The Internet of Me: 
Data Empowering Patients

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I could not figure out how to take my pulse.
270 beats per minute
Maui, Hawaii
atrioventricular node ablation
(electrocution)
100%

battery dependent
How would I feel?

What would a pacemaker look like in my chest?

Would I ever wear a swimsuit again?
Am I really a heart patient?

How do I prepare for open heart surgery?

I need a goal: LOTOJA Classic bike race!
Everything was going so well...
post-surgery training plan

- walking laps at the hospital
- 4 minutes on hotel spin bike
- getting back on my mountain bike
- 10 mile road bike event
- 50 mile LOTOJA
- 100 mile Tour de Palm Springs
Field testing:
I refuse to sit still. Since having open heart and lung surgery in 2010, I've competed in multiple 200-mile, single-day road and gravel bike races around the world.

This has given me a unique experience as to how data collection, analysis and management can prove beneficial to personal health.
Healthcare: A Patient’s Perspective
I have relied on machines for 30 years.

100% dependent on a pacemaker (on my seventh one).

Current Boston Scientific device collects data on every heartbeat, checks for abnormal rhythms, and monitors voltage settings and battery life. The information is transferred via a wifi-enabled communicator and made available to doctor for analysis.

Data to live my life… and keep my Doctors in the Loop
Data from my Pacemaker:

**LATITUDE® Patient Management - Combined Follow-up Report**

**Date of Visit:** Jan 23, 1984  
**Device:** ADVANTIO K03/121/439  
**Clinic:** UCSF EP & Device Clinic  
**Search Tag:** PACER  
**Report Created:** Jun 22, 2016

### My Alerts
There are no alerts to display.

### Events Since Last Reset (Apr 09, 2016)
- Apr 10, 2016 03:48: RV Auto

### Battery
- **ON**
- Approximate time to explant: 6 years from Apr 11, 2016
- Magnet Rate: 100 ppm

See last page for additional battery information.

### Leads
|------------------------|-----------------------------------------------|-----------------------------------------------|
| **Atrial**  
Intrinsic Amplitude | 2.0 mV | 1.8 mV | 1.7 mV |
| Pace Impedance | 650 Ω | 682 Ω | 794 Ω |
| Pace Threshold | 0.5 V @ 0.4 ms | 0.7 V @ 0.4 ms | 0.7 V @ 0.4 ms |
| **Ventricular**  
Intrinsic Amplitude | N/IR | N/IR | N/IR |
| Pace Impedance | 500 Ω | 534 Ω | 508 Ω |
| Pace Threshold | 0.7 V @ 0.4 ms | Auto 0.8 V @ 0.4 ms | 0.8 V @ 0.4 ms |

### Settings
- **Ventricular Tachy EGM Storage:** Off
- **Detection Rate:** 190 bpm (316 ms)

### Atrial Tachy
- **ATR Mode Switch:** 150 bpm
- **DDIR:** 60 bpm

### Brady
- **Mode:** DDD
- **Lower Rate Limit:** 80 ppm
- **Maximum Tracking Rate:** 150 ppm
- **Maximum Sensor Rate:** 150 ppm
- **Paced AV Delay:** 100 - 150 ms
- **Sensed AV Delay:** 85 - 100 ms
- **A-Adaptation (PVARP):** 200 - 300 ms
- **V-Adaptation (VRVP):** 150 - 250 ms

### Pacing Output
- **Ventricular:** Auto 1.1 V @ 0.4 ms
- **Ventricular Sensitivity:** Fixed 0.5 mV
- **Rate Adaptive Pacing:** Bipolar

### Trend Graphs
- **Heart Rate**
- **APTAF Burden**
- **Atrial Intrinsic Amplitude**
- **Ventricular Intrinsic Amplitude**
- **Ventricular Auto Pacing Threshold**
Genomic Data:
- Link to heart issues?
- Donate to research
There are 536 conditions in NHGRI CGD associated with genes where you have variants with information.

CARDIOVASCULAR
You have 176 conditions with findings in this category.

Remember, you may see variants that have been associated with medical conditions in the scientific literature. That doesn’t mean you have those conditions. Genes is not intended for diagnostic or prognostic use. If you have any health-related questions about your DNA sequence information, contact your doctor.
The impact technology, devices and data have had:

Devices offer a “window” into my body

Better discussions with my care team
It is not just about how “I feel” but having actual data points to support what is or is not going on!

Not all successful “healthcare” comes from the clinic:
Peer-to-peer support and sharing of information.
No one understands like someone that has been there.
Online support communities

Overcoming the fear:
- Feeling safe
- Doing more
- Confidence
Everytime we go to the doctor in the United States we are handed the HIPAA consent form. We are conditioned to think that horrible things will happen should anyone even glance at our medical data.
When your quality of and length of life is dependant on the medical world making advances, you don’t mind sharing your data.

Personally, I just want to control who is using it and for what. I want to give the consent and be valued for my contribution.
Current State of Healthcare Technology
# Healthcare Market Segments:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Payers and Providers</strong></td>
<td><strong>Patient Centered Care</strong></td>
<td><strong>Pharma / Medical</strong></td>
</tr>
<tr>
<td>• Hospitals / Clinics</td>
<td>• Telemedicine</td>
<td>• Population Health</td>
</tr>
<tr>
<td>• Insurance companies</td>
<td>• Customized care</td>
<td>• Big Data / Genomics</td>
</tr>
</tbody>
</table>

**Opportunities:**
- Data interoperability between EHR systems and patient portals
- Image archiving / data storage

**Opportunities:**
- Patient generated data
- IoMT / Sensors / Wearables
- Smart Home
- Doctor on your mobile device

**Opportunities:**
- Find the “needle in a haystack” for diagnosis and treatment of disease
- Machine Learning

**Key to success:** Data must be interoperable and flow across segments
# Healthcare IT Scenarios:

<table>
<thead>
<tr>
<th>Prevention</th>
<th>Diagnostics</th>
<th>Therapy &amp; Surgery</th>
<th>Treatment &amp; Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardware</strong></td>
<td><strong>Software &amp; Services</strong></td>
<td><strong>Hardware</strong></td>
<td><strong>Software &amp; Services</strong></td>
</tr>
<tr>
<td>Smart Clothing</td>
<td>Fitness Apps</td>
<td>Connected Sonographic Unit</td>
<td>Diabetis Diary</td>
</tr>
<tr>
<td>Smart Watches</td>
<td>Nutrition Apps</td>
<td>Connected Breathing Rate Appliance</td>
<td>Digital Care Diary</td>
</tr>
<tr>
<td>Portable Asthma Sensors</td>
<td>Telemonitoring Software</td>
<td>Connected Blood Glucose Meter</td>
<td>Online Pharmacy</td>
</tr>
<tr>
<td>Smart Scales</td>
<td>Health-Destination Websites</td>
<td>Telemedical Services</td>
<td>Digital Self-Help Groups</td>
</tr>
<tr>
<td>Digital Microscope</td>
<td>Online Fitness Centres</td>
<td>Blood Pressure Monitoring Apps</td>
<td>Online Experts Platforms</td>
</tr>
<tr>
<td>Tele-EEG</td>
<td>Medical Records Software</td>
<td>Mobile Digital Medical Round</td>
<td>Online Consultation</td>
</tr>
<tr>
<td>Tele-EKG</td>
<td>Medical E-Learning Platform</td>
<td>Online Experts Platforms</td>
<td>Surgery Support</td>
</tr>
<tr>
<td>Connected Blood Pressure Meter</td>
<td>Connected Breathing Rate Appliance</td>
<td>Online Experts Platforms</td>
<td>Telemedical Services</td>
</tr>
<tr>
<td>Cardiac Implants</td>
<td>Motion Control for Surgery</td>
<td>Connected Blood Pressure Meter</td>
<td>Online Experts Platforms</td>
</tr>
<tr>
<td>Robotic Surgery</td>
<td>Connected Breathing Rate Appliance</td>
<td>Connected Blood Pressure Meter</td>
<td>Online Experts Platforms</td>
</tr>
<tr>
<td>Smart glasses</td>
<td>Connected Breathing Rate Appliance</td>
<td>Connected Blood Pressure Meter</td>
<td>Online Experts Platforms</td>
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<tr>
<td>Connected Sonographic Unit</td>
<td>Connected Breathing Rate Appliance</td>
<td>Connected Blood Pressure Meter</td>
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</tr>
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</table>
IoT & App eHealth Opportunities
eHealth Trends: Fitness and Heart Failure Solutions

Revenue eHealth products in the U.S. in million US$ in 2016

<table>
<thead>
<tr>
<th>Prevention</th>
<th>Health surveillance</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitness Apps</td>
<td>Fitness Wearables</td>
<td>Apps</td>
</tr>
<tr>
<td>1,193</td>
<td>759</td>
<td>433</td>
</tr>
<tr>
<td>366</td>
<td>265</td>
<td>48</td>
</tr>
<tr>
<td>949</td>
<td>50</td>
<td>23</td>
</tr>
</tbody>
</table>
Revenue Growth of Heart Failure eHealth solutions from 2017 to 2022:

Revenue forecast for ‘eHealth solutions for Heart Failure’ in the U.S. in million US$
Fitness Products will continue to grow:

Revenue forecast for fitness products in the U.S. in million US$: 

- **Fitness Apps**
- **Fitness Wearables**

<table>
<thead>
<tr>
<th>Year</th>
<th>Fitness Apps</th>
<th>Fitness Wearables</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>1,193</td>
<td>433</td>
<td>1,626</td>
</tr>
<tr>
<td>2017</td>
<td>1,466</td>
<td>526</td>
<td>1,992</td>
</tr>
<tr>
<td>2018</td>
<td>1,726</td>
<td>620</td>
<td>2,346</td>
</tr>
<tr>
<td>2019</td>
<td>1,977</td>
<td>711</td>
<td>2,688</td>
</tr>
<tr>
<td>2020</td>
<td>2,217</td>
<td>799</td>
<td>3,016</td>
</tr>
<tr>
<td>2021</td>
<td>2,447</td>
<td>880</td>
<td>3,327</td>
</tr>
</tbody>
</table>

Growth rate: +15%
Ambient Assisted Living Products are Growing Fast:

Revenue forecast for AAL products in the U.S. in million US$
<table>
<thead>
<tr>
<th>Reason</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve my health</td>
<td>63%</td>
</tr>
<tr>
<td>Ability to take greater control over my health</td>
<td>56%</td>
</tr>
<tr>
<td>Improve my fitness</td>
<td>56%</td>
</tr>
<tr>
<td>More information</td>
<td>33%</td>
</tr>
<tr>
<td>Better overview of my health</td>
<td>28%</td>
</tr>
<tr>
<td>Obtaining information which is hard to get</td>
<td>26%</td>
</tr>
<tr>
<td>Reducing my healthcare costs</td>
<td>25%</td>
</tr>
<tr>
<td>Make every-day life easier</td>
<td>21%</td>
</tr>
<tr>
<td>Ability to access healthcare providers more effectively</td>
<td>21%</td>
</tr>
<tr>
<td>Accessing better quality healthcare</td>
<td>20%</td>
</tr>
<tr>
<td>Better treatment</td>
<td>18%</td>
</tr>
<tr>
<td>Use innovative technology</td>
<td>17%</td>
</tr>
<tr>
<td>Other</td>
<td>8%</td>
</tr>
</tbody>
</table>
Cloud Solutions to Support eHealth

Google Cloud Platform
Cloud IoT Core: Real Time Stream Processing - eHealth IoT
Cloud IoT Core: Secure device connection and management

End-to-end security
Enable end-to-end security using asymmetric key authentication over TLS 1.2; CA signed certificates can be used to verify device ownership. Devices running Android Things or supporting the Cloud IoT Core security requirements can deliver full-stack security.

Single global system
Connect all devices and gateways to Google Cloud over standard protocols, such as MQTT and HTTP, through the protocol endpoints and manage all your devices as a single global system. The service uses Cloud Pub/Sub underneath, which retains data for 7 days.

Out-of-box data insights
Use downstream analytic systems by integrating with Google Big Data Analytics and ML services such as Dataflow, BigQuery, Bigtable, ML, Data Studio, or partner BI tools.

Fully managed and scalable
The service is serverless and doesn’t require any upfront software installation. It scales instantly without limits using horizontal scaling of Google Cloud Platform.

Role-level access control
Apply IAM roles to device registries to control user access to devices and data.

Device deployment at scale
Use REST APIs to automatically manage the registration, deployment, and operation of devices at scale. Also, use the APIs to retrieve and update device properties and state even when the devices are not connected.
Analysis Engine

- Medical Records
- Genomics
- Devices
- Imaging
- Patient Reports

Public Data
Controlled Access Data
Digital Healthcare is changing how individuals manage and allocate their data:

- **Health eHeart Study**
  - Using patient-generated data to change how heart disease is diagnosed and treated.
  - Patients are considered peers with researchers and doctors and have a voice.
  - Big Data buckets that can be shared, with patient consent, with other researchers.

[www.health-eheartstudy.org](http://www.health-eheartstudy.org)
Conclusions
Final Thoughts...

As a lifelong heart patient, I have waited a long time for all the pieces to come together and we are finally here!

Today, we have the data-collection devices and the infrastructure to successfully empower patients and enhance research opportunities.

We can see the potential to monitor health in new ways with wearable devices and apps on mobile.

In the near future we will be able to completely customize healthcare with the use of genomics data and proactively diagnose health issues before they become expensive to treat.
Thank you!