HFES 2016, Human Factors and Ergonomics in Healthcare: Shaping the Future
San Diego April 15, 2016

From Devices to Platforms

Implications of the Internet of Things for Healthcare

Hugh Dubberly, Dubberly Design Office
Stephen B. Wilcox, Design Science

"...software is eating the world.

...we are in the middle of a dramatic and broad technological and economic shift in which software companies are poised to take over large swathes of the economy...

Health care and education, in my view, are next up for fundamental software-based transformation."

— Marc Andreessen, founder, Netscape and Andreessen-Horowitz

Wall Street Journal OpEd
www.wsj.com/articles/SB10001424053111903480904576512250915629460

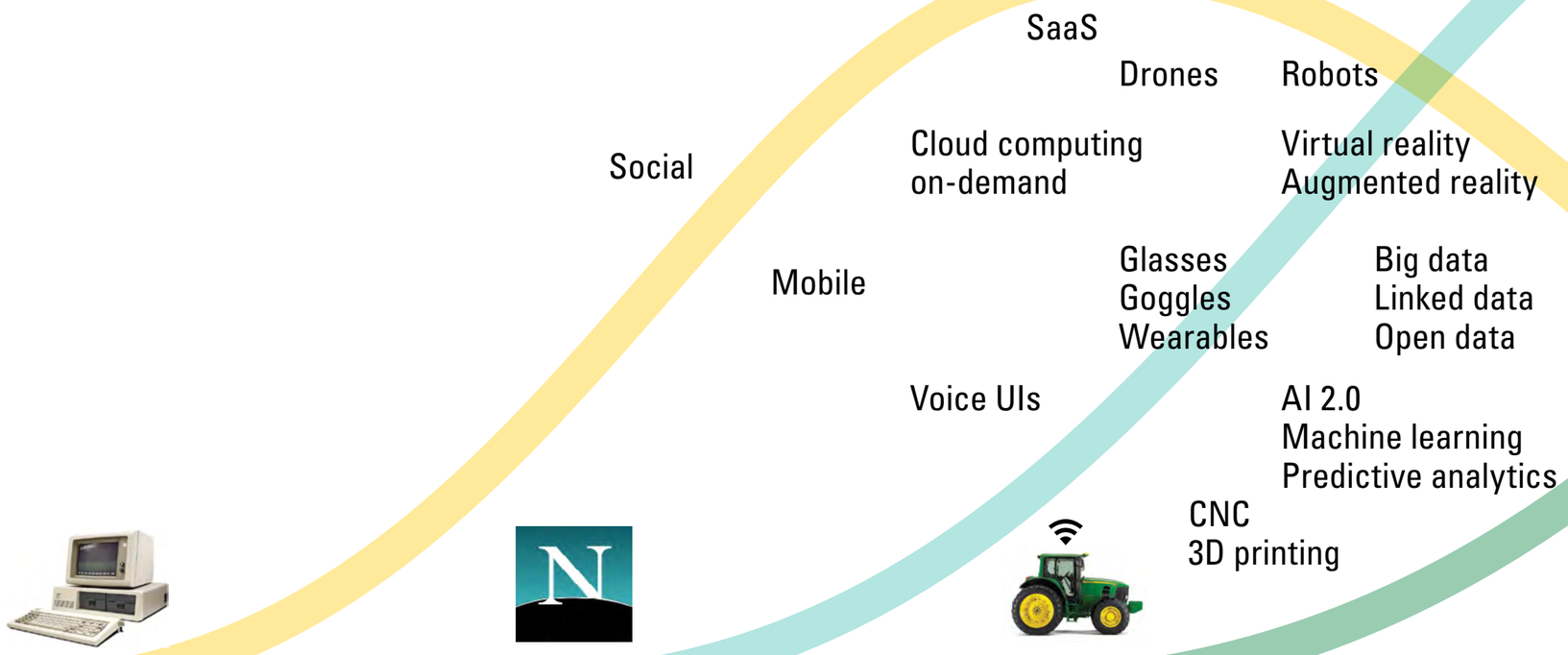
"If you went to bed last night thinking you're an industrial company, you're going to wake up this morning as a software and analytics company."

— Jeff Immelt, Chairman and CEO, General Electric

Minds + Machines 2014
www.ge.com/stories/industrial-internet

Technological change comes in waves, which interact to create "combinatorial innovation." [1]

- Work has *gone digital*.
- People *got connected*.
- Now, *things* are connecting, too.



Personal Computers
1981

The Internet
1995

Internet of Things (IoT)
2016

[1] Hal Varian

2016 is like 1981 and 1995 all over again.
You can see the next wave coming.

It goes by many names:

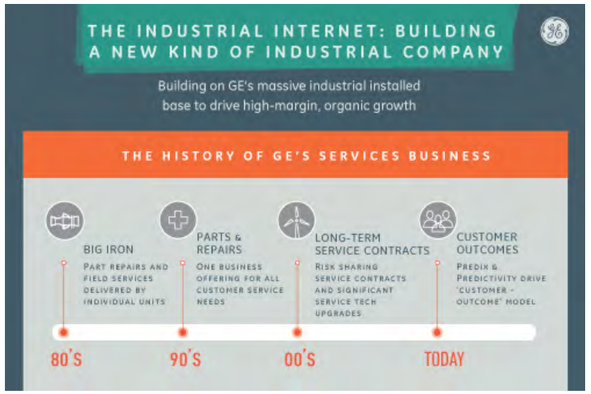
- Internet of Things (IoT)
- Internet of Everything, Cisco
- Industrial Internet, GE
- Smarter Planet, IBM
- Living Services, Accenture
- Platform World, Sapient.Publicis
- Social CRM or Social Business
- Digital Engagement
- Digital Transformation

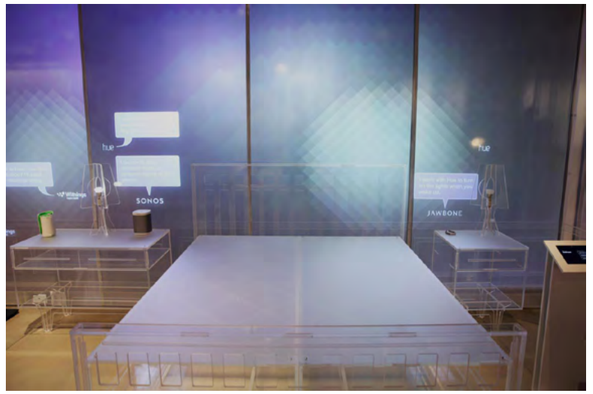
The change has already begun,
for example

Amazon announced **AWS IoT**, also testing pop-up stores in malls featuring IoT devices and Echo.

Sears opens a series of **"Connected Home"** showcase stores.

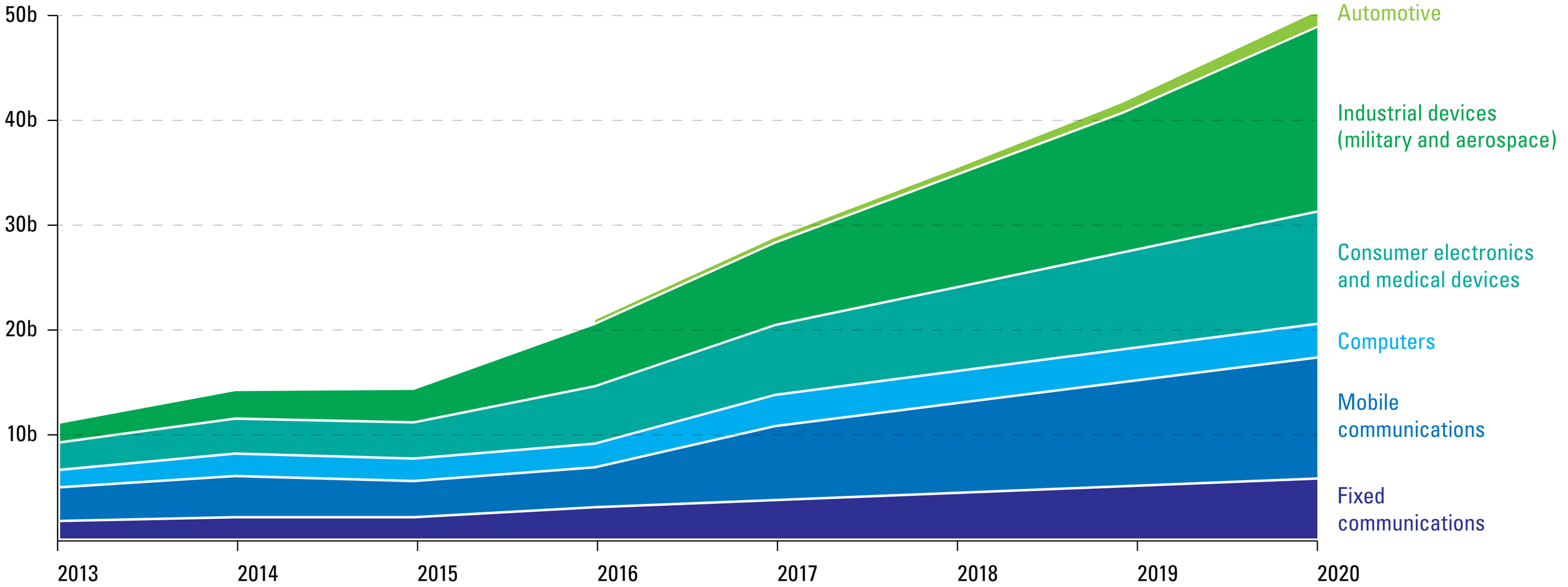
GE hired 2,000 engineers in San Ramon, builds **Predix platform**, GE Digital now has 30,000 employees.





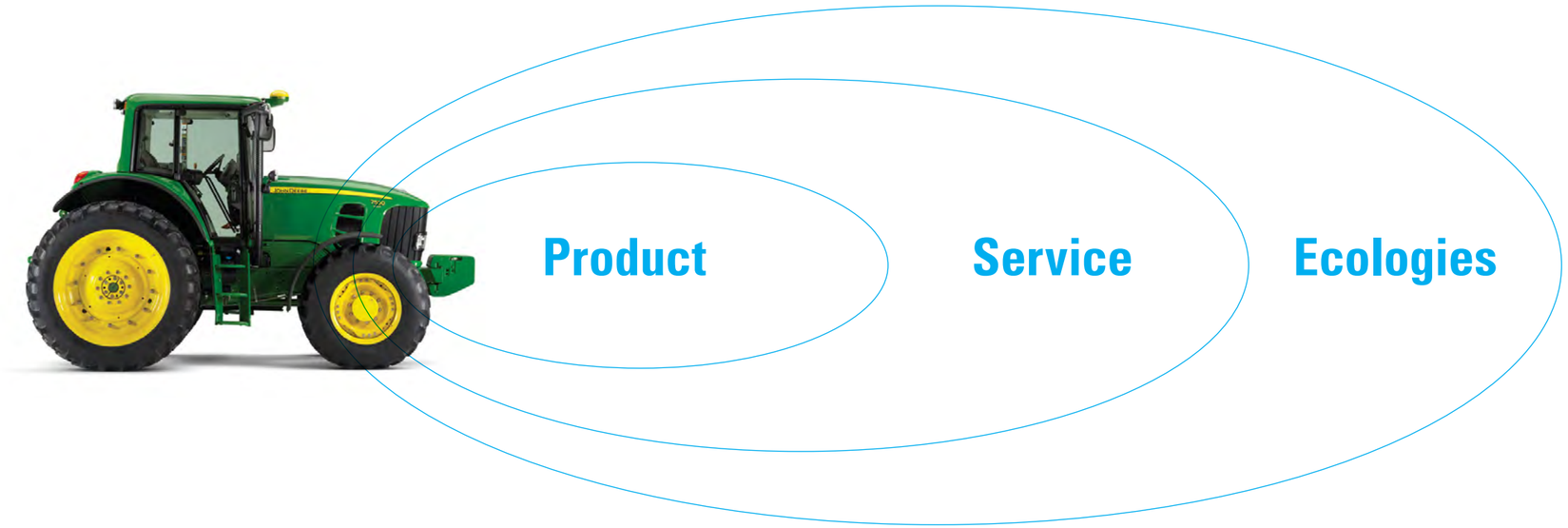
Target launches **"Open House"** IoT showcase store in San Francisco.

By 2020, ~50 billion devices will be connected to the Internet; today, ~7 billion computers and tablets are connected.



Sources: The Economist and Cisco

Products no longer stand alone.
Increasingly, they exist in complex service webs.



The average vehicle includes 60–100 sensors; that figure may grow to 200 by 2020. [1]

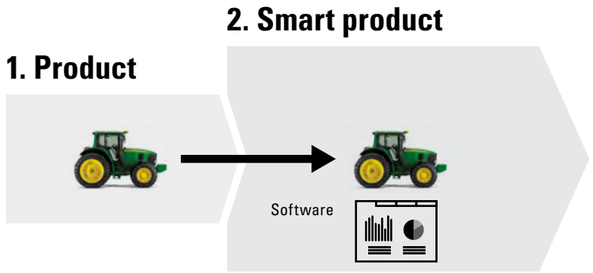
In 2010, basic cars included 30 microprocessors; luxury cars had as many as 100. [2]

[1] Source: Automotive Sensors and Electronics Expo 2015
http://www.automotivesensors2015.com/

[2] Source: The New York Times
http://www.nytimes.com/2010/02/05/technology/05electronics.html

Products are becoming “smart”.

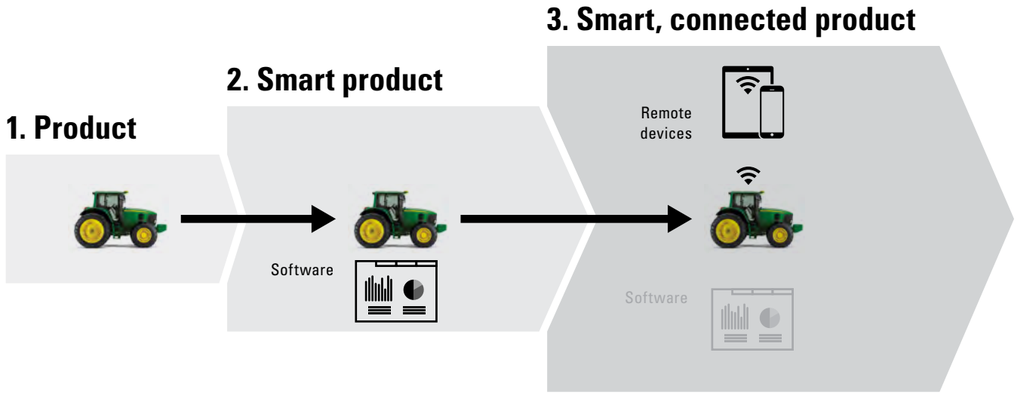
Product
+ Sensor
+ Computer
= Smart Product



—Michael Porter and James Heppelmann, How Smart, Connected Products Are Transforming Competition
Harvard Business Review, November 2014
https://hbr.org/2014/11/how-smart-connected-products-are-transforming-competition

Sets of smart products are connecting.

Smart Product
+ Network
+ Cloud Service
= Smart, Connected Product



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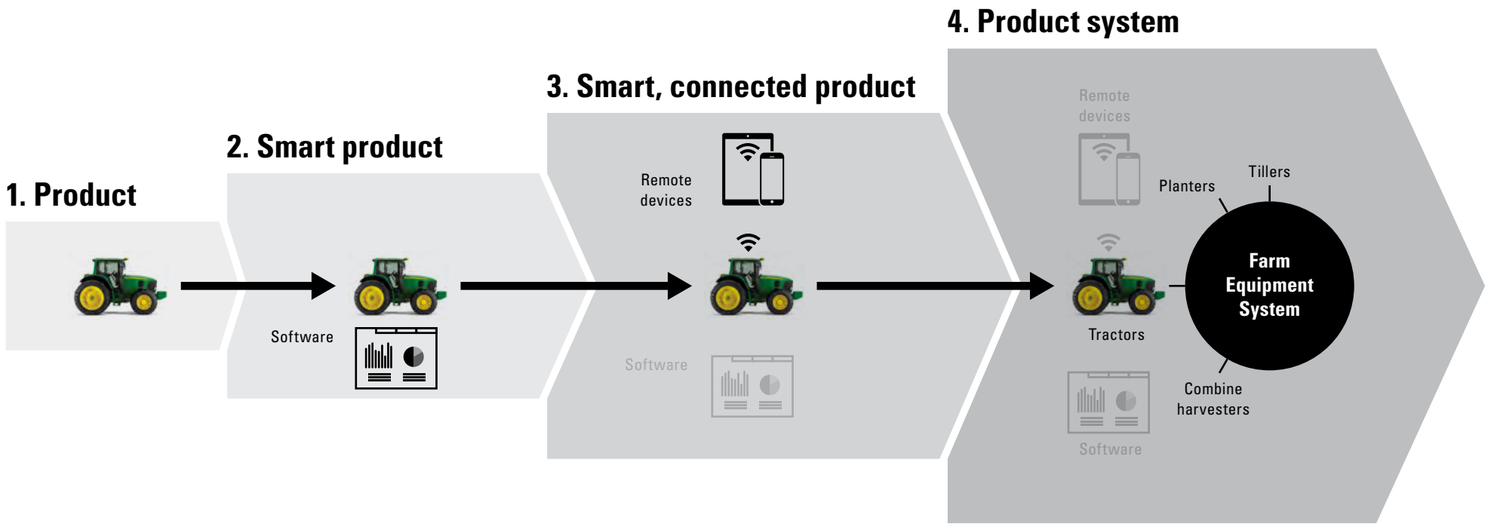
Sets of connected products form product systems.

Smart, Connected Product

\+ other Smart, Connected Products

= Product System



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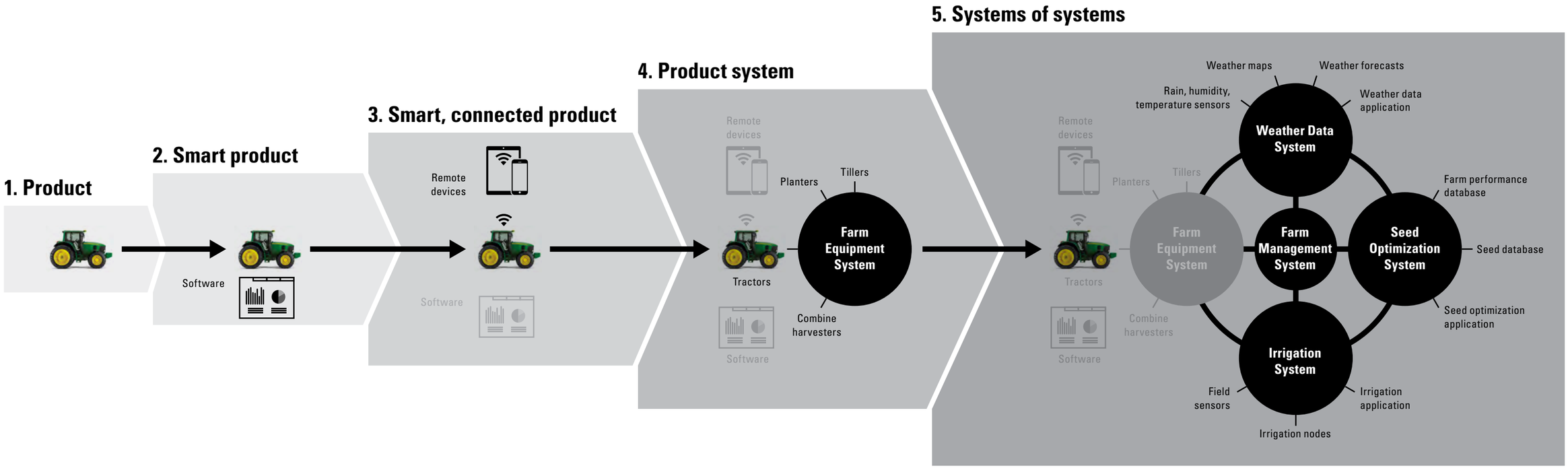
Systems connect to other systems, forming **ecologies.**

Product Systems

\+ other Product Systems

= Product-Services Ecology



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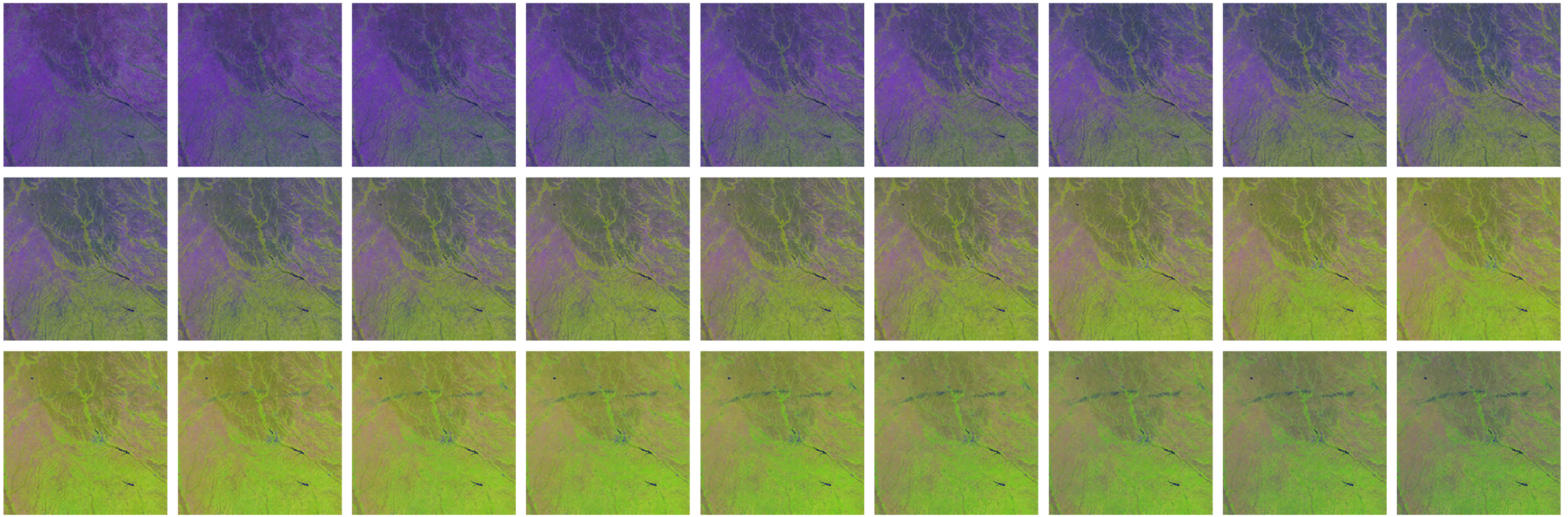
Farms are becoming automated factories.

Plants are attached to sensors, connected to networks, generating data.

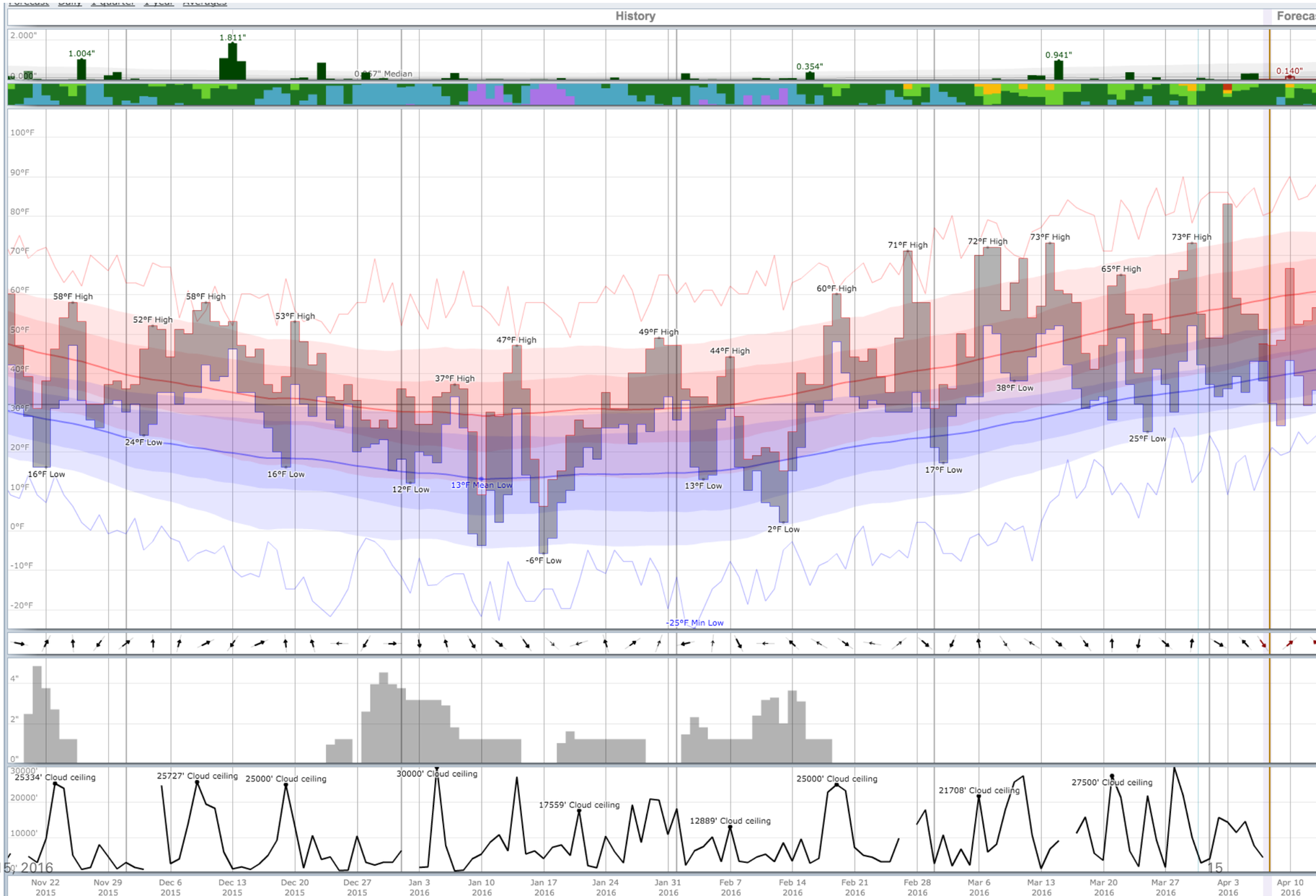
Macro view: processed satellite images of crop growth over time, e.g., central Iowa, March 29 to October 23, in 8 day increments.

Algorithms automatically align images,
remove clouds,
and detect vegetation.

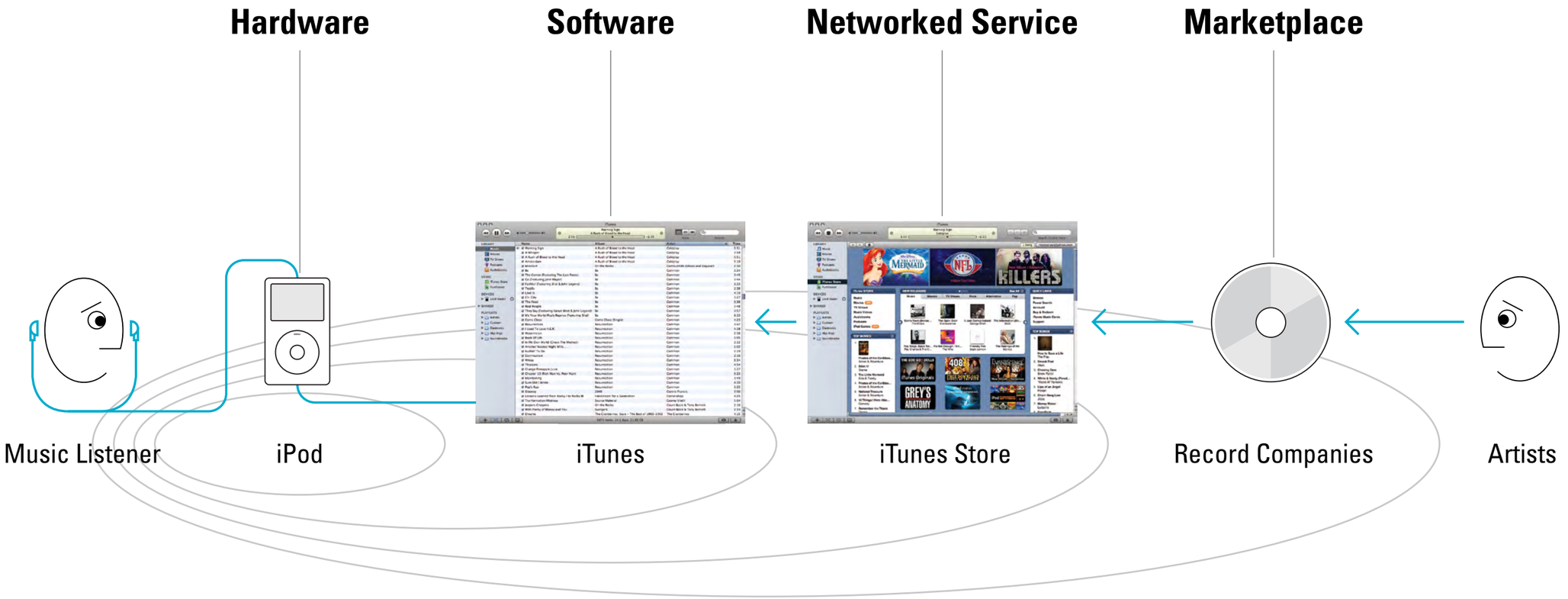


Daily weather data can augment machine learning.

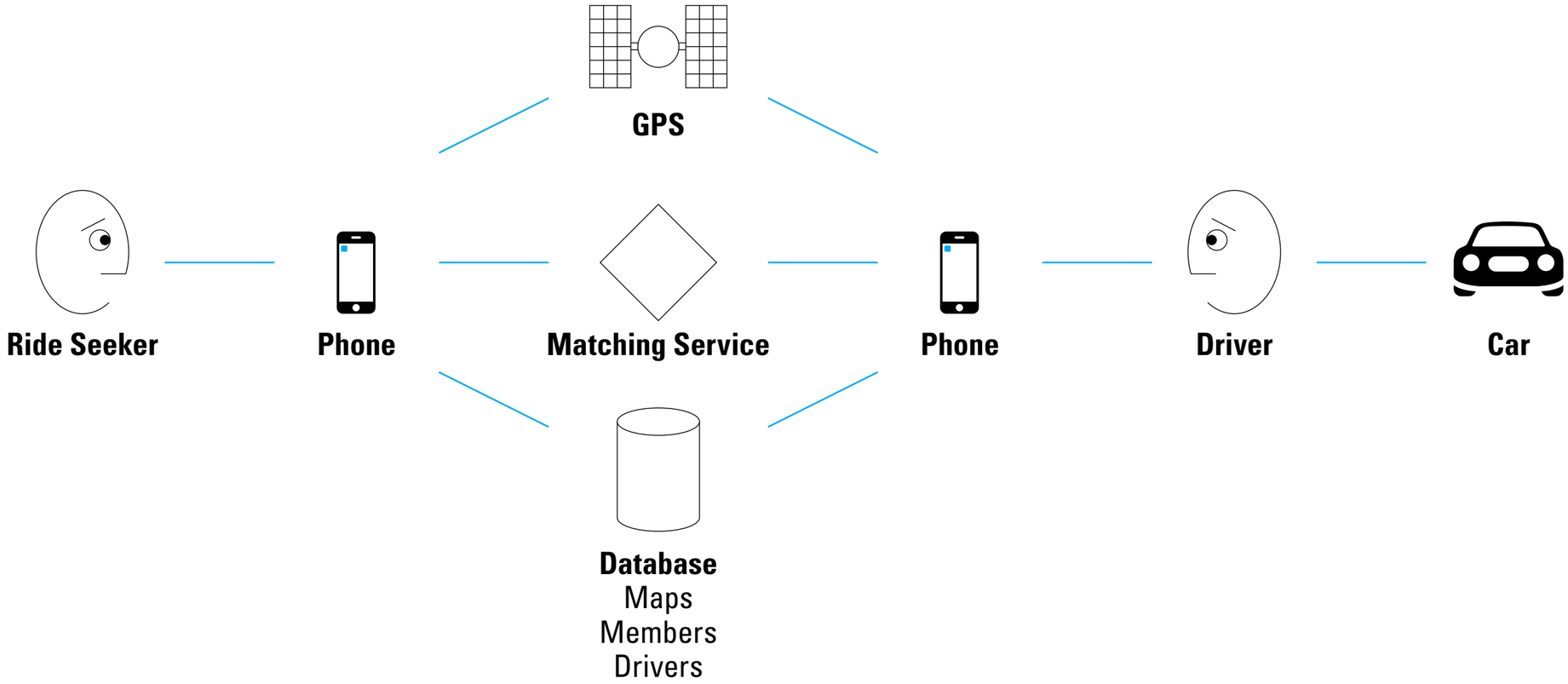
Precipitation,
temperature,
wind direction and speed,
snow cover,
and cloud cover
can aid forecasting.



iPod was the proto-IoT device—an integrated system of hardware, software, and networked services.



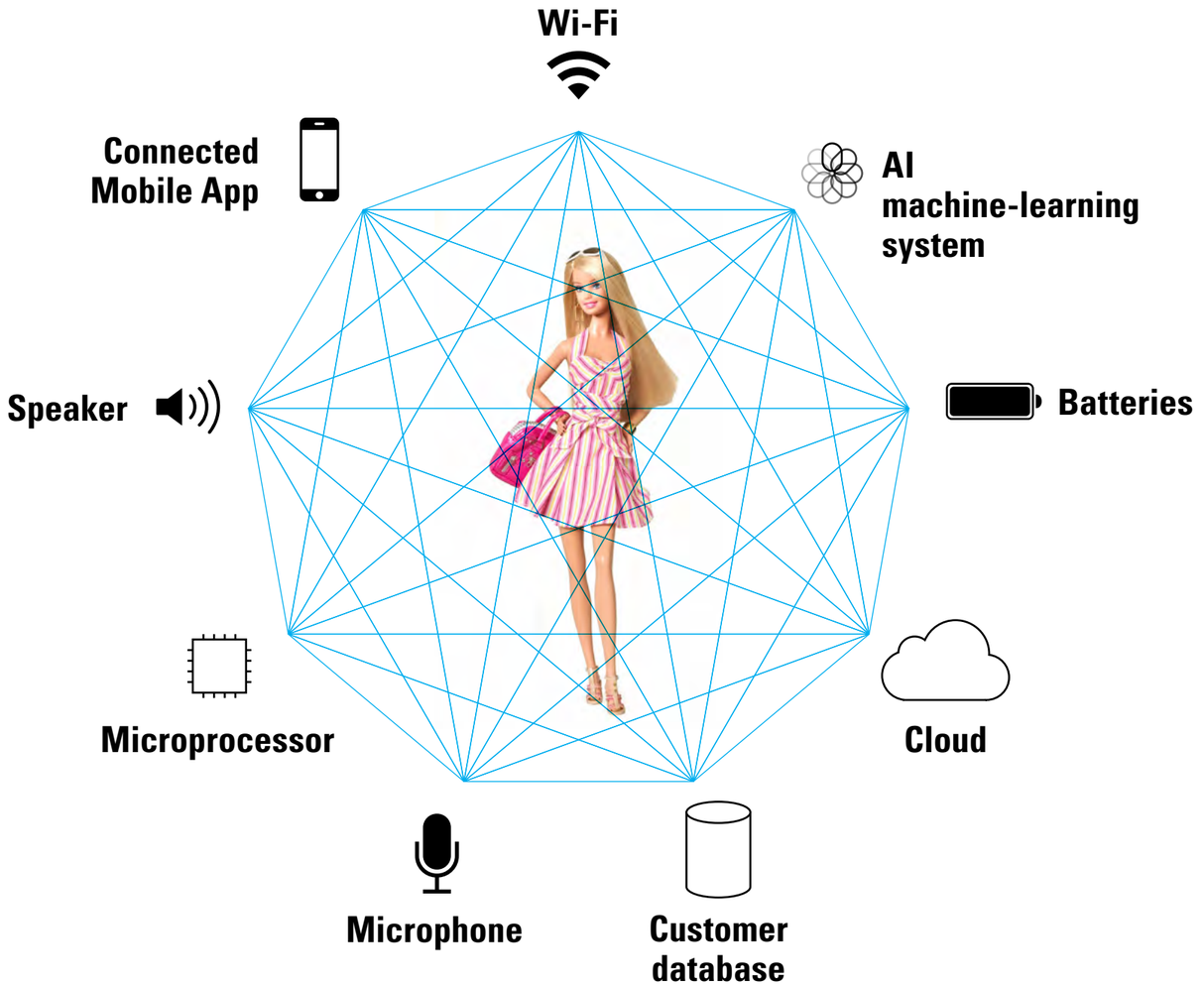
VCs are no longer funding stand-alone apps;
Uber isn't just an app; it's an IoT platform for logistics.



Last fall, Mattel relaunched Barbie, as a smart, connected product.

Barbie + sensor + computer + network + cloud services = Eliza 2016

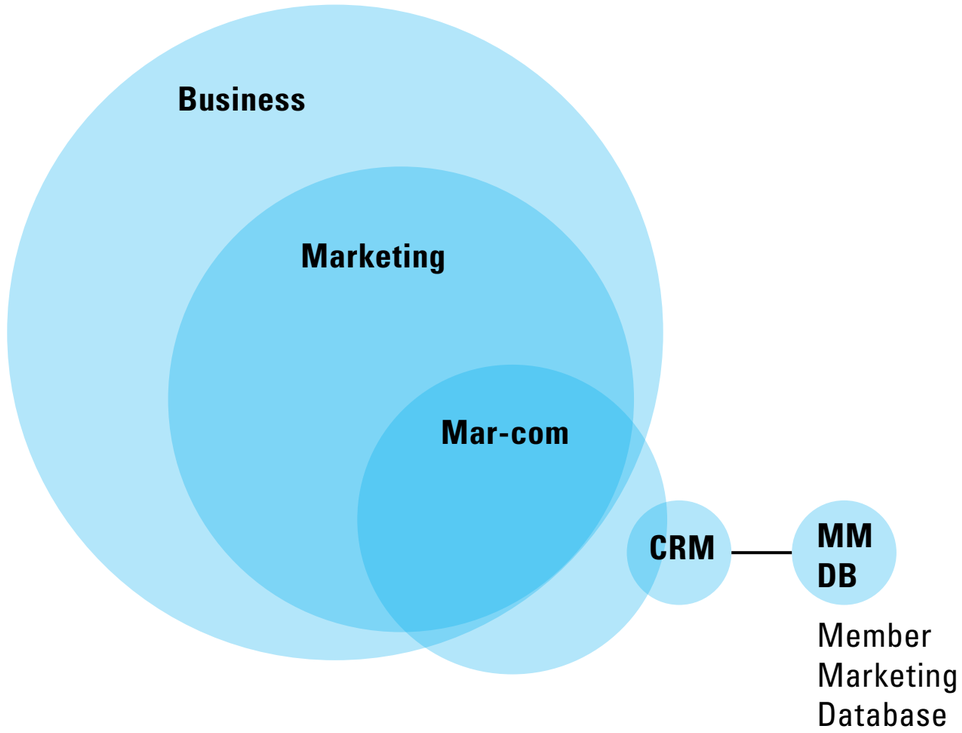
- Recognizes you and what you say
- Learns about you
- Converses with you,
  using 8,000 pre-recorded phrases
- Extends up to 120 exchanges

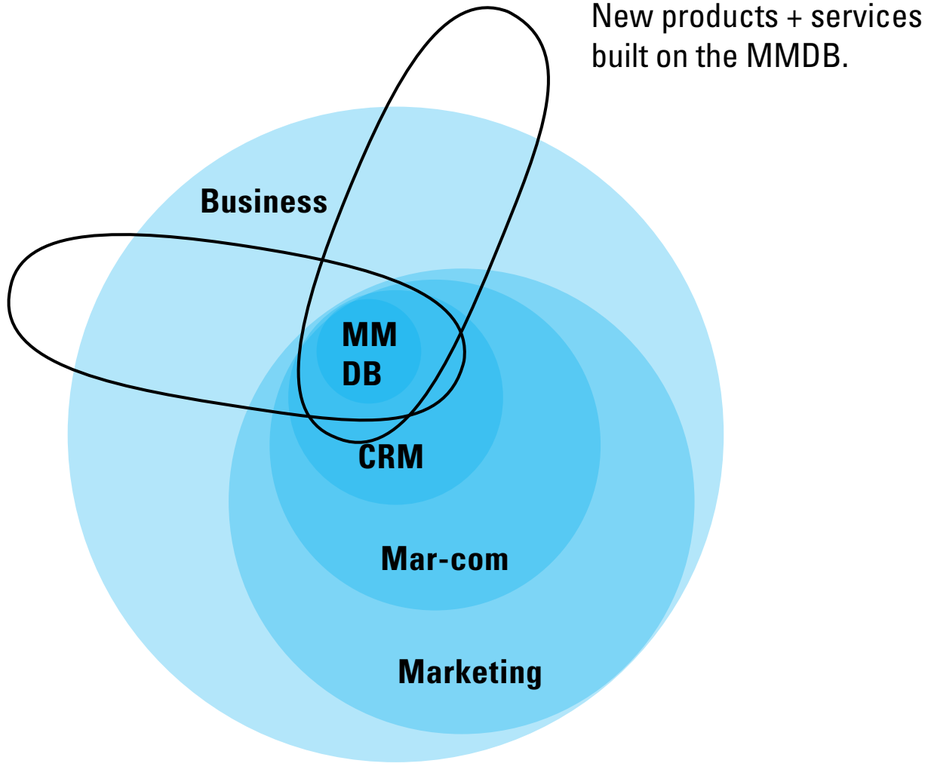


https://en.wikipedia.org/wiki/ELIZA
http://www.nytimes.com/2015/09/20/magazine/barbie-wants-to-get-to-know-your-child.html
http://www.nytimes.com/2015/10/16/business/mattel-aims-to-reanimate-sales-with-interactive-barbie.html

Now imagine Barbie's AI connected to a CRM system.

"Have you told Grandma what you'd like for your birthday?"





What does the IoT mean for healthcare and healthcare usability?

Consumer tracking devices (AKA “wearables”) have become common.

Apple Watch

Basis B1

Fitbit Flex

Garmin Vivofit

Jawbone Up

Microsoft Band

Misfit Shine

Moto 360

Narrative Clip

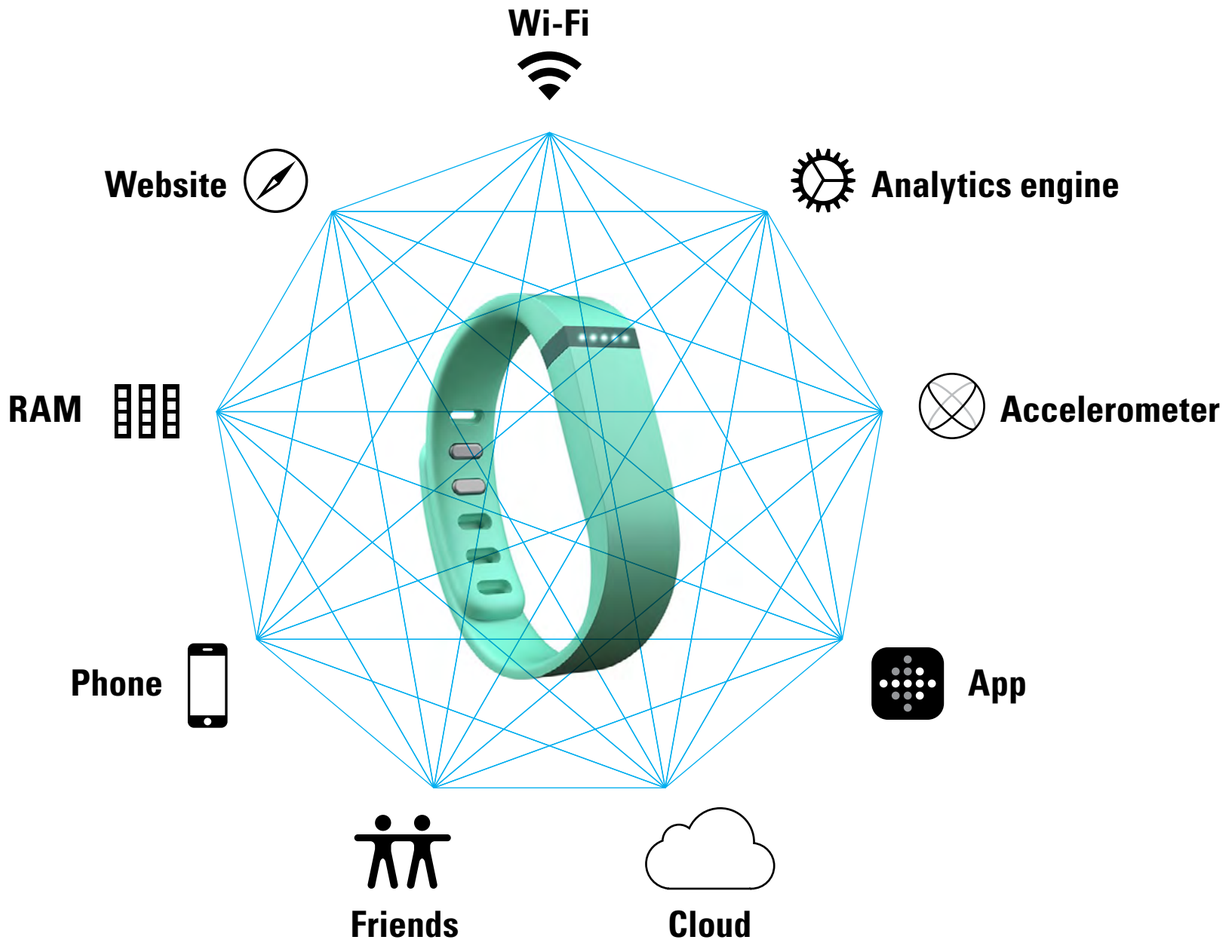
Nike Fuel

Pebble Classic

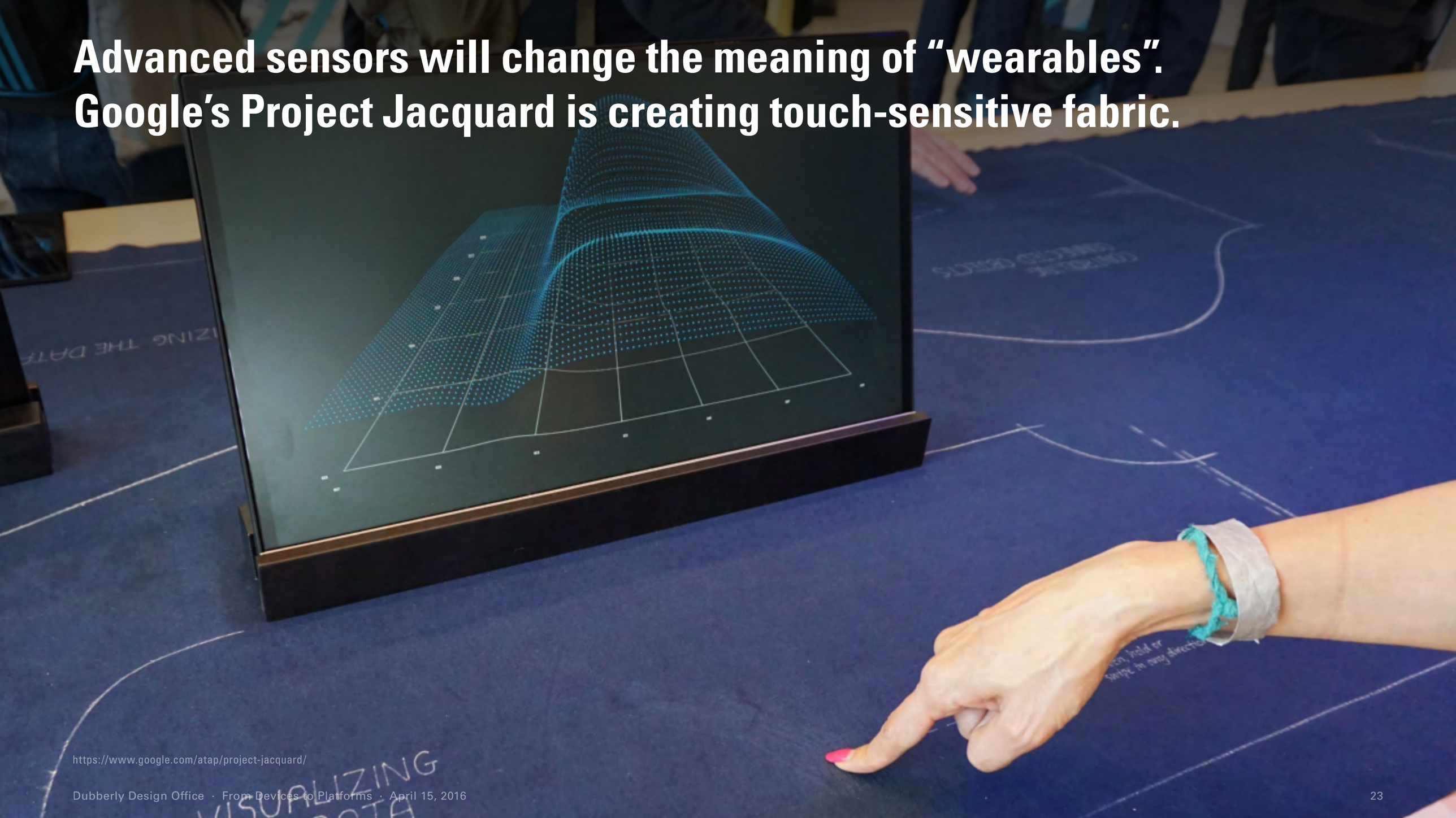
Samsung Gear

Sensors collect data and pass it to web-based apps; users set goals and share data with friends and family.

Feedback loops can promote change and help manage health.



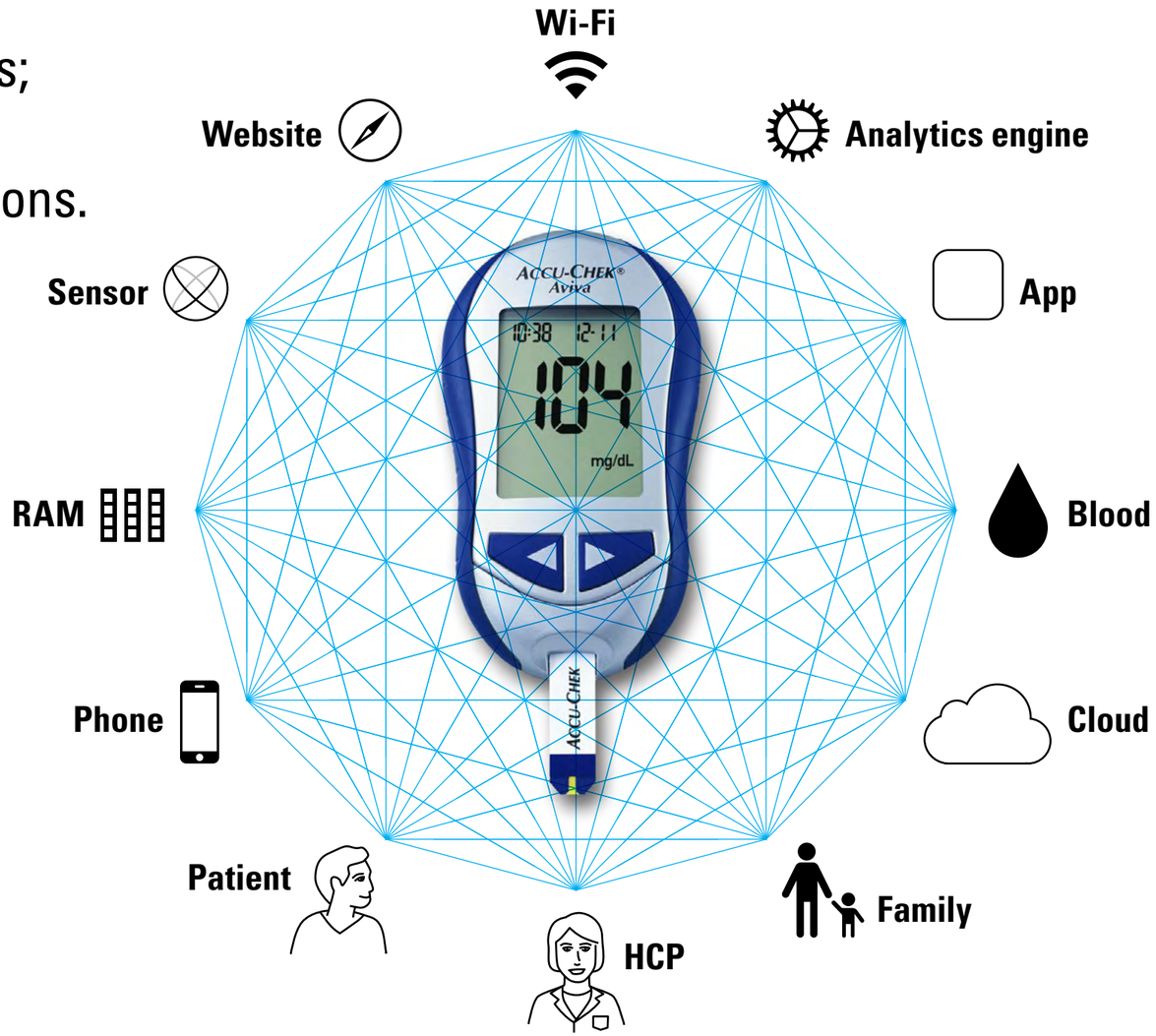
Advanced sensors will change the meaning of “wearables”. Google’s Project Jacquard is creating touch-sensitive fabric.



https://www.google.com/atap/project-jacquard/

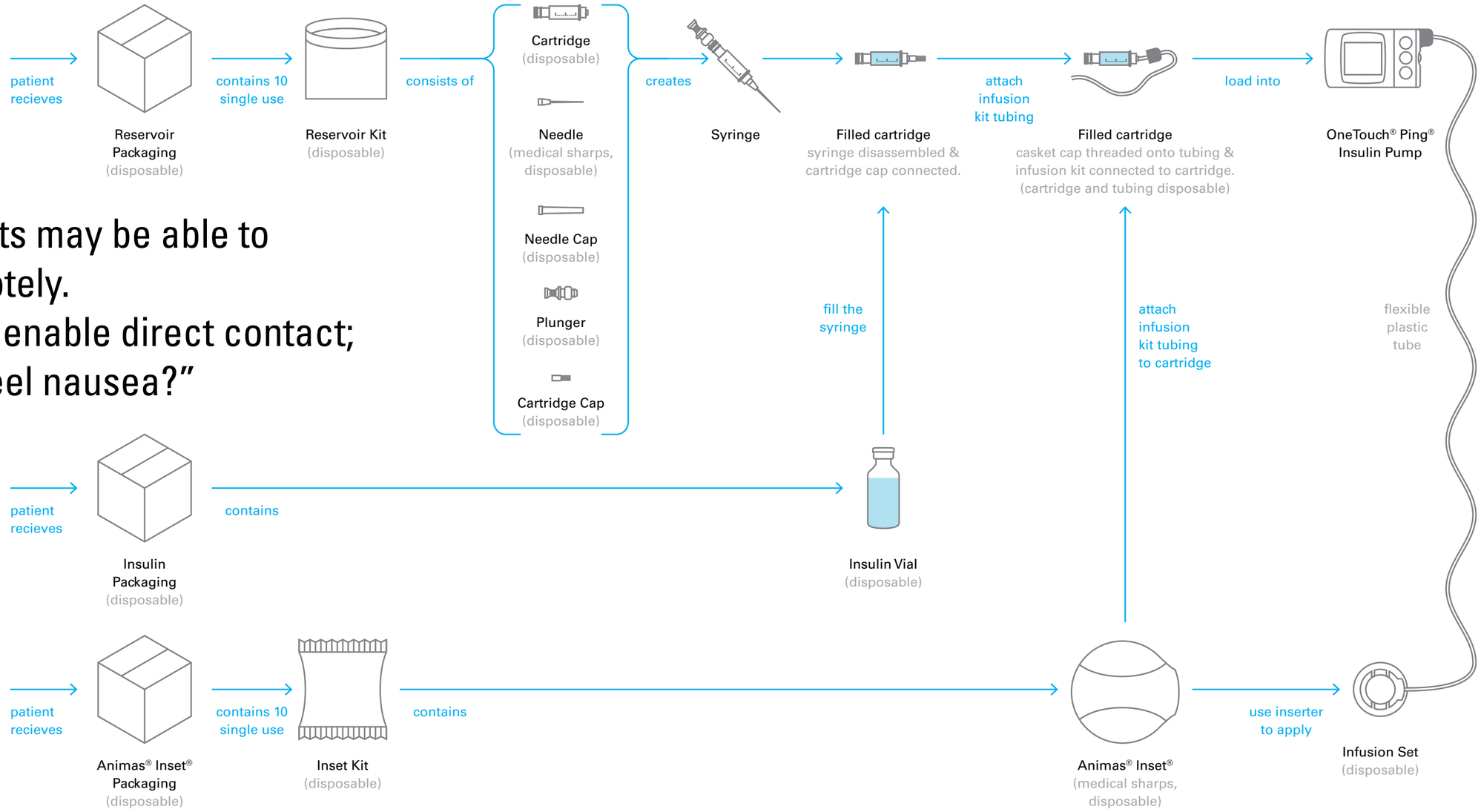
Medical devices are connecting to the cloud, too,
including pacemaker-defibrillators, autoinjectors, and glucometers.

Smart, connected glucometers
can alert family and HCPs about extreme lows;
they also collect data automatically
and help users see trends and make correlations.



And they are connecting to other smart, connected devices.

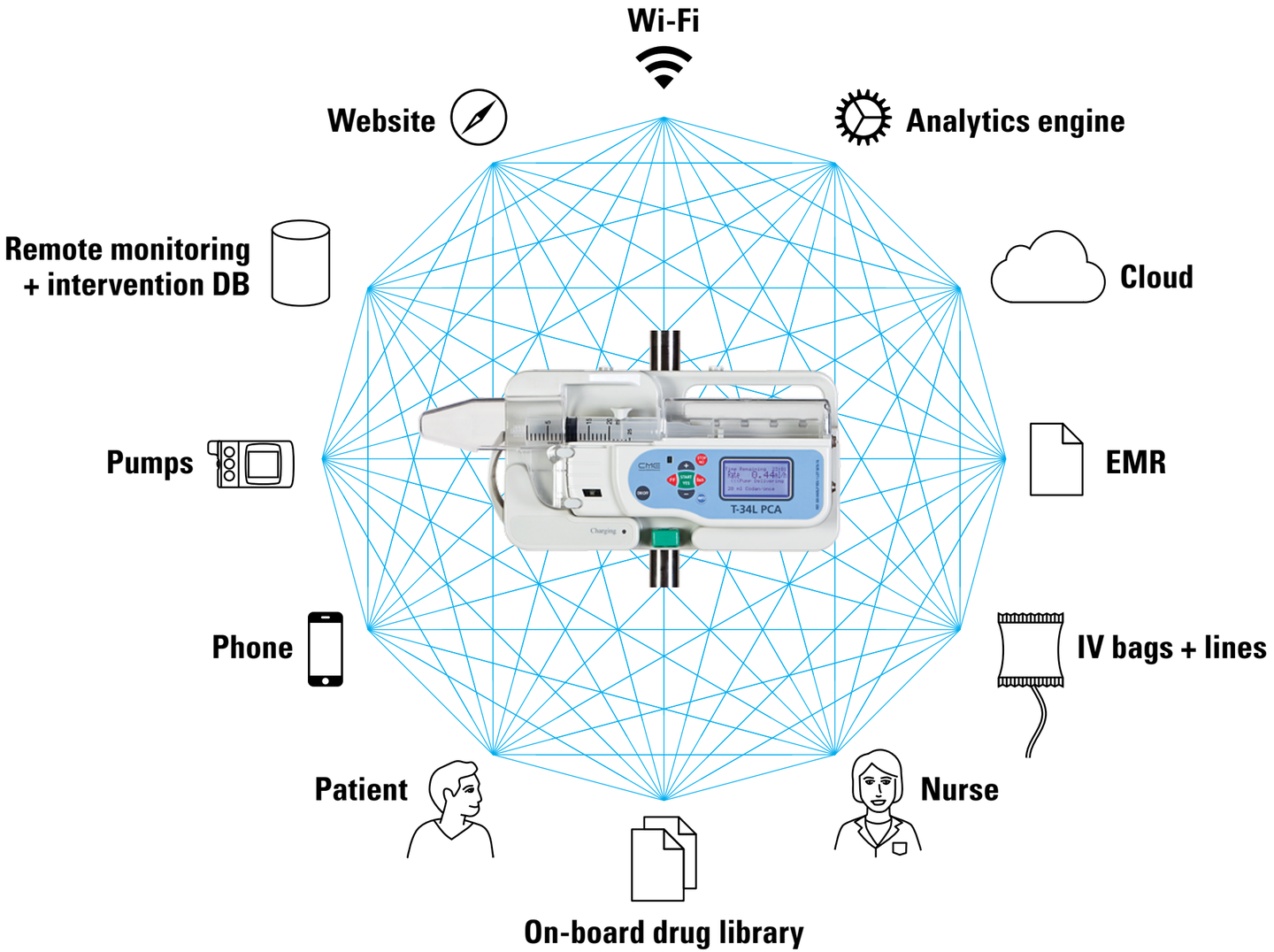
A smart glucometer + a smart insulin pump = artificial pancreas



Endocrinologists may be able to set doses remotely.
Systems could enable direct contact; e.g., “Do you feel nausea?”

Similar changes are beginning in clinical settings, too.

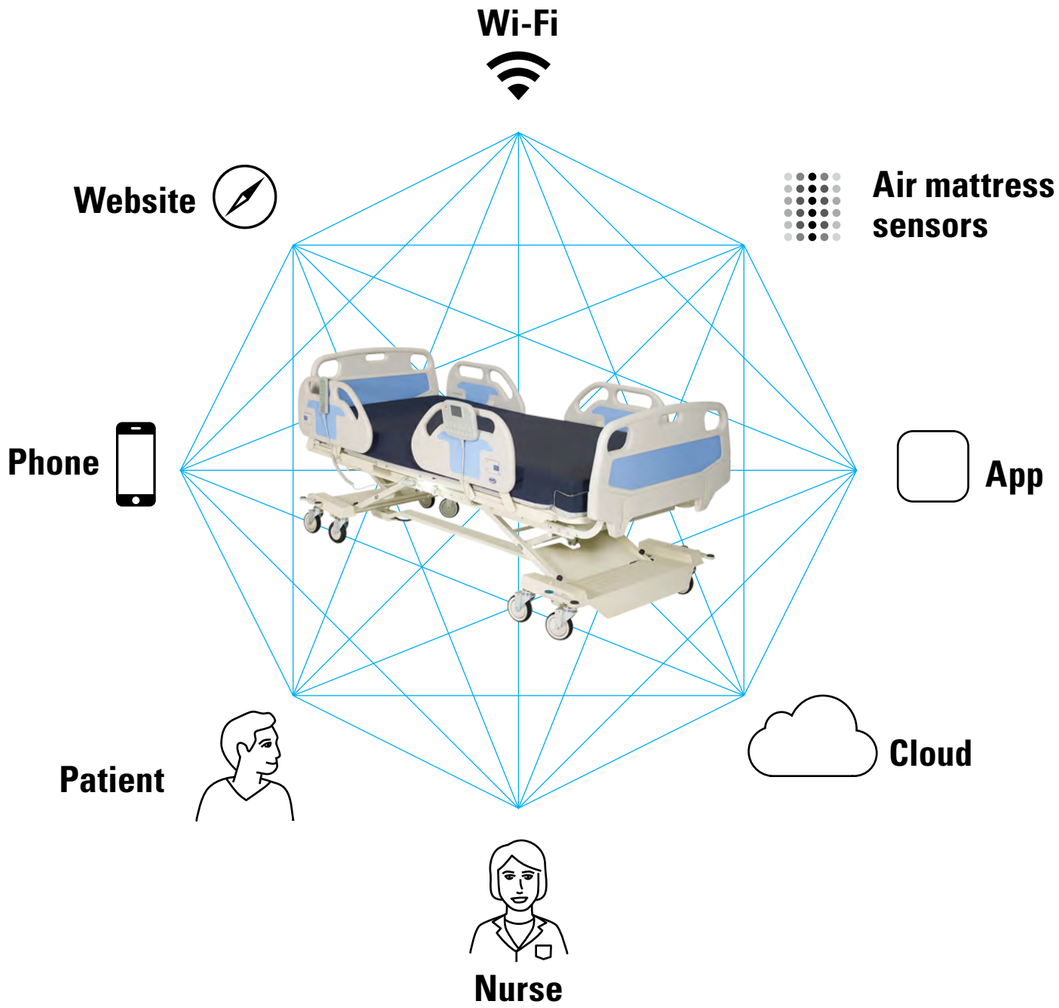
Large volume infusion pumps (LVPs) used to stand-alone.



Even hospital beds will become smart, connected devices and join the medical product-services ecology.

Already, some beds can measure:

- Patient weight
- Heart rate
- Breathing rate
- Intensity and duration of movement
- Bed entrance + exit
- Sleep

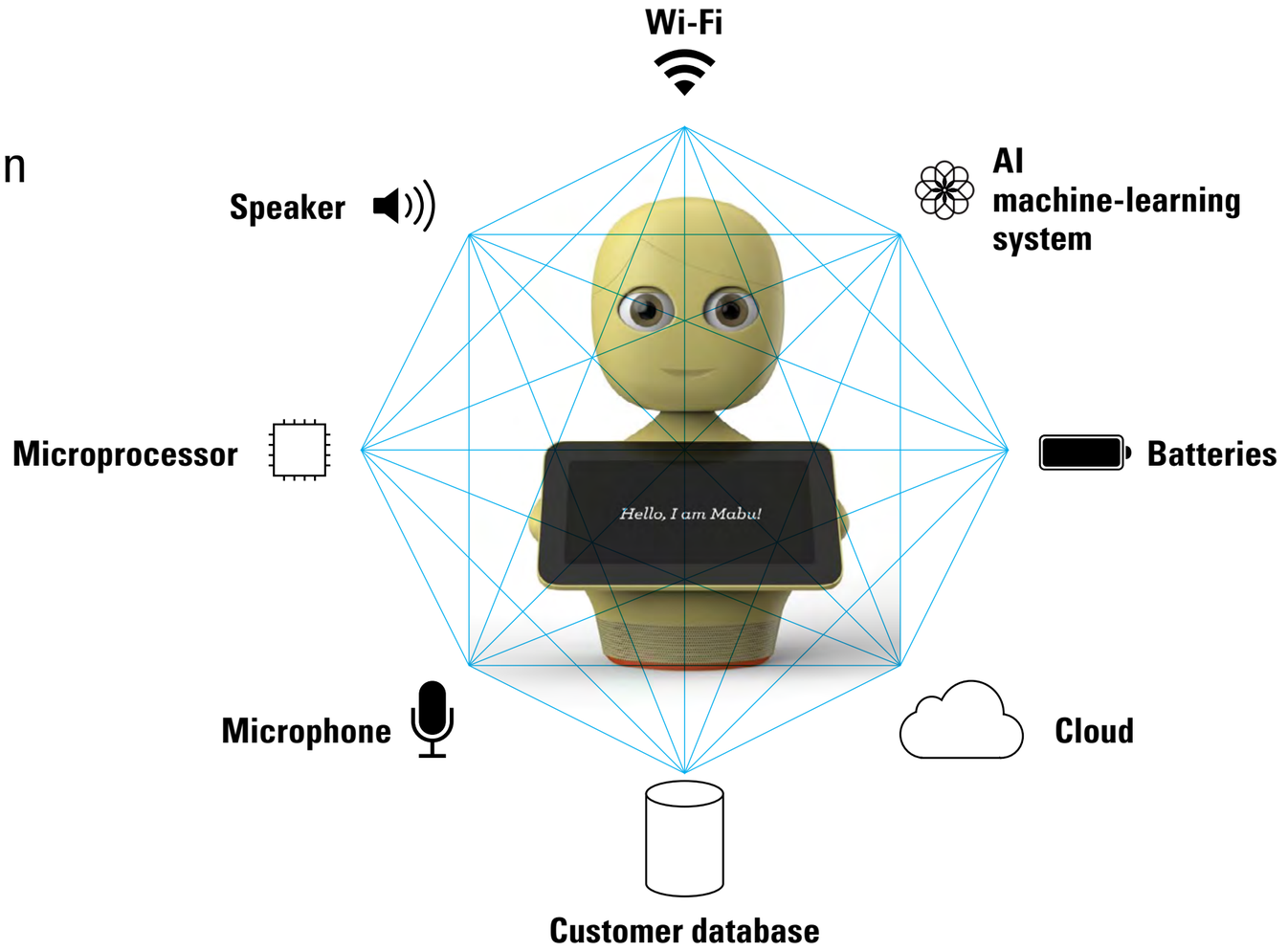


http://smartbed.goodmarkmedical.com/smart-bed-technology-new/learn-smart-bed-solution/

Catalia Health is developing Mabu, a personal healthcare companion.

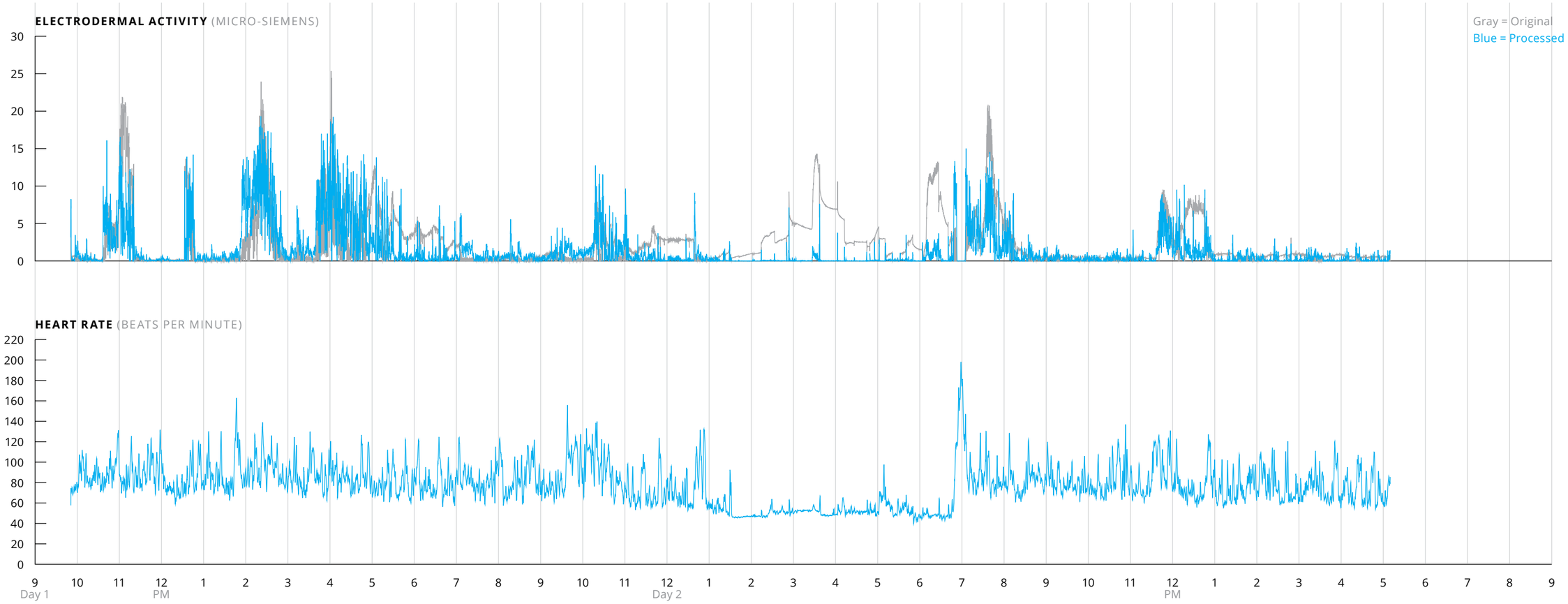
Robot + touch-screen + network + cloud services = Mabu

- Recognizes you and what you say
- Learns about you
- Imports data from health trackers
- Converses with you about your condition
- Reminds you to take medications
- Connects with HCPs

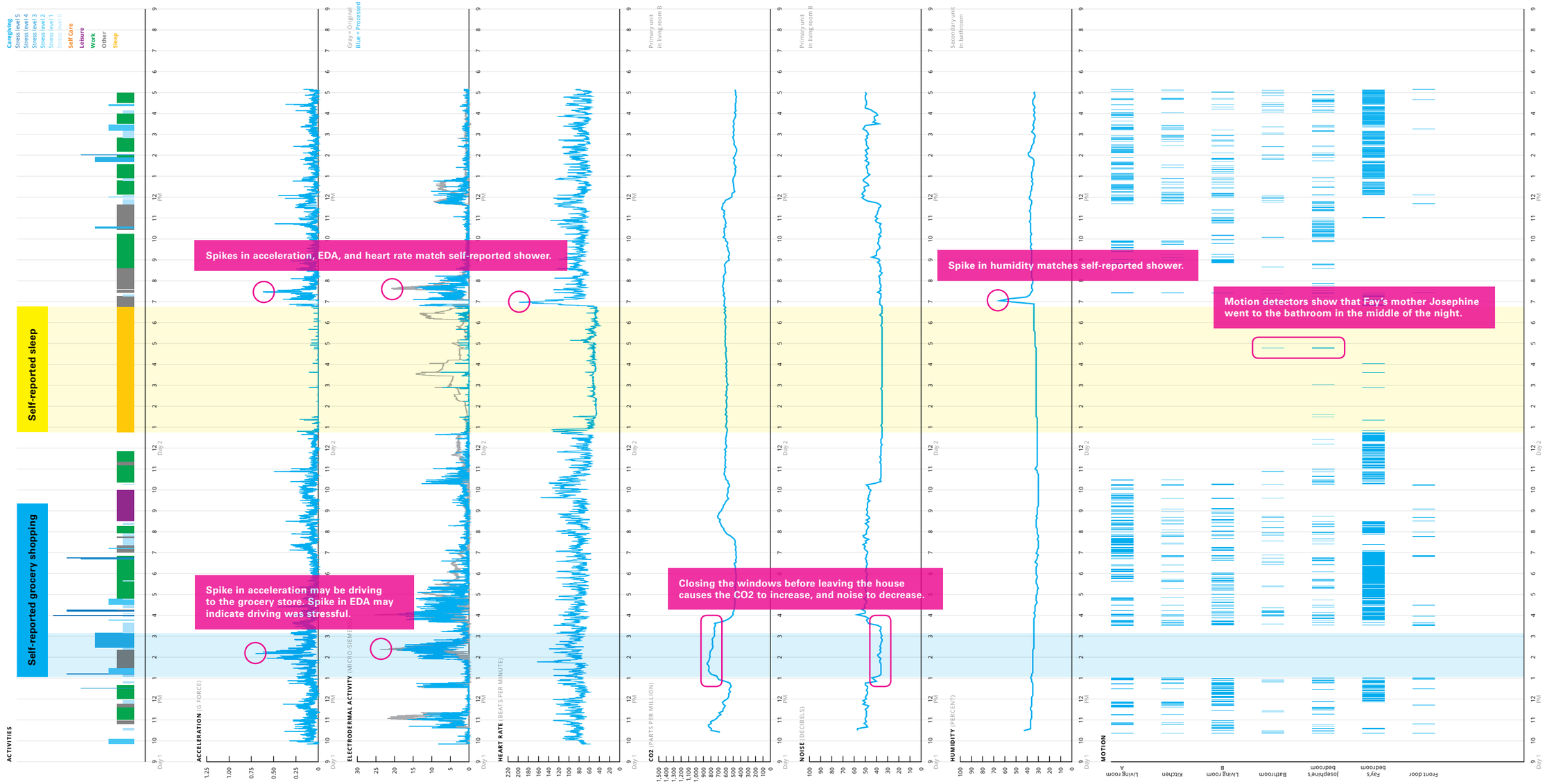


IoT devices will generate huge amounts of data, requiring monitoring, analysis, and visualization.

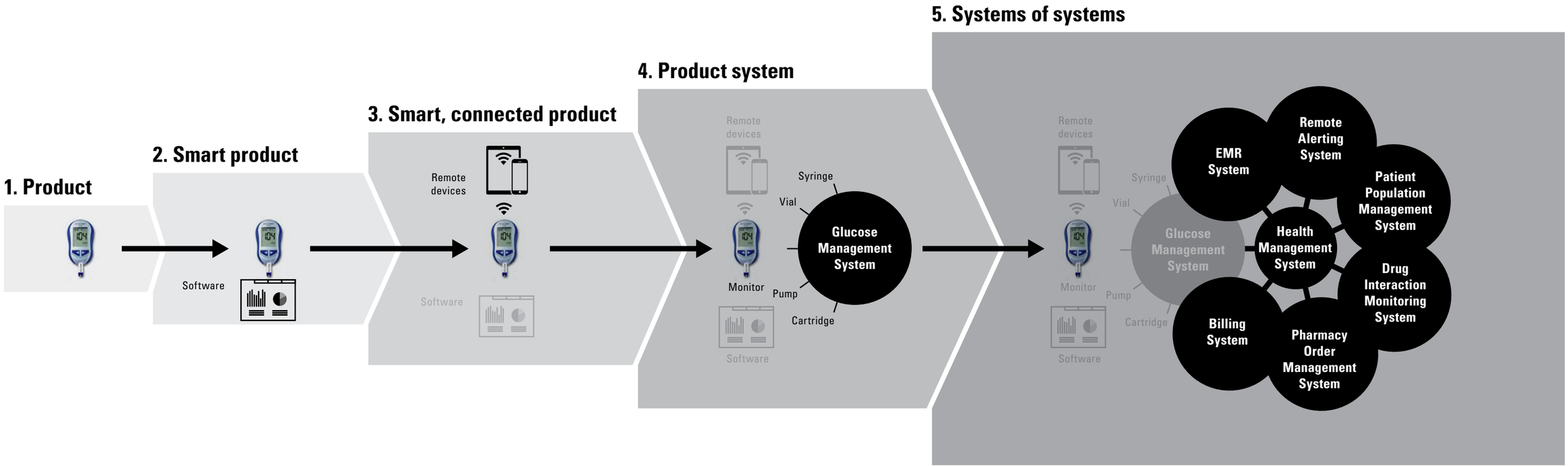
Stress data from a RWJF study of family caregiving,
over ~24 hours, 20 participants with a dozen sensors, generated 5GB of data.



Comparing data sets enables us to recognize patterns
and becomes the basis for ongoing machine learning.



In the future, medical products will no longer stand alone. Increasingly, they will exist in complex service webs.



Glucometer + processor = computer that can run apps; e.g., bolus calculator, calorie estimator and tracker.

When a glucometer connects to a smart-phone, cost can come down, because the meter can build on the phone's processor and display. Plus data can be shared with family and HCPs.

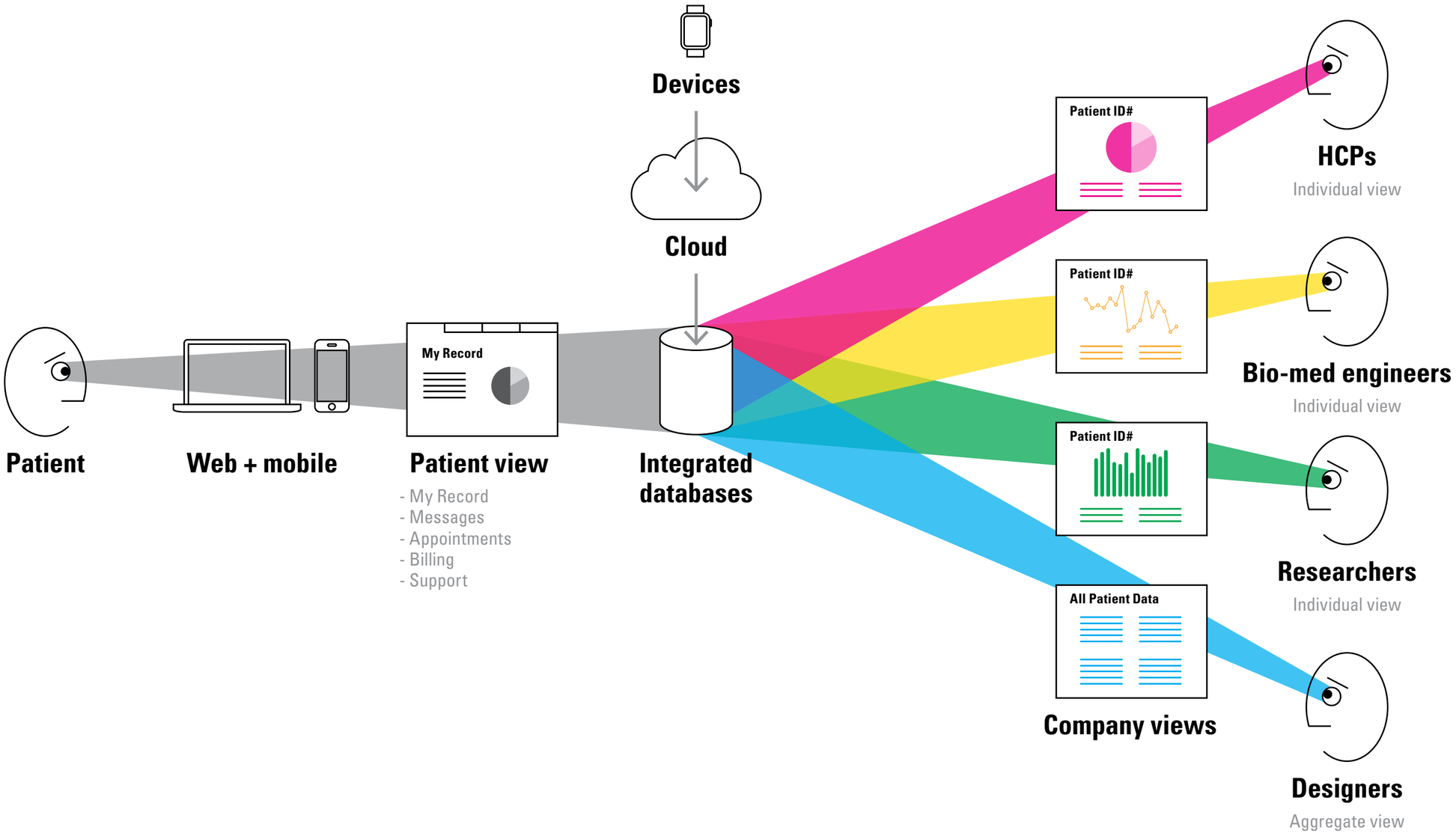
A near continuous glucose monitor can be coupled with an insulin pump, forming a glucose management system.

The glucose management system can connect with many other systems, such as EMRs, remote alerting, patient population management, drug interaction monitoring, pharmacy order management, and billing.

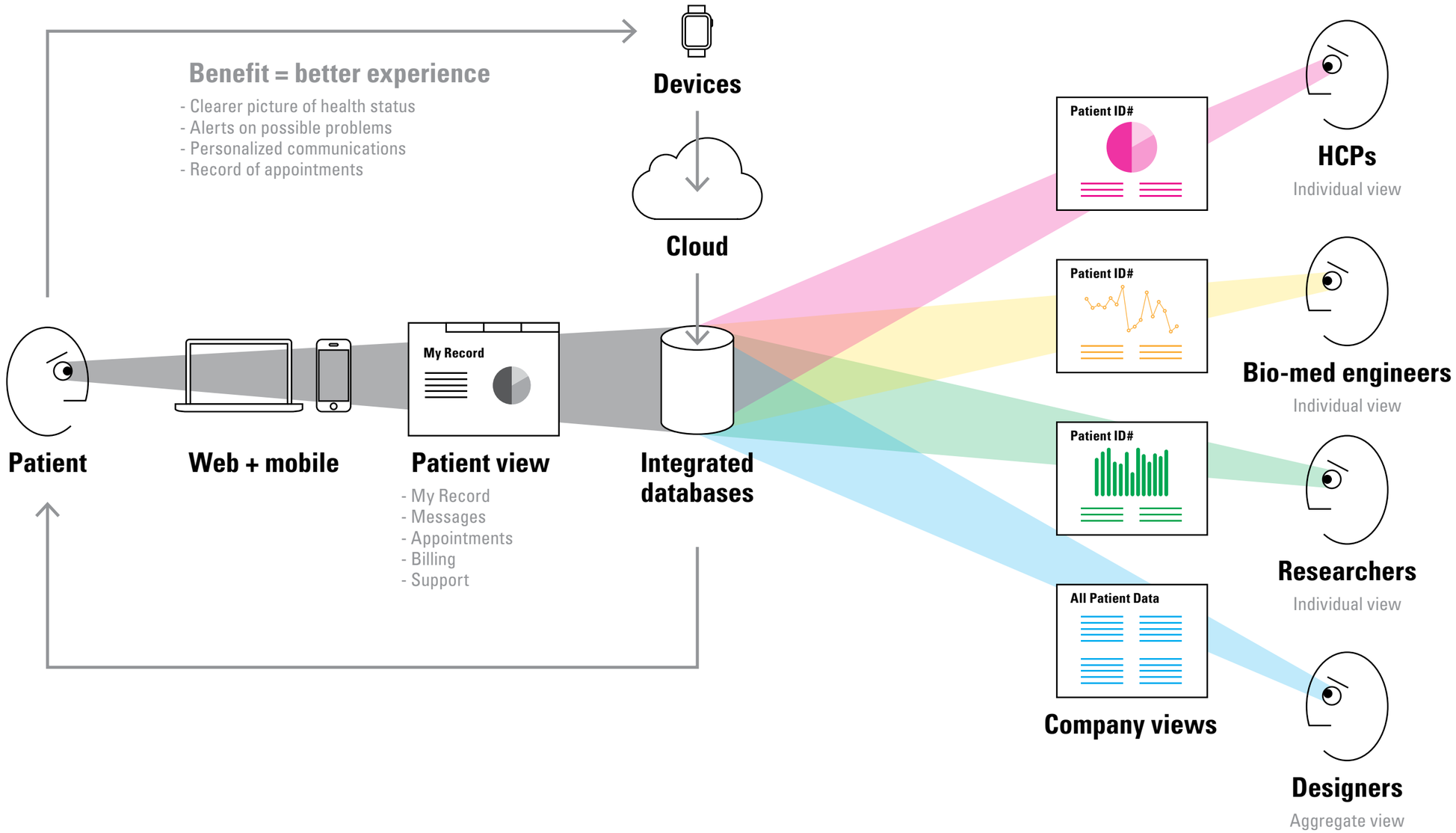
As medical products connect with service webs, they are also connecting with drug development systems.

- Systems for funding research and development, creating and protecting “intellectual” property, and rewarding investment
- The drug-knowledge-package system
- Compound sourcing, manufacturing, and distribution systems
- Drug delivery devices
- Systems for educating physicians and patients
- Systems for helping patients integrate the drug into their lives
- Insurance and government payment systems
- Government regulatory systems and professional association practices

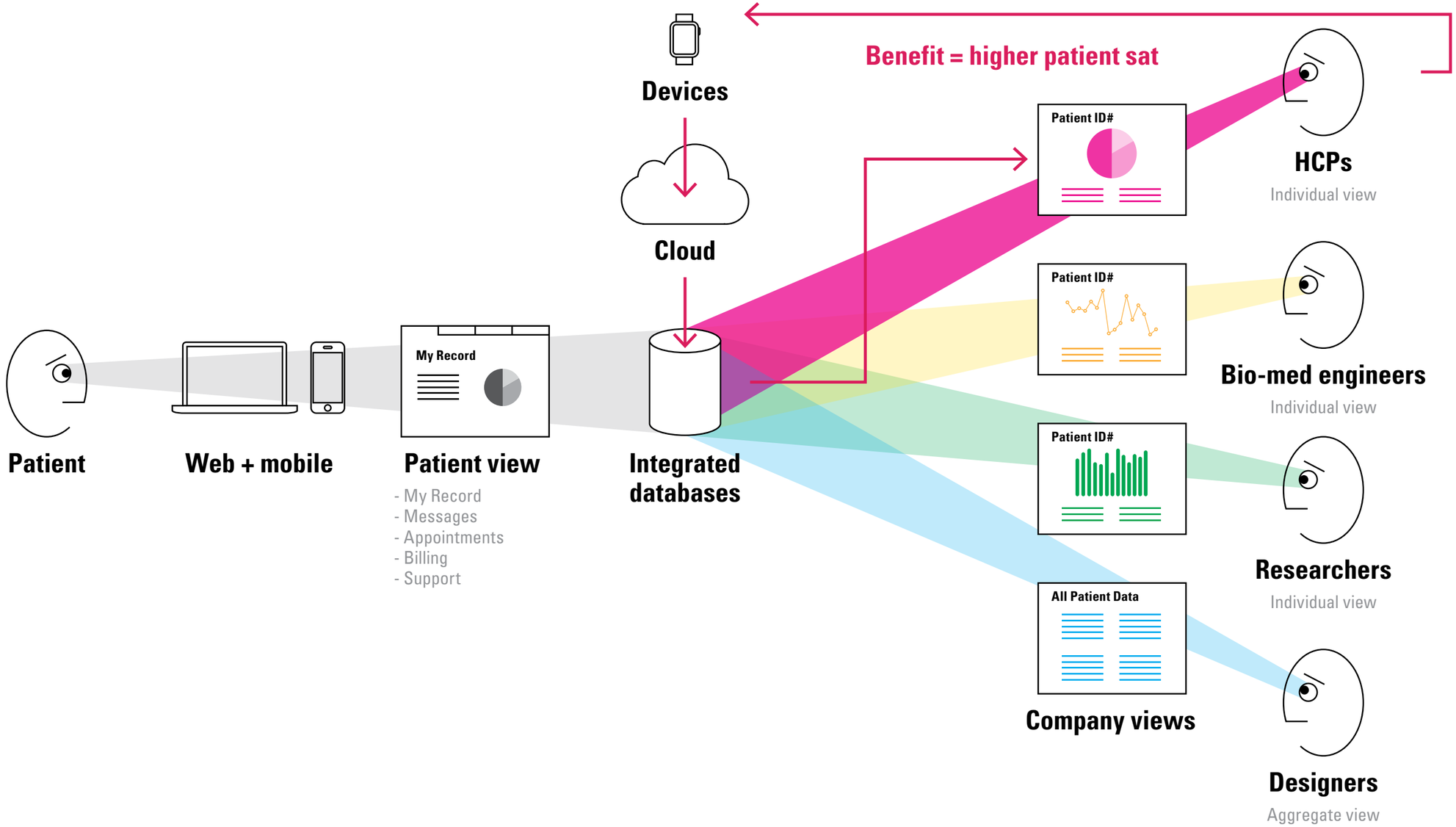
Unified patient and device data will afford useful views to many constituents.



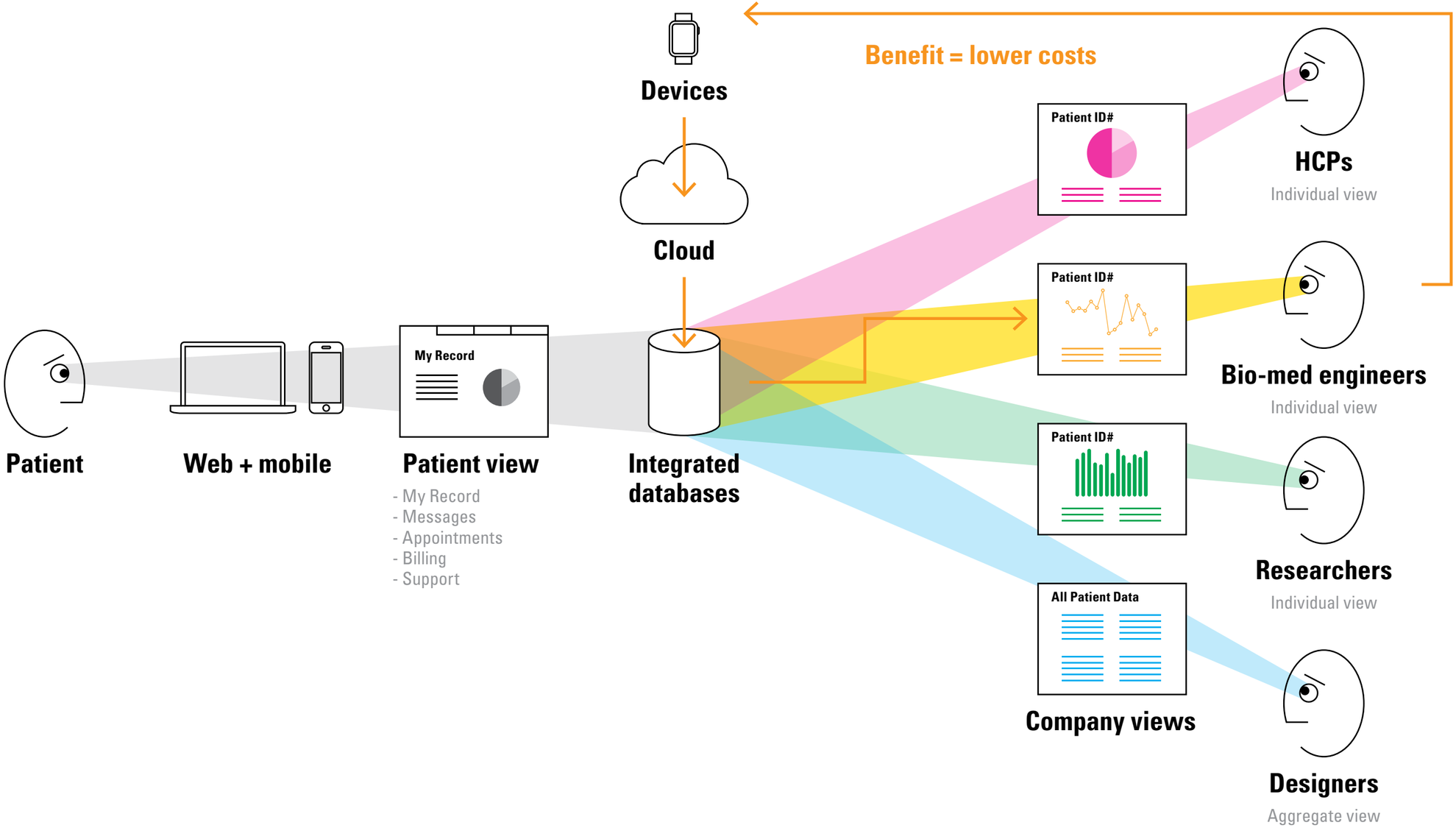
Patients can know much more about what's happening and can share information with family, friends, and HCPs.



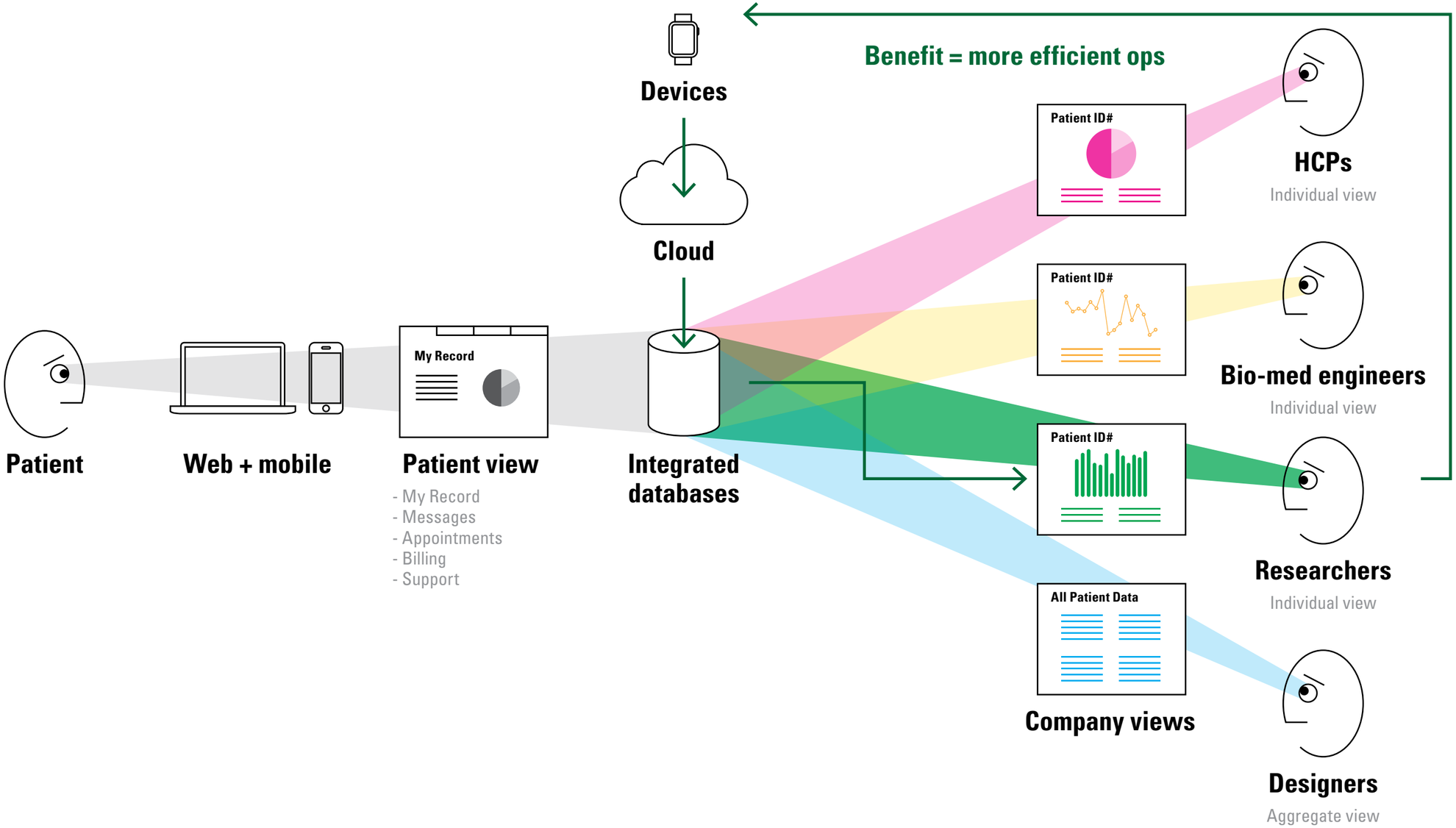
HCPs can receive a more holistic view of each patient and can manage groups of patients more efficiently.



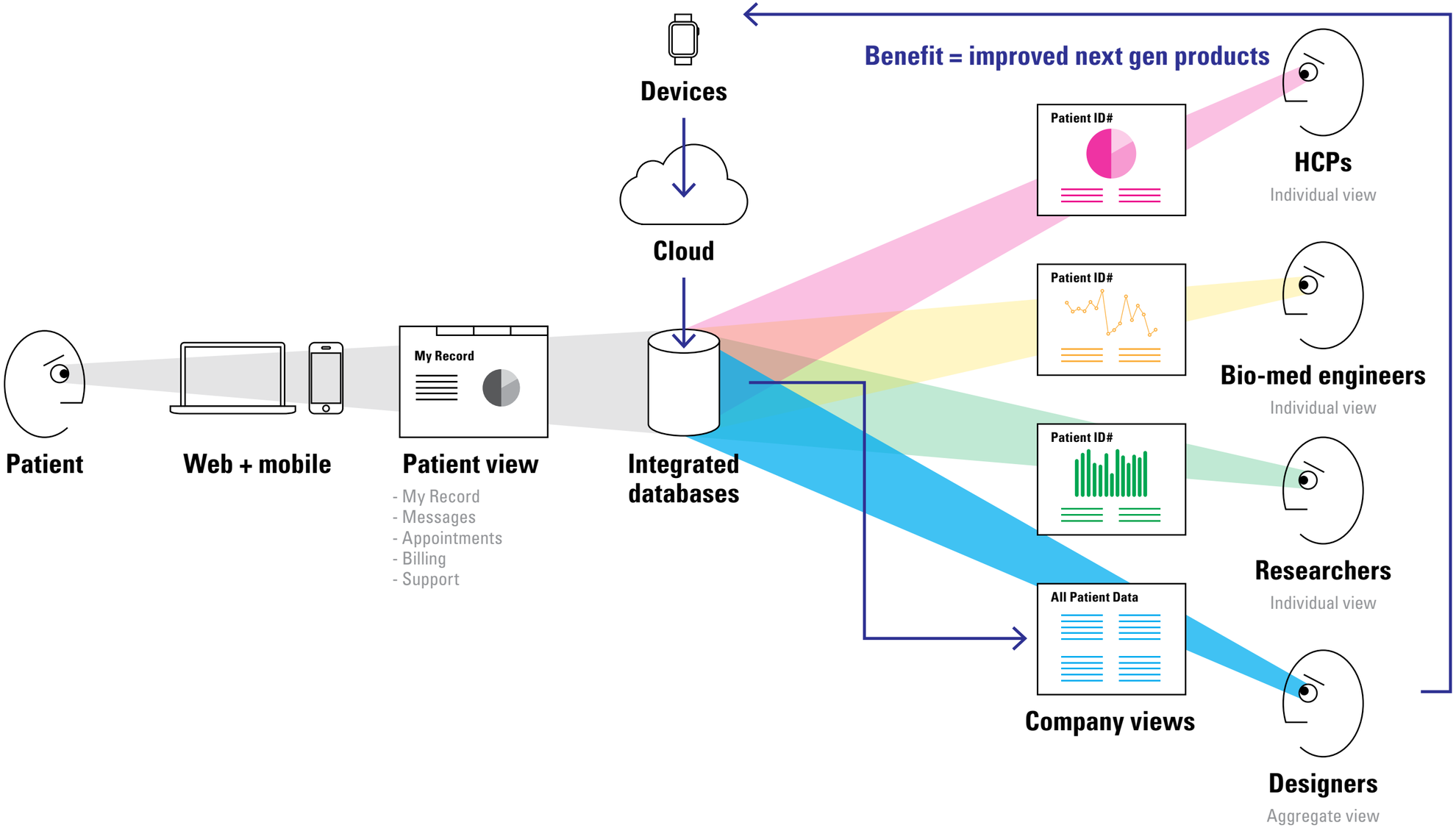
Bio-med engineers can better manage equipment, improve service, and reduce support costs.



Researchers can learn from aggregate data, to improve procedures and care-facility operations.



Designers can get detailed usage data, to improve next generation products.



Questions raised by the Internet of Things:

Of course, more UIs will have to be validated,
but will FDA require the whole interconnected system
to be validated together
or treat each component as a separate device?

Will all parts of the system be considered Class 2 or 3,
or will parts of it be Class 1?

How will usability engineering and usability testing change?

What other skills will usability professionals need?

What changes in methods will be required?

The IoT signals a larger cultural shift

From	To	
Industrial Age	Information Age	
Cathedral	Bazaar	—Eric Raymond
Age of Enlightenment	“Age of Entanglement”	—Danny Hillis
Machine metaphors	Ecology metaphors	
Tree structures (e.g., the tree of life)	Network structures (e.g., web of life)	—Manual Lima
Direct causality	Systemic causality	—George Lakoff
Patient coordination of specialists	“Patient medical home” or “patient population management”	
“Mechanism of disease”	“Context of living in which disruptions arise” or other “integrative approaches”	—Fritjof Capra

Special thanks to
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Anthony Andre
Sean Hägen
Ryan Reposar

hugh@dubberly.com
sbw@dscience.com

Presentation posted at
http://presentations.dubberly.com/HFES_health.pdf