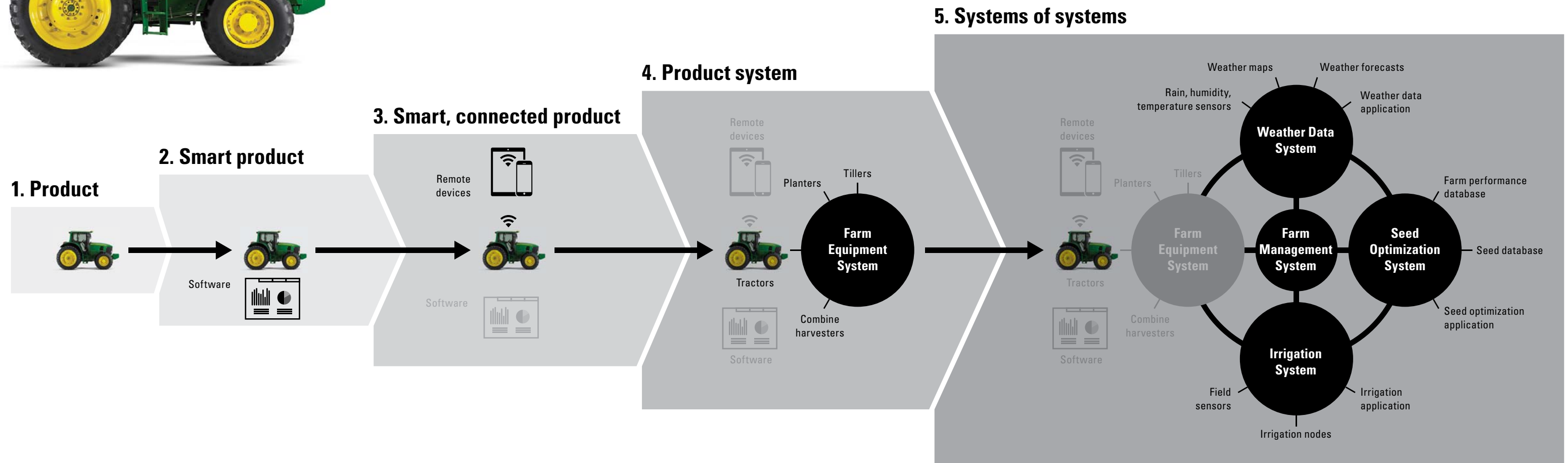
Porter's model applies across industries,
as organizations 'go digital'.

1. Product

2. Smart product

Software

3. Smart, connected product

Remote devices

Software

4. Product system

Remote devices

Syringe
Vial
Monitor
Pump
Cartridge

Glucose Management System

Software

5. Systems of systems

Remote devices

Syringe
Vial
Monitor
Pump
Cartridge

Glucose Management System

Software

EMR System

Remote Alerting System

Patient Population Management System

Health Management System

Drug Interaction Monitoring System

Billing System

Pharmacy Order Management System

Designing for systems means creating situations in which others can design — that is, 'meta-design.'

creates conditions in which

creates conditions in which

Meta-Designer

Designer

acts on

User

teaches

teaches

teaches

Product
(physical or virtual artifact)
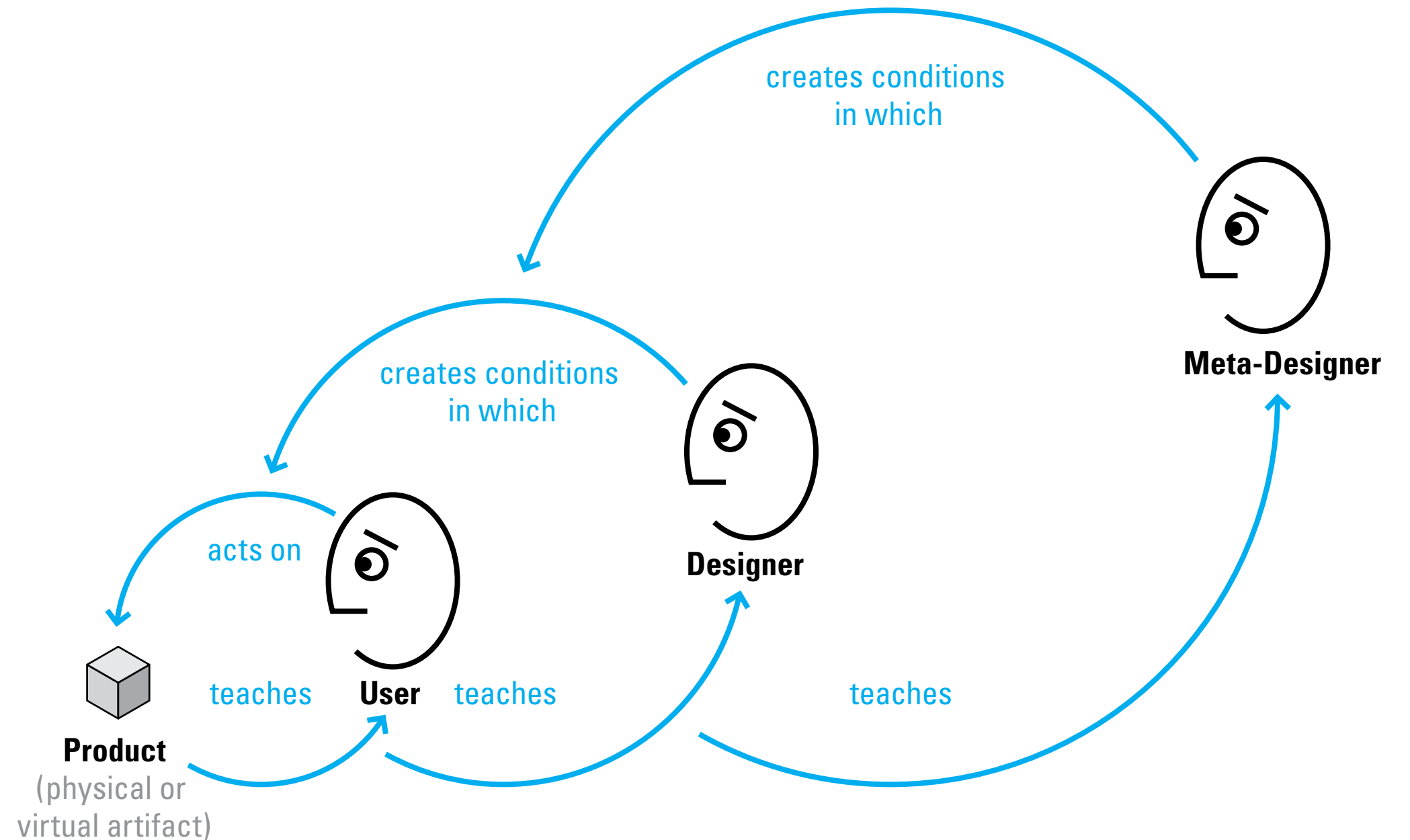
Meta-design means moving

from the **particular**   to the **system.**

Traditional design practice working within existing rules

- at the component level
- at the ensemble level
- at the product level
- at the network of products level

Emerging meta-design practice creating new rules

- for new types of components
- for new types of ensembles
- for new types of products
- for new types of industries

Our futures are not ordained; in this shift, **we have to choose.**

"We human beings can do whatever we imagine if we respect
the structural coherences of the domain
in which we operate.

But we do not have to do all that we imagine, we can choose, and it is there where our behavior as socially conscious human beings matters."

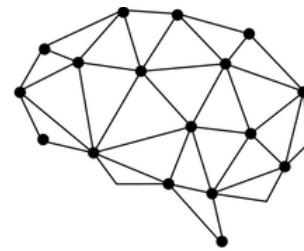— Humberto Maturana, 'Meta-design', 1997

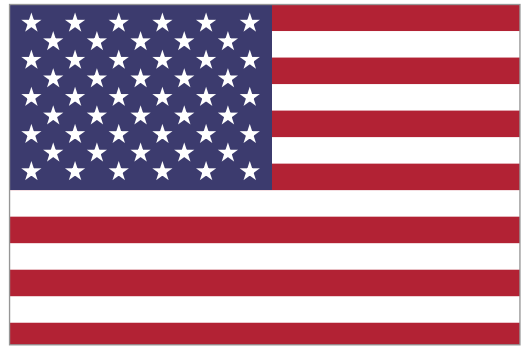# However, the first semi-autonomous organizations are already here.

Internet Research Agency

What are our goals? and thus what will we conserve? for whom?
(Choices need not be exclusive.)

Prosperity	Stability	Happiness	Health
Surveillance Capitalism	Confucian Big Brother	Digital Socialism	Quantified Self
Facebook + FICO	Social Credit Score	A modern CyberSyn	Ubiquitous testing + feedback
Sales machine	Control machine	Planning machine	Experiment machine

Cf. Suzanna Zuboff (2018); Evgeny Morozov (2014) + Eden Medina (2011).
https://www.newyorker.com/magazine/2014/10/13/planning-machine

A few words of caution:
ethics, responsibility, trust—
unintended consequences—
First, do no harm.

In 2017, exercise tracking service Strava caused a sensation, when **user data identified the perimeters of 'secret' military bases.**

Users place their trust in services;
thus providers shoulder responsibility
for respecting privacy + stewarding data.

The image is a heatmap of activity
around Bagram Air Base in Afghanistan.
Made from GPS data from activity trackers.

Smartphones also generate similar information,
including histories of locations,
which may not be entirely anonymized.

Source: https://ichef.bbci.co.uk/news/976/cpsprodpb/112EA/production/_99787307_bagram_airbase.jpg

In the latest Atlantic, AI expert Kai-Fu Lee argues that **"The Third Revolution in Warfare" has begun** — AI + drones.
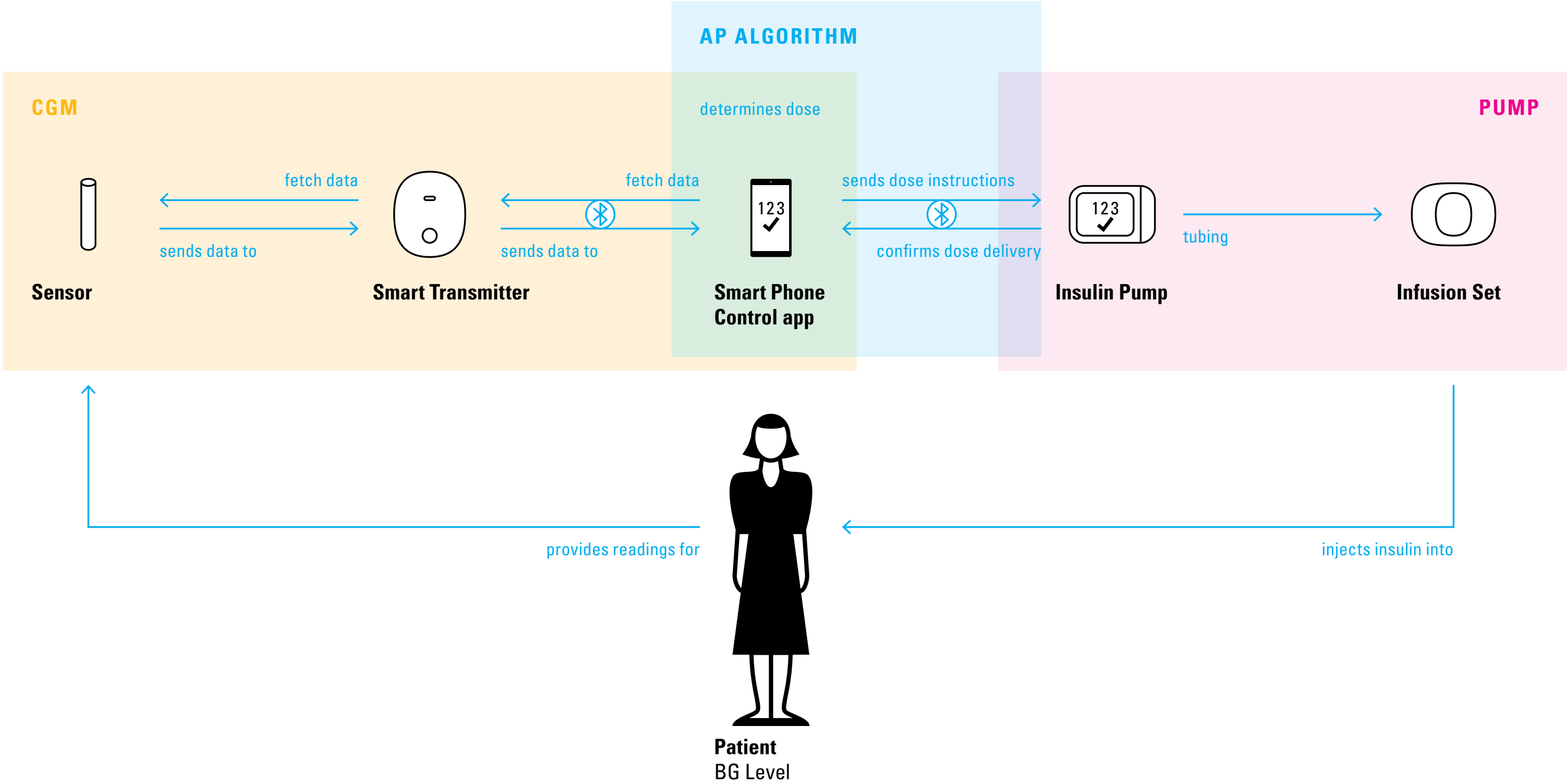
The US sanctions robot-assisted assassinations outside of war zones;
on Nov. 27, 2020, Israel's Mossad killed Mohsen Fakhrizadeh inside Iran.

Source: https://www.nytimes.com/2021/09/18/world/middleeast/iran-nuclear-fakhrizadeh-assassination-israel.html

At the same time, automatic feedback systems offer the potential for radical improvements in healthcare for individuals.

AP ALGORITHM

CGM

PUMP

determines dose

fetch data

sends data to

fetch data

sends data to

sends dose instructions

confirms dose delivery

tubing

Sensor

Smart Transmitter

Smart Phone Control app

Insulin Pump

Infusion Set

provides readings for

injects insulin into

Patient
BG Level

Aggregating data will enable system-wide improvements for entire patient populations.

Devices

Cloud

Patient

Web + mobile

My Record

Patient view
- My Record
- Messages
- Appointments
- Billing
- Support

Integrated databases

Patient ID#

HCPs
Individual view

Patient ID#

Bio-med engineers
Individual view

Patient ID#

Researchers
Individual view

All Patient Data

Company views

Designers
Aggregate view
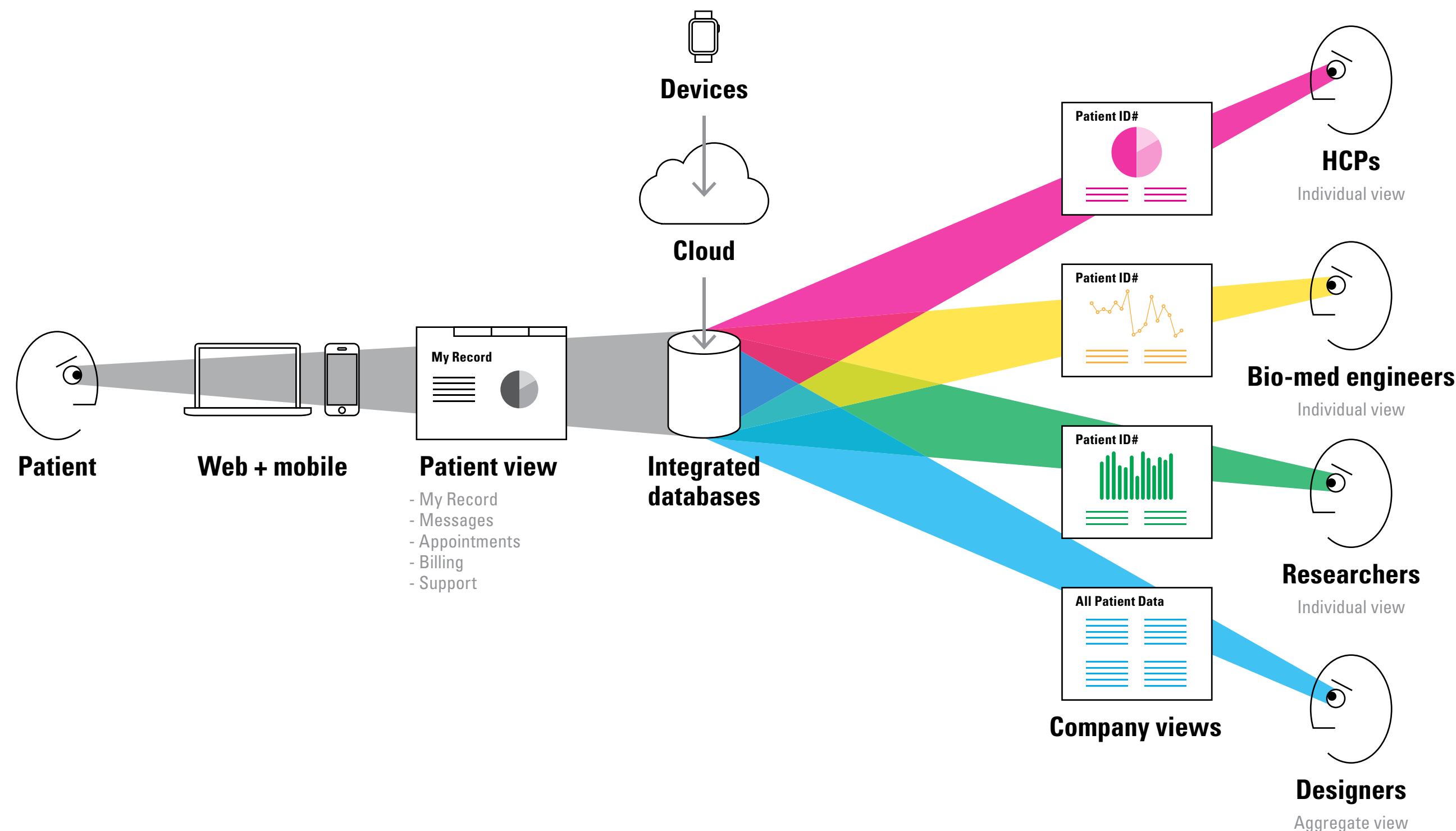
Special thanks to
Rick Griffith
Kathleen Budny
Susan Augenbraun
Lee-Sean Huang
Meredith Davis
Shelley Evenson
Gavin Miller
Ryan Reposar
Jamie Ikeda

hugh@dubberly.com

Presentation posted at
www.dubberly.com/presentations/design+systems.pdf