

PANAMA NATIONAL COMPETITIVENESS FORUM 2017

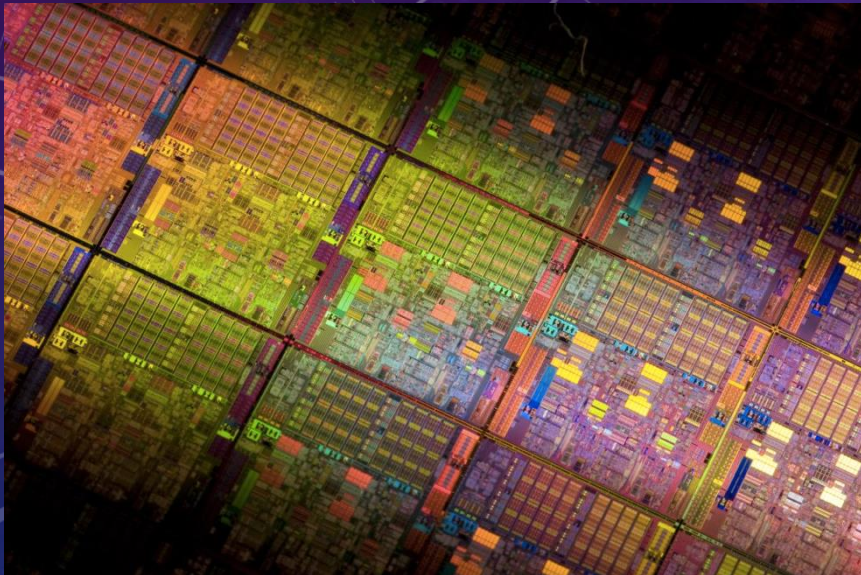
EXPONENTIAL TECHNOLOGIES

Leading Change in the World

KEVIN A. SHAW, PH.D.

CTO / Co-FOUNDER | ALGORITHMIC INTUITION INC.

ADJUNCT FACULTY | SINGULARITY UNIVERSITY



Silicon Wafer

EXPONENTIAL TECHNOLOGIES

- Exponential Thinking
- Four Technology Revolutions
 - Silicon/Cloud, IoT/Sensors, Manufacturing & Machine Learning
- The New Beginning
- Opportunities for Panama



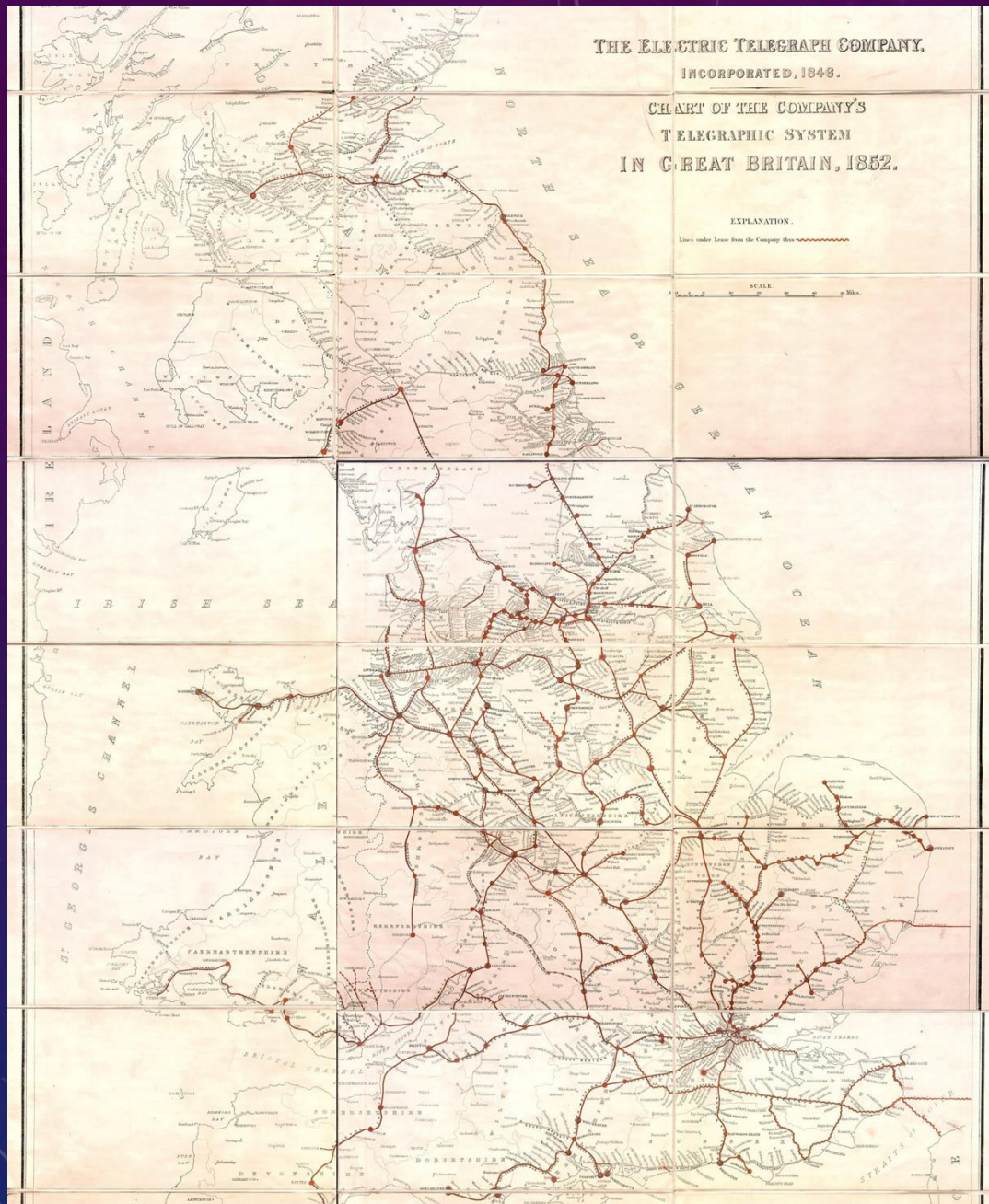
The 1850's





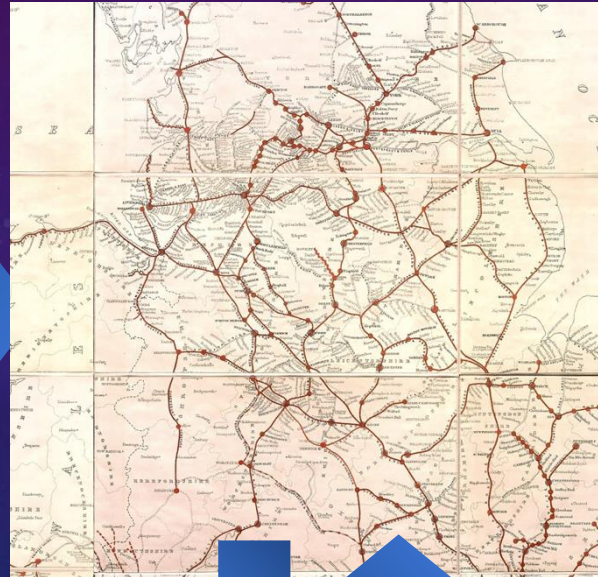
The 1850's





Admiral Robert FitzRoy

Telegraph route map for Great Britain. 1852.



First storm forecasts in 1860



WEATHER



Local weather

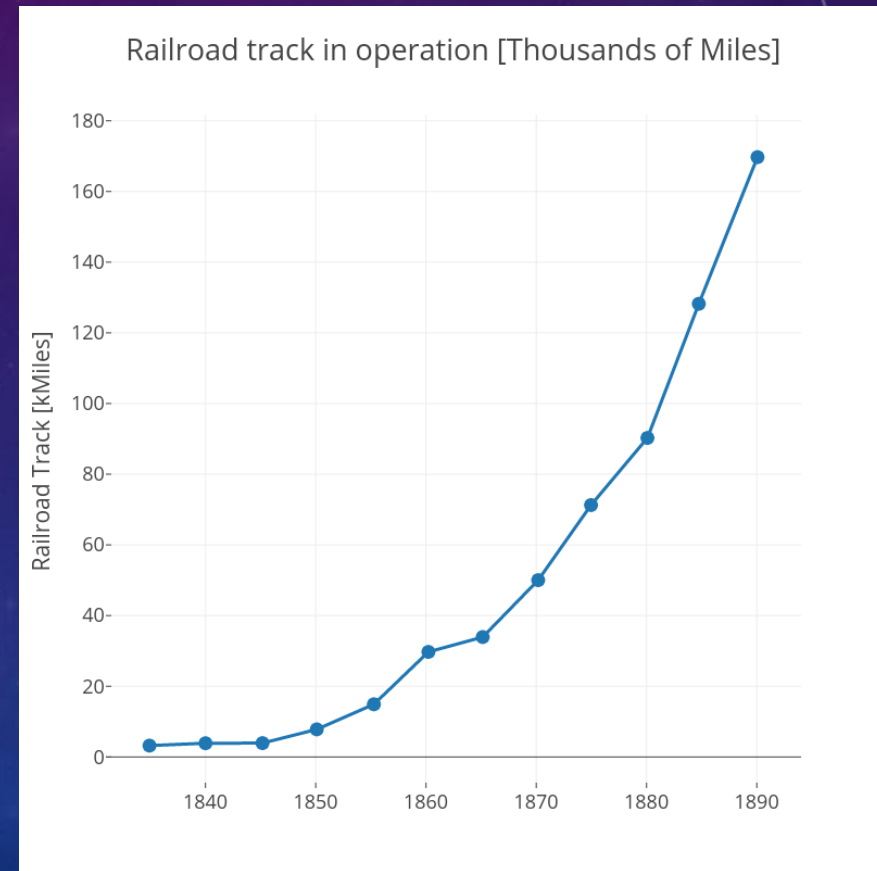
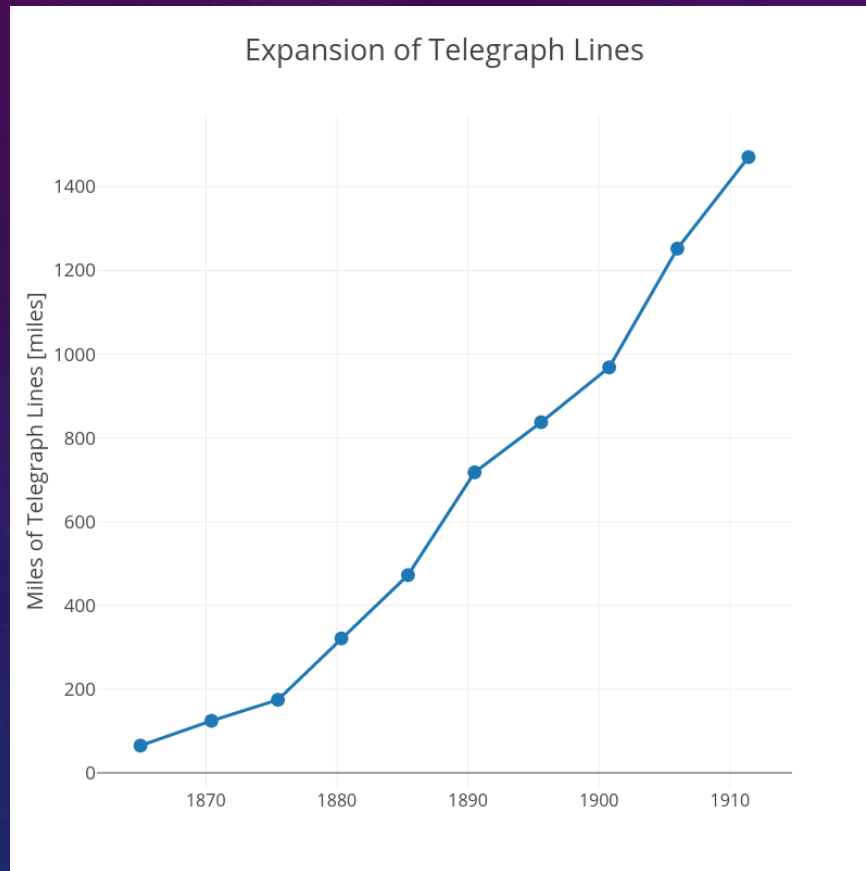


Distributed
Information

THE WEATHER.								
METEOROLOGICAL REPORTS.								
Wednesday, July 31, 8 to 9 a.m.	B.	E.	M.	D.	F.	C.	I.	S.
Nairn.. ..	29°54	57	56	W.S.W.	6	9	o.	3
Aberdeen.. ..	29°60	59	54	S.S.W.	5	1	b.	3
Leith.. ..	29°70	61	55	W.	3	5	c.	2
Berwick.. ..	29°69	59	55	W.S.W.	4	4	c.	2
Ardrossan.. ..	29°73	57	55	W.	5	4	c.	5
Portrush.. ..	29°72	57	54	S.W.	2	2	b.	2
Shields.. ..	29°80	59	54	W.S.W.	4	5	o.	3
Galway.. ..	29°83	65	62	W.	5	4	c.	4
Scarborough.. ..	29°86	59	56	W.	3	6	c.	2
Liverpool.. ..	29°91	61	56	S.W.	2	8	c.	2
Valentia.. ..	29°87	62	60	S.W.	2	5	o.	3
Queenstown.. ..	29°88	61	59	W.	3	5	c.	2
Yarmouth.. ..	30°05	61	59	W.	5	2	c.	3
London.. ..	30°02	62	56	S.W.	3	2	b.	—
Dover.. ..	30°01	70	61	S.W.	3	7	o.	2
Portsmouth.. ..	30°01	61	59	W.	3	6	o.	2
Portland.. ..	30°03	63	59	S.W.	3	2	c.	3
Plymouth.. ..	30°00	62	59	W.	5	1	b.	4
Penzance.. ..	30°04	61	60	S.W.	2	6	c.	3

Regional weather

EXPONENTIAL GROWTH



<http://teachers.d11.org/teachers/rathmmm/Industril%20Revolution/Industrialization%20graphs.pdf>

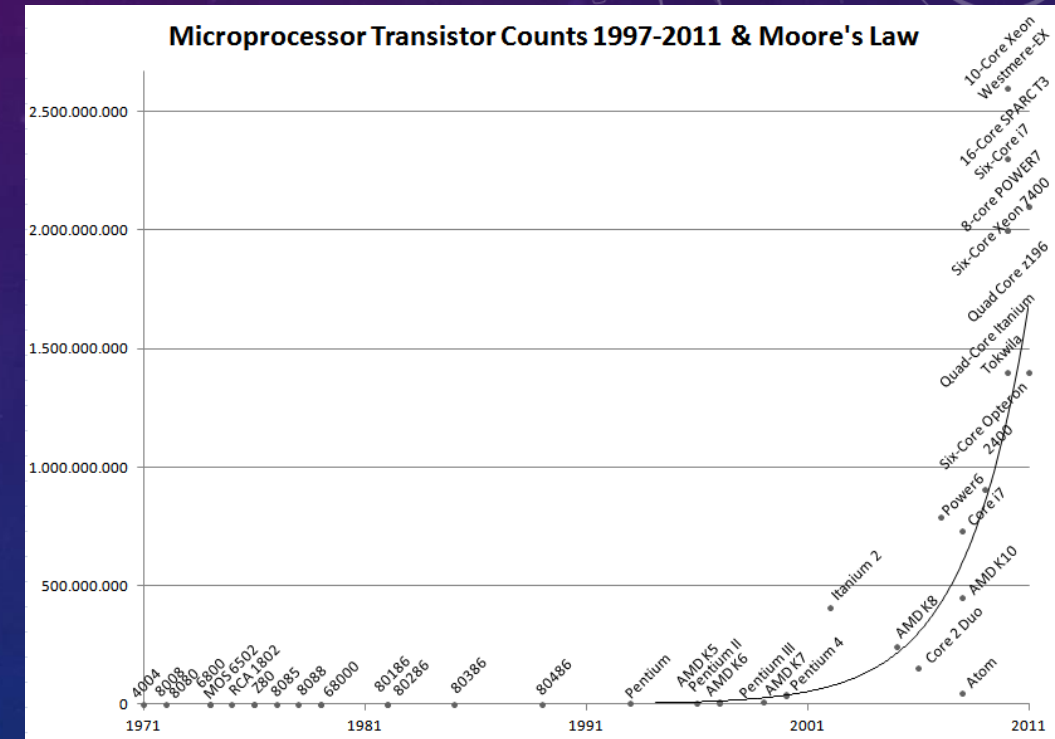
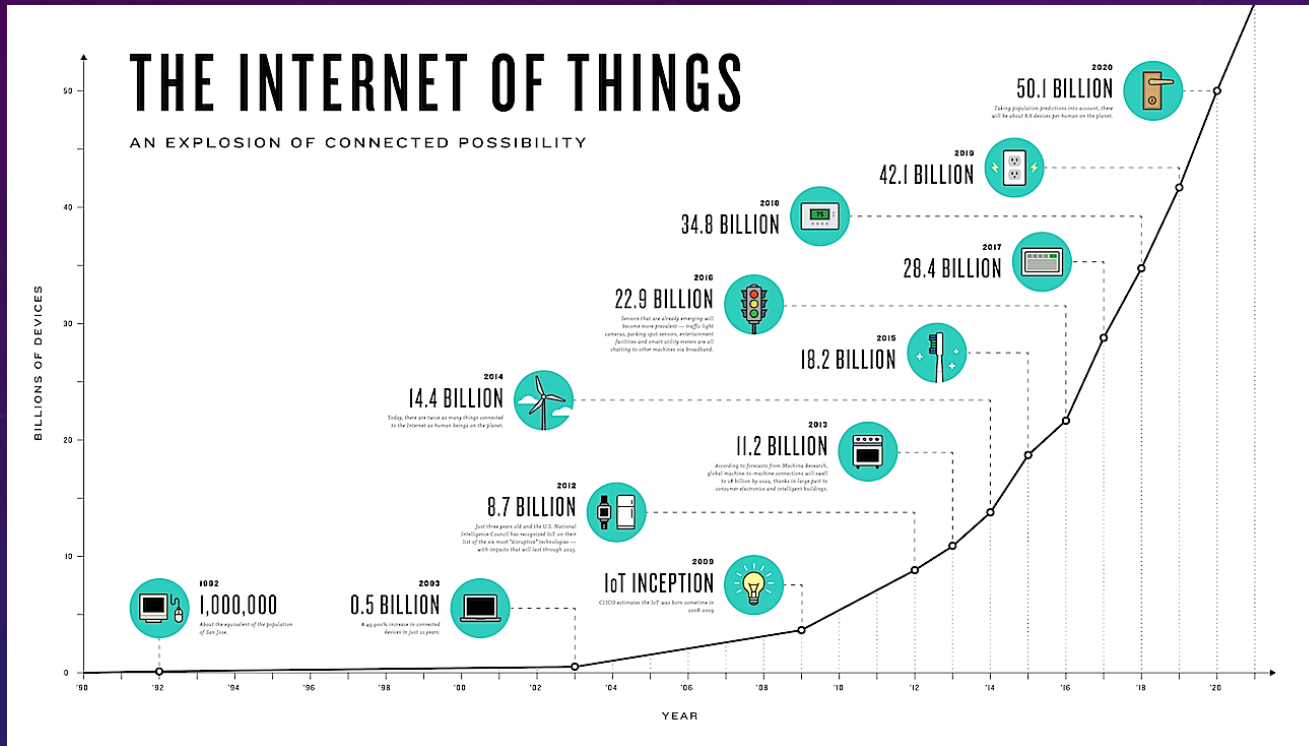


Now...it's our turn

WE ARE IN THE NEXT BEGINNING



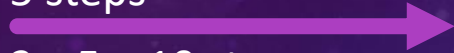
EXPONENTIAL GROWTH: NOW



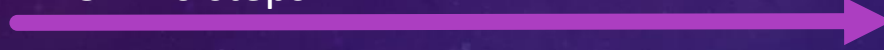
LINEAR AND EXPONENTIAL THINKING

Linear

5 steps



$2 \times 5 = 10$ steps

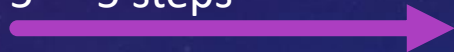


$3 \times 5 = 15$ steps



Exponential

$5^1 = 5$ steps



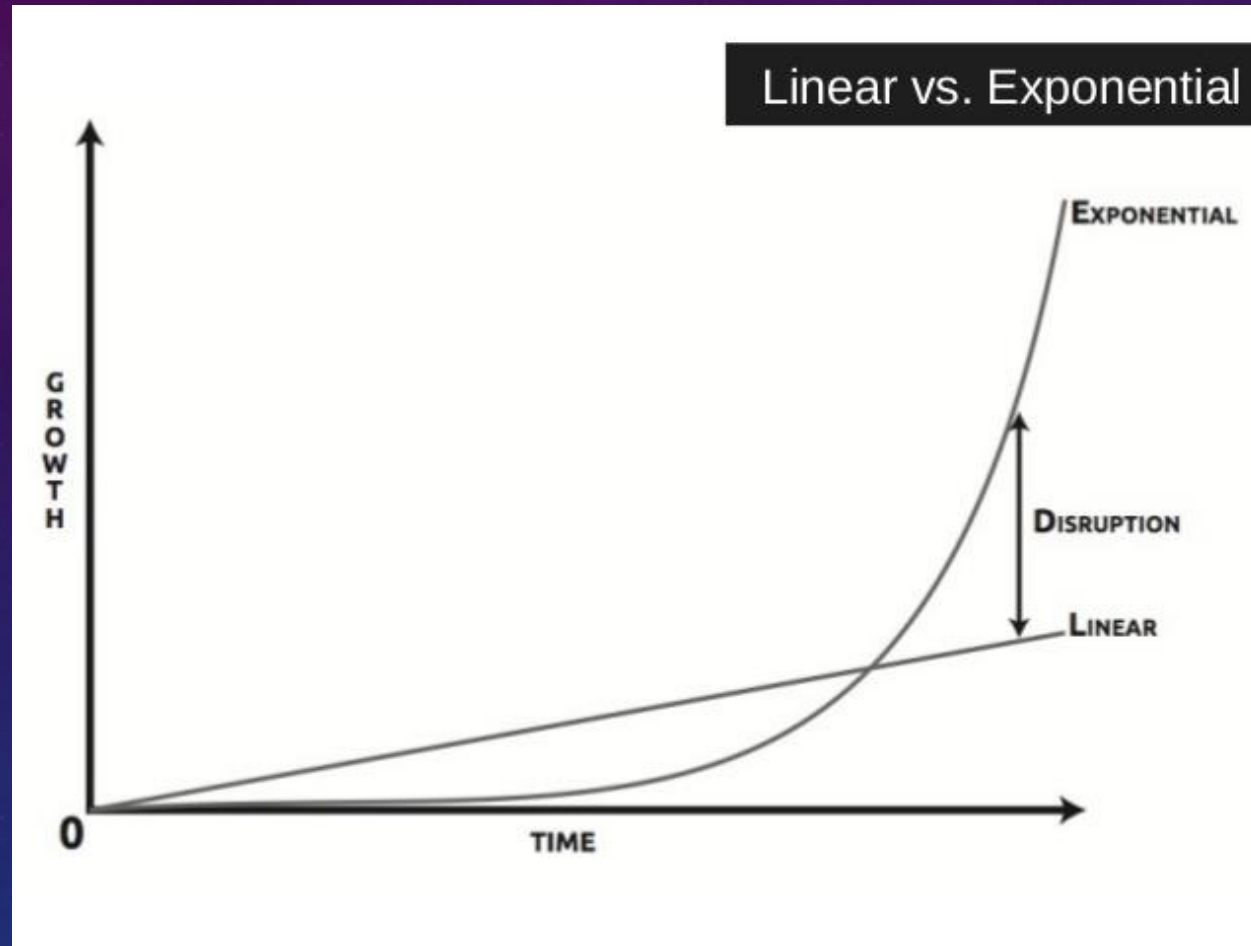
$5^2 = 25$ steps



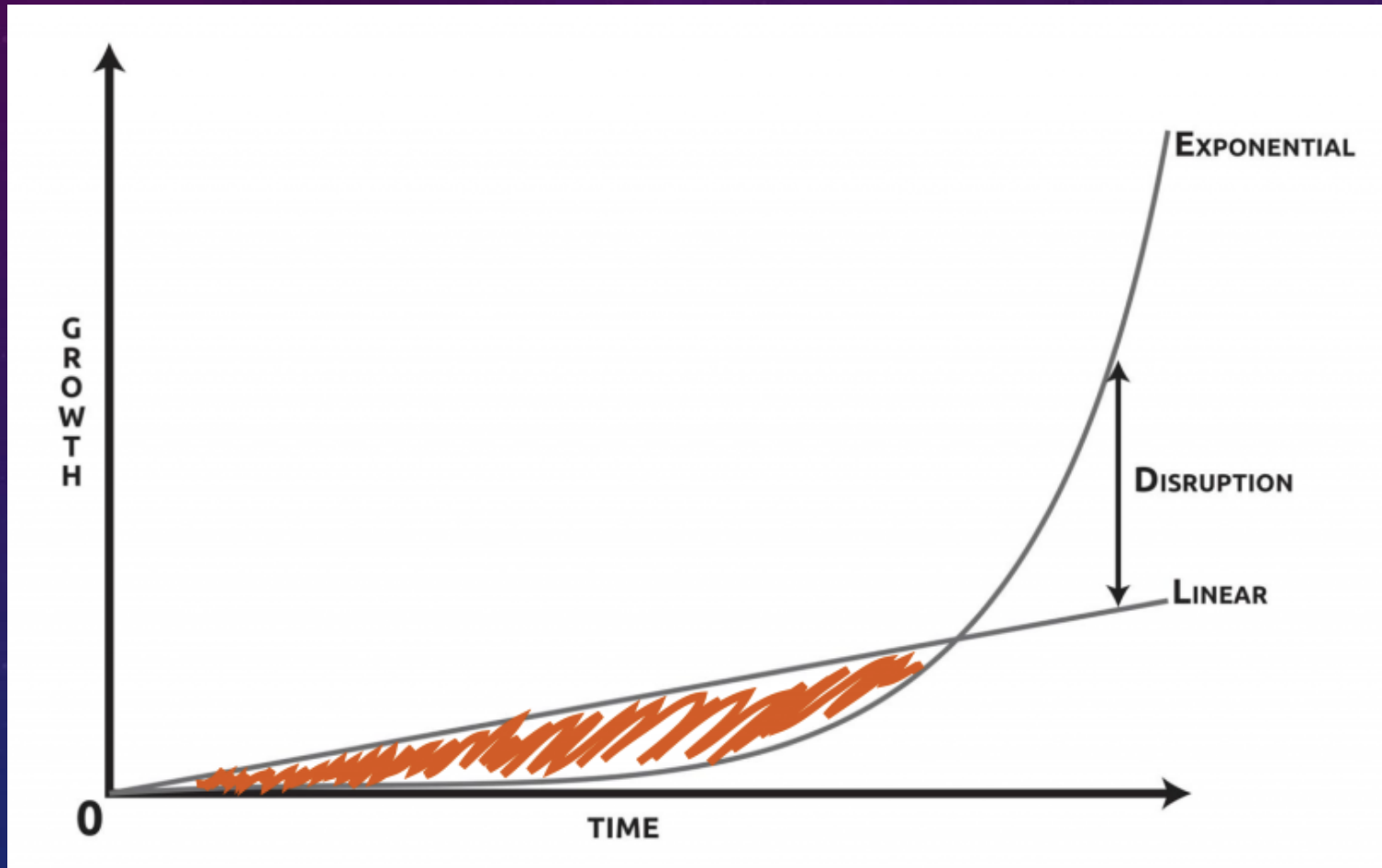
$5^3 = 125$ steps



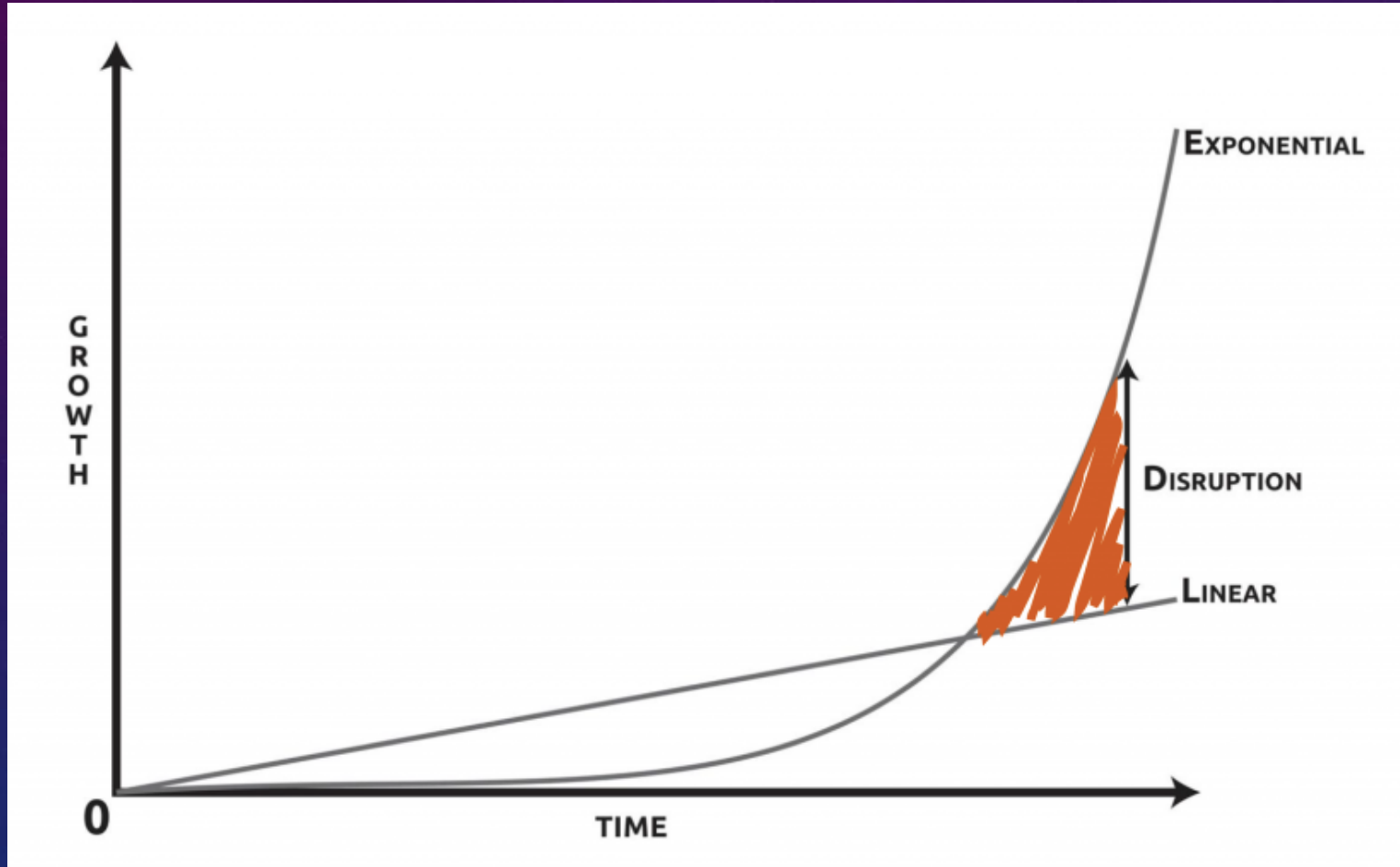
LINEAR AND EXPONENTIAL THINKING



LINEAR AND EXPONENTIAL THINKING



LINEAR AND EXPONENTIAL THINKING



Disruptive
Stress?

Or?

Disruptive
Opportunity!

EXPONENTIAL DISRUPTION

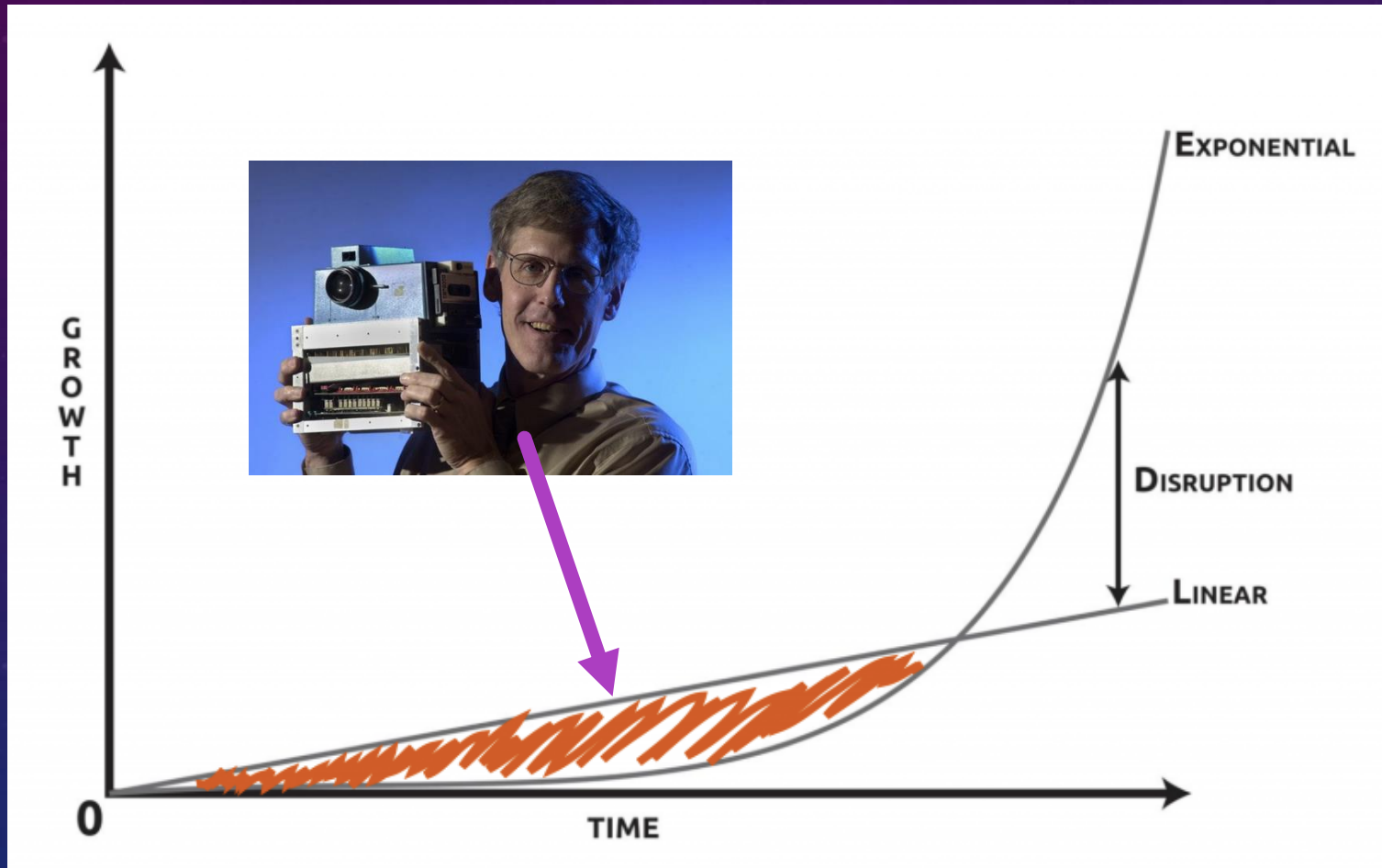


1996

Market Cap = \$28B

Employees = 140K

LINEAR AND EXPONENTIAL THINKING



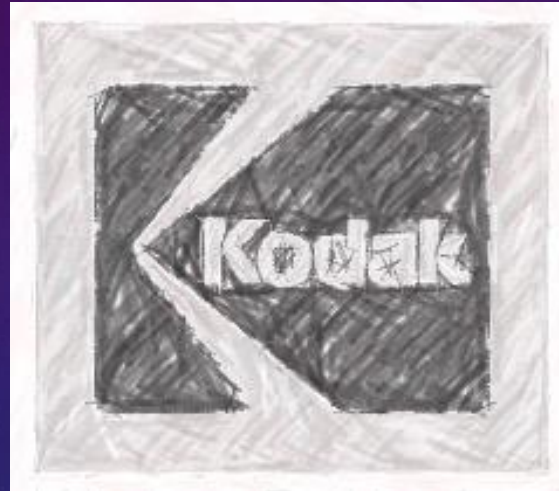
EXPONENTIAL DISRUPTION



1996

Market Cap = \$28B

Employees = 140K



2012

Bankrupt

Employees = 17K



2012

FB acquired = \$1B

Employees = 13!

EXPONENTIAL DISRUPTION



Robotics



Virtual Reality



Books



Medicine



Delivery / Fast Food



Self-driving cars

Industrial
Manufacturing

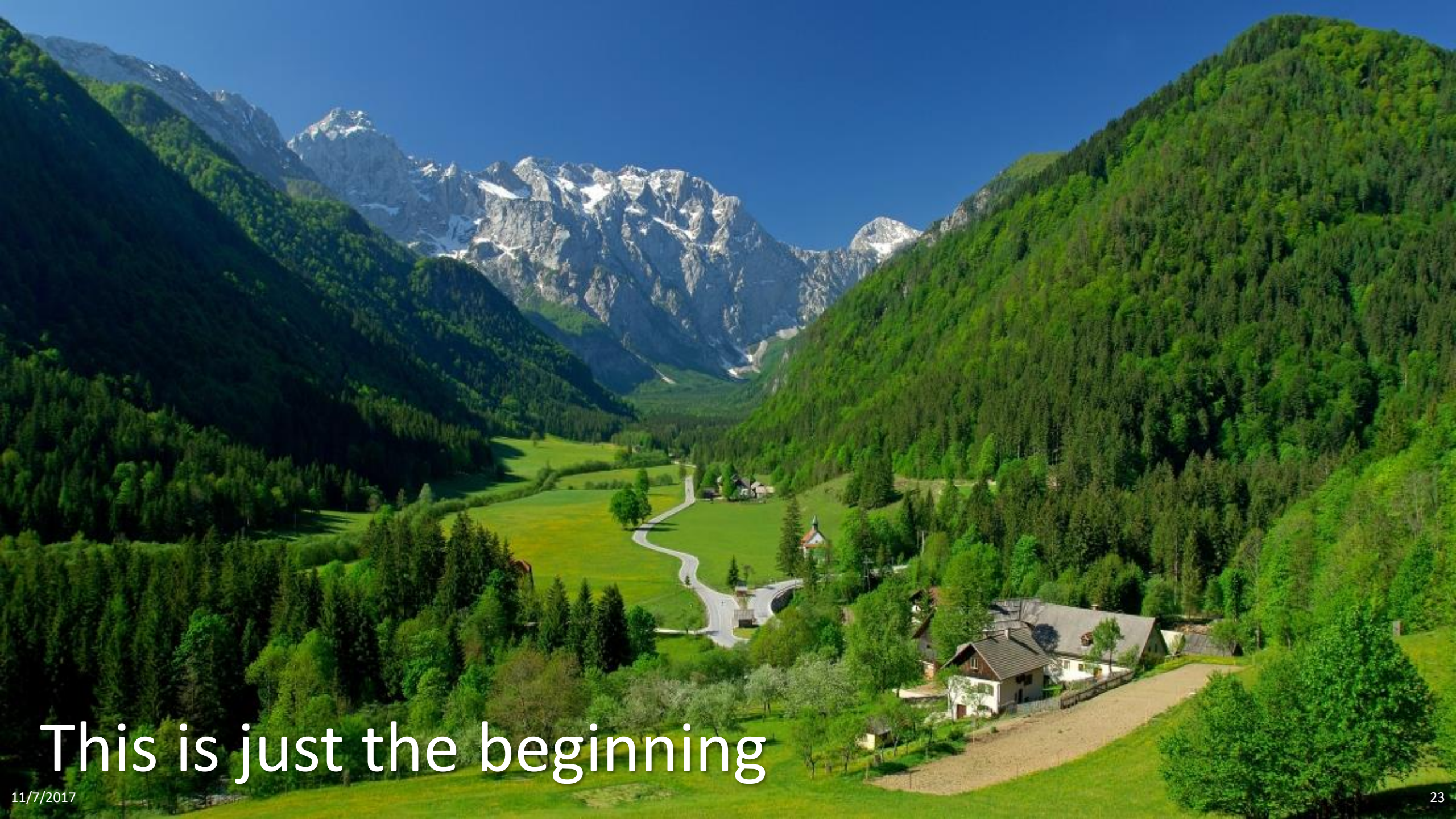


Language Translation

DEMOCRATIZING INNOVATION

- 20 years ago
 - Needed a \$Billion company to influence a billion people
 - Needed the best education; best pedigree
- Now
 - Need a laptop, the internet and free software -- and coffee!
 - Now a kid in Mumbai with ambition can do something groundbreaking
 - The best code libraries are free (Open Source → “GitHub”)
 - The best courses are free (Coursera, YouTube, etc)
 - Venture investors are looking for these start ups
 - Big companies now depend on Startups for innovation

*“I didn’t know that
it wasn’t possible.
So I just did it.”*



This is just the beginning

TECHNOLOGY REVOLUTIONS

TECHNOLOGY REVOLUTIONS

- Silicon/Cloud Revolution
 - Moore's law and exponential effects
- IoT / Sensing revolution
 - World sensing everywhere
- Manufacturing revolution
 - Decreasing cost and size. New devices can go everywhere
- Machine learning revolution
 - Impossible becoming possible

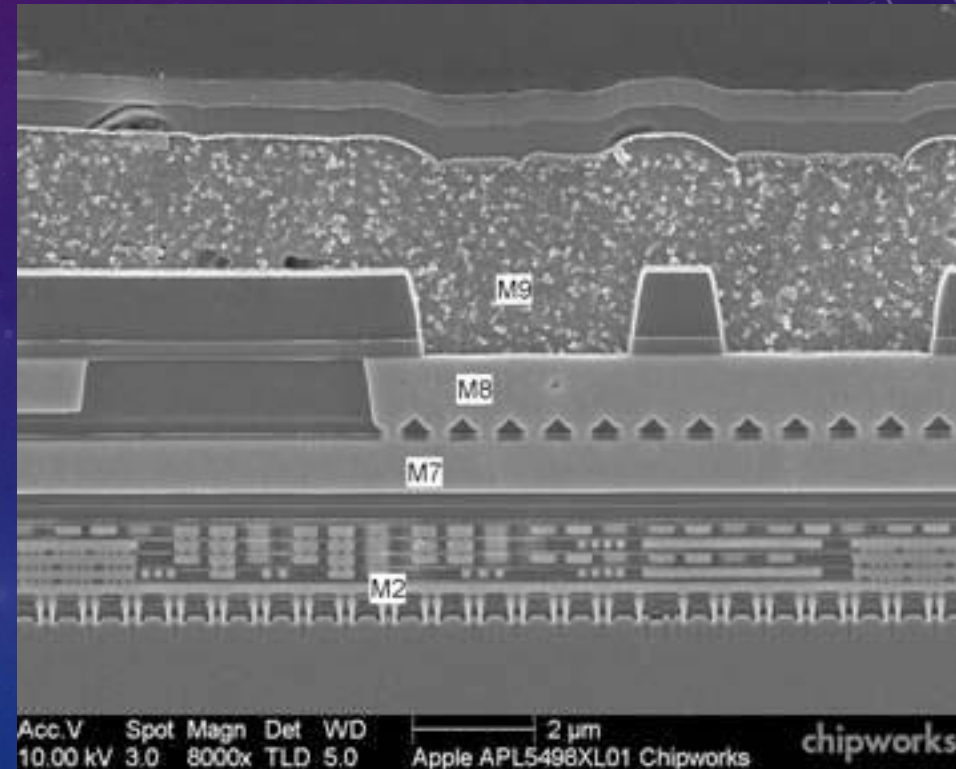
SILICON REVOLUTION



SILICON REVOLUTION



First transistor

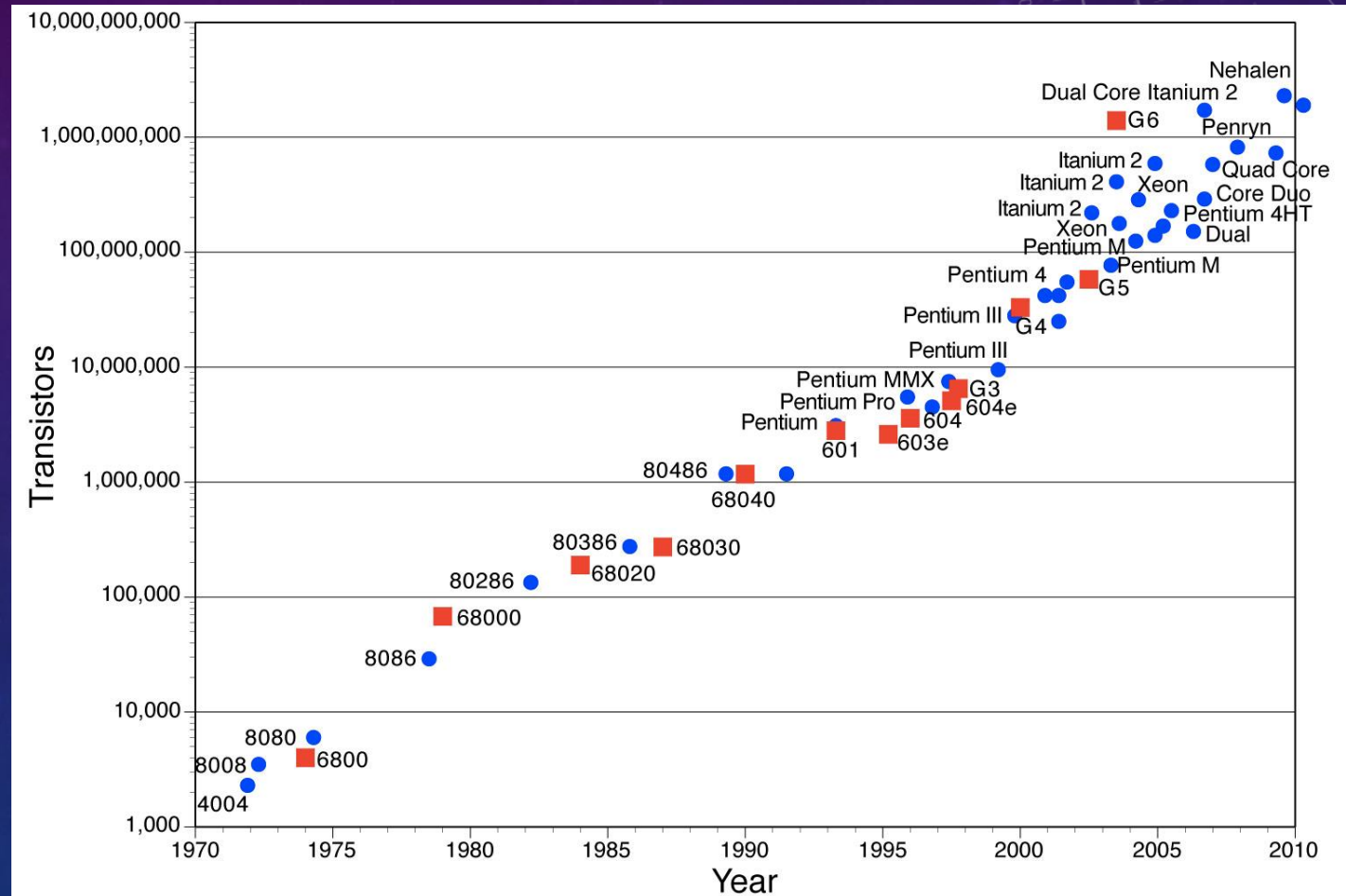


Apple iPhone Processor

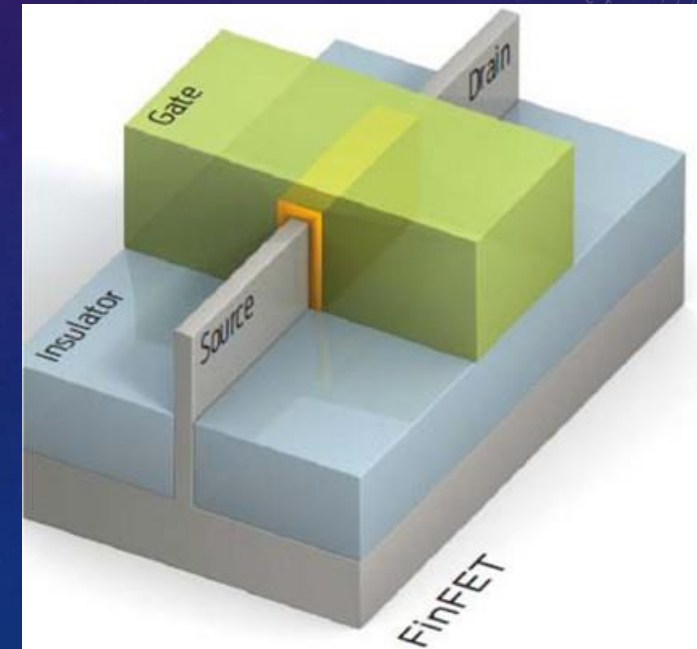
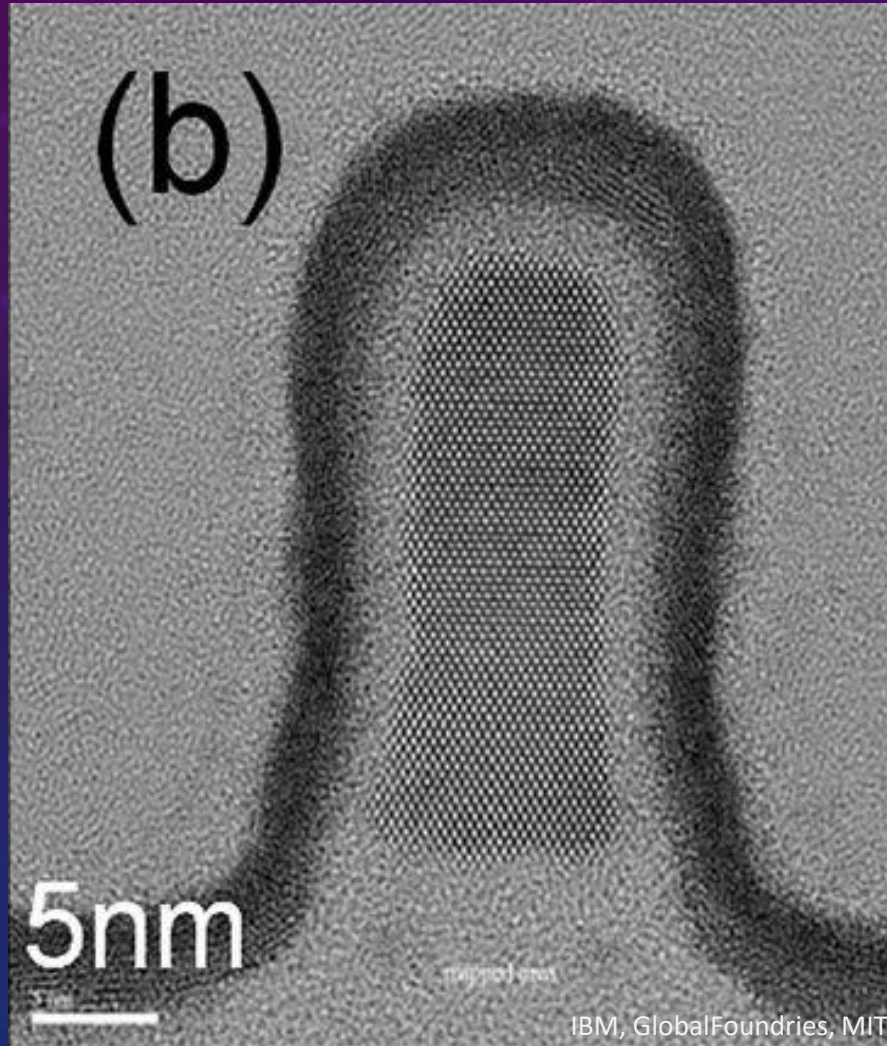
SILICON REVOLUTION

Moore's Law (1965)

- Transistors per chip double every 2 years.



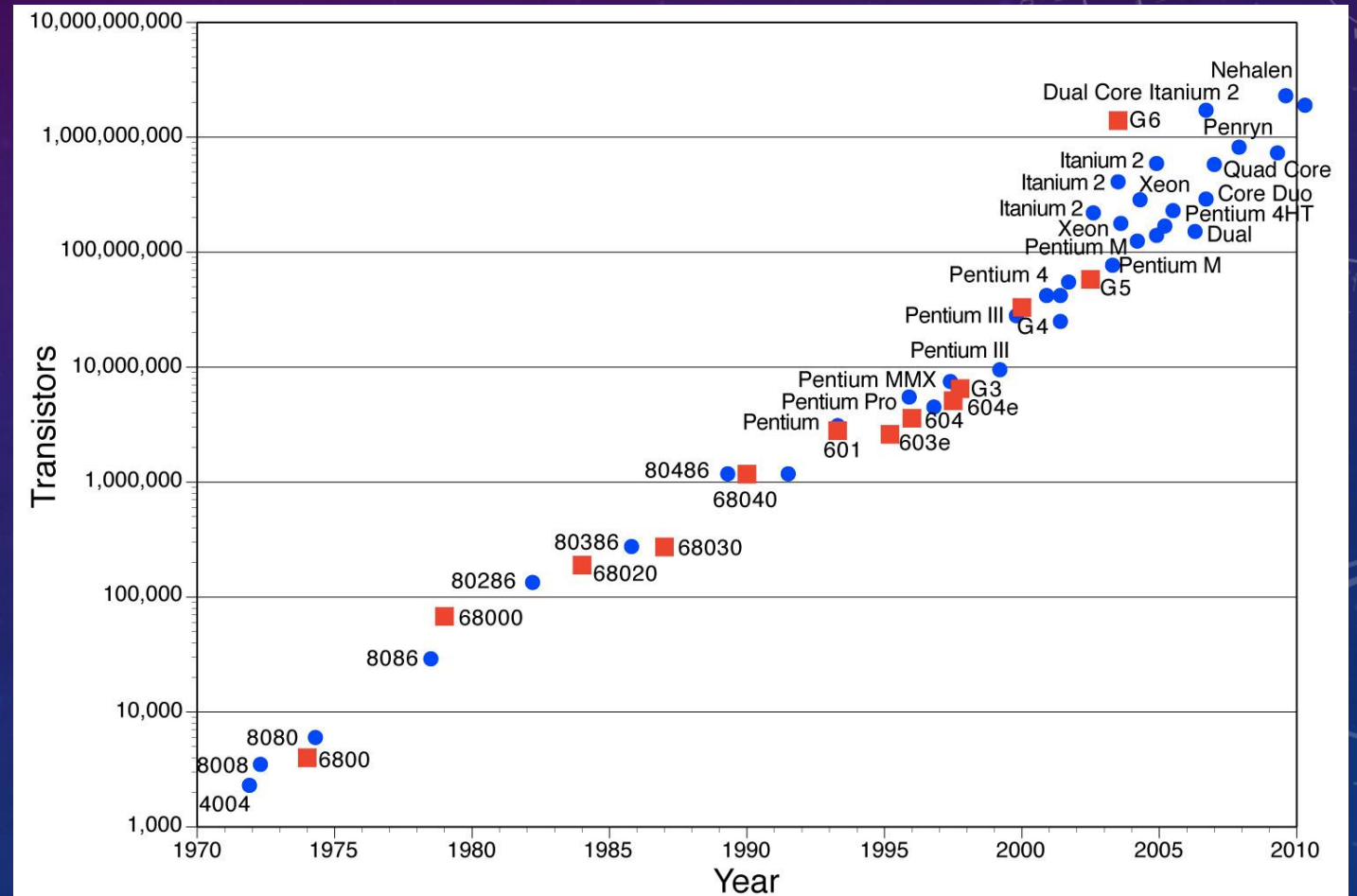
SILICON REVOLUTION



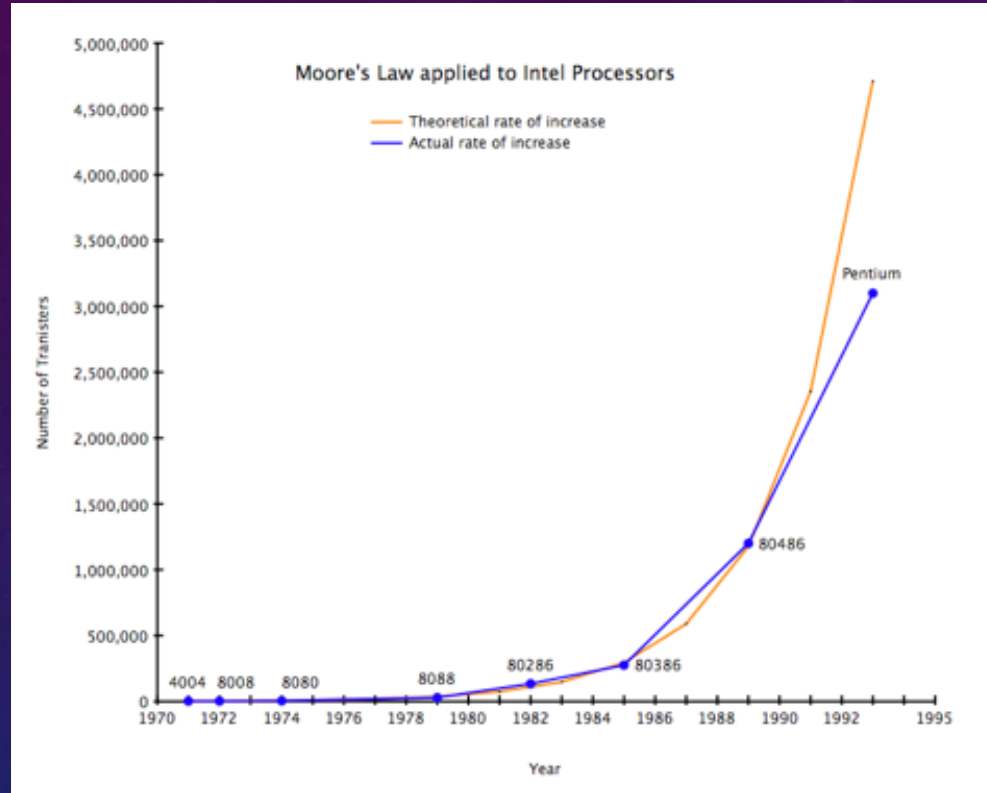
SILICON REVOLUTION

Moore's Law (1965)

- Transistors per chip double every 2 years.



SILICON REVOLUTION: RESULTS



- Results:
 - Enormous computational resources are available now
 - Exponential changes are hard to anticipate
 - New solutions are solving old problems

CLOUD REVOLUTION

- Netflix
- Pinterest
- NASA
- etc



CLOUD REVOLUTION

- AWS: Amazon Web Srvcs
- 2.4 Million servers avail.
- Mid-size server pricing:
 - \$0.01 to \$0.50/hour
- Easy to use
 - Request server(s)
 - Wait to Load instance
 - Ready to go
 - Add instances on demand

The screenshot displays the AWS Management Console interface, specifically the Amazon EC2 Console Dashboard. The top navigation bar includes the AWS logo and a list of services: Elastic Beanstalk, S3, EC2 (highlighted), VPC, CloudWatch, Elastic MapReduce, CloudFront, CloudFormation, RDS, ElastiCache, SNS, and IAM. The user's name, Nick Hardiman, and a Help link are in the top right corner.

The left sidebar contains a 'Navigation' section with a 'Region' dropdown set to 'EU West (Ireland)'. Below this, the 'EC2 Dashboard' is expanded, showing links to INSTANCES (Instances, Spot Requests, Reserved Instances), IMAGES (AMIs, Bundle Tasks), ELASTIC BLOCK STORE (Volumes, Snapshots), and NETWORK & SECURITY (Security Groups, Elastic IPs, Placement Groups, Load Balancers, Key Pairs).

The main content area is titled 'Amazon EC2 Console Dashboard' and is divided into three columns:

- Getting Started:** A yellow box with the text 'To start using Amazon EC2 you will want to launch a virtual server, known as an Amazon EC2 instance.' and a 'Launch Instance' button. A note below states: 'Note: Your instances will launch in the EU West (Ireland) region.'
- My Resources:** A section showing the number of resources in the EU West (Ireland) region. It includes a 'Refresh' button and the following counts: 0 Running Instances, 0 Elastic IPs, 0 EBS Volumes, 0 EBS Snapshots, 0 Key Pairs, 1 Security Group, 0 Load Balancers, and Not Supported.
- Service Health:** A section showing the status of the Amazon EC2 service. It includes a 'Service Status' table and an 'Availability Zone Status' table.

Service Status Table:

Current Status	Details
✓ Amazon EC2 (EU - Ireland)	Service is operating normally

[View complete service health details](#)

Availability Zone Status Table:

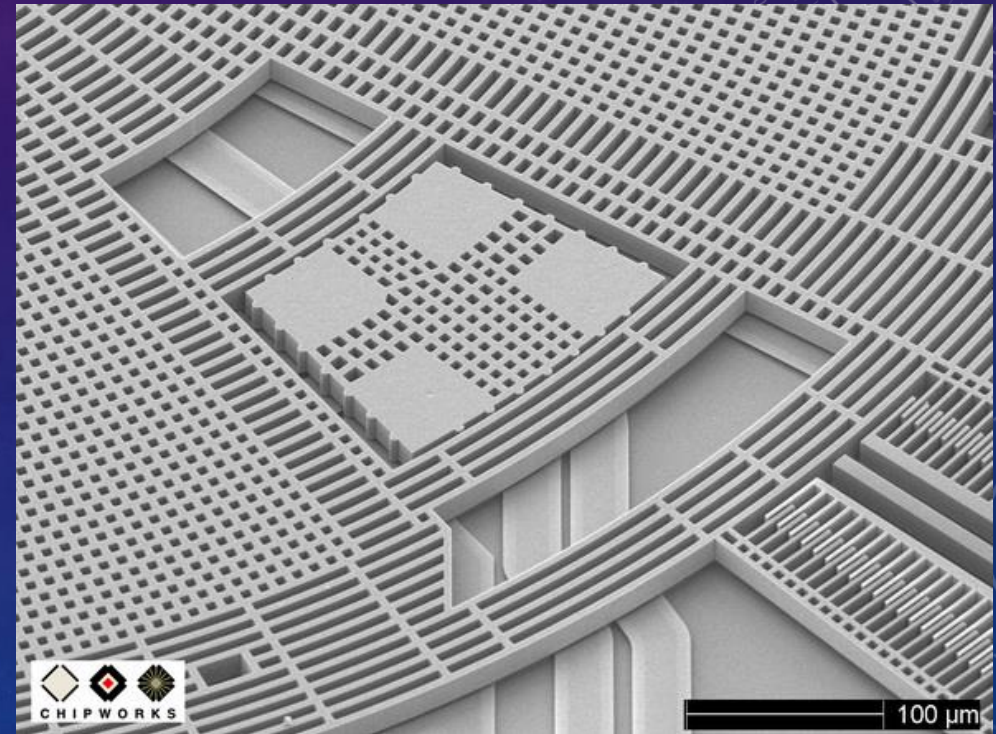
Current Status	Details
✓ eu-west-1a	Availability zone is operating normally
✓ eu-west-1b	Availability zone is

Related Links:

- > Documentation
- > All EC2 Resources
- > Forums
- > Feedback
- > Report an Issue

INTERNET OF THINGS/ SENSING REVOLUTION

WORLD SENSING EVERYWHERE



SENSING REVOLUTION



Our world is defined by what we sense:
vision, touch, smell, taste and smell.

SENSING REVOLUTION



www.dailymail.co.uk

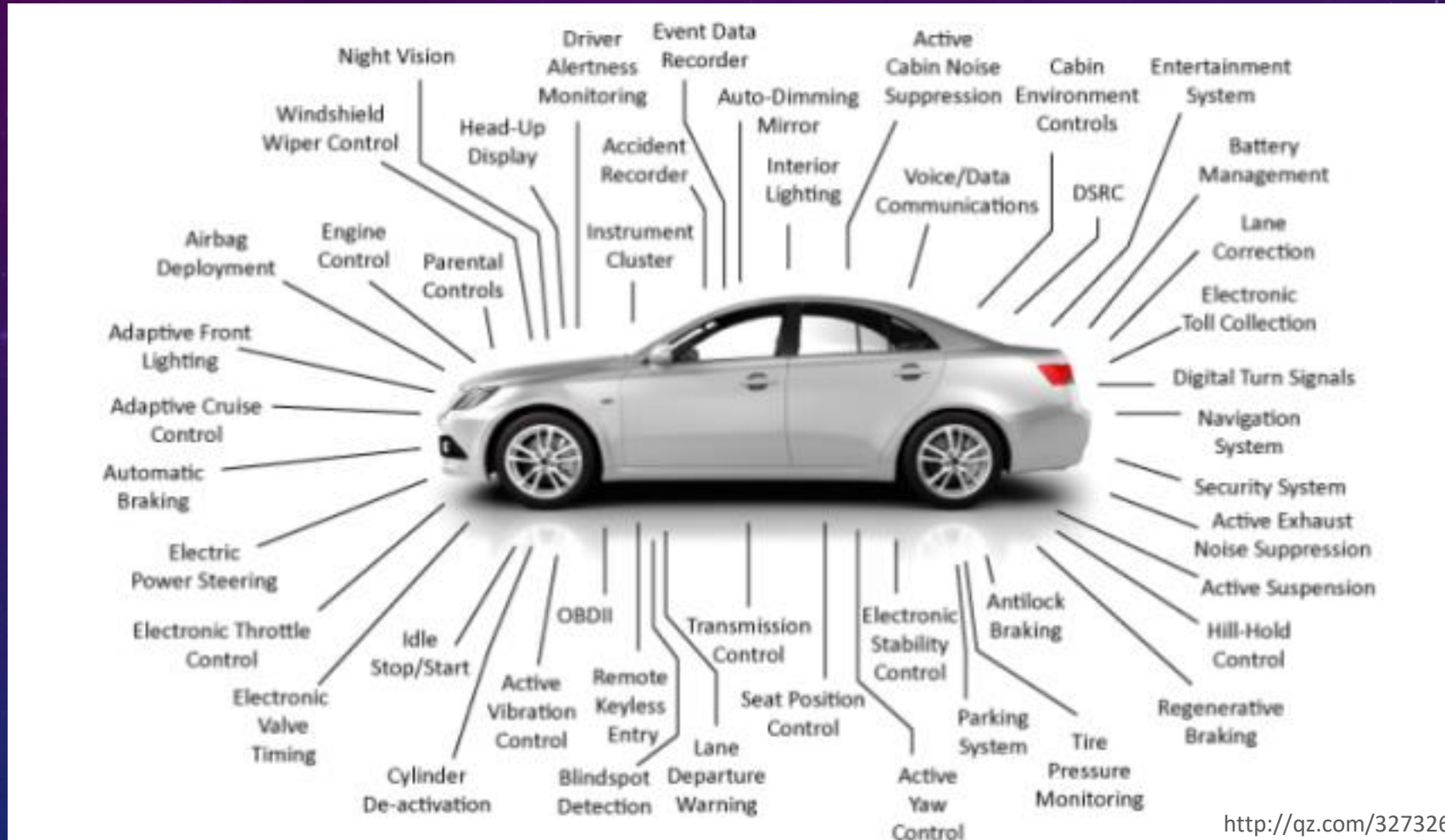
SENSING REVOLUTION : PHONES



apple.com

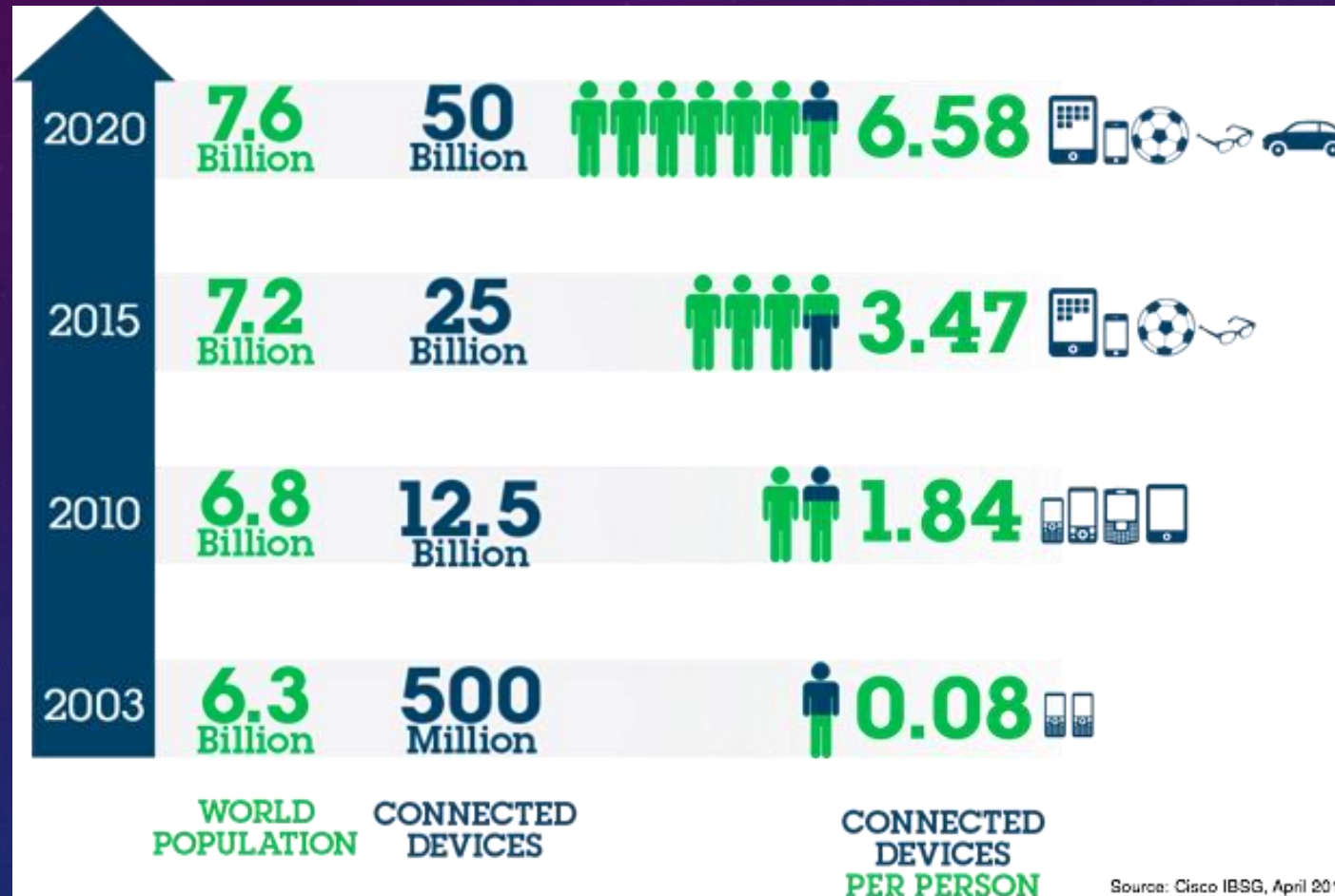
- 25 sensors
 - Accelerometer, Magnetometer, Gyro, Barometer, Humidity, GPS, WiFi, Bluetooth, LTE, NFC, Touch screen, buttons, fingerprint sensor, ALS, Optical Proximity, Camera front, Camera back, Temperature, Microphone x 3, Ultrasonic Gesture, Colorimeter, Heart Rate PPG, Magnetic cover switch

SENSING REVOLUTION : CARS



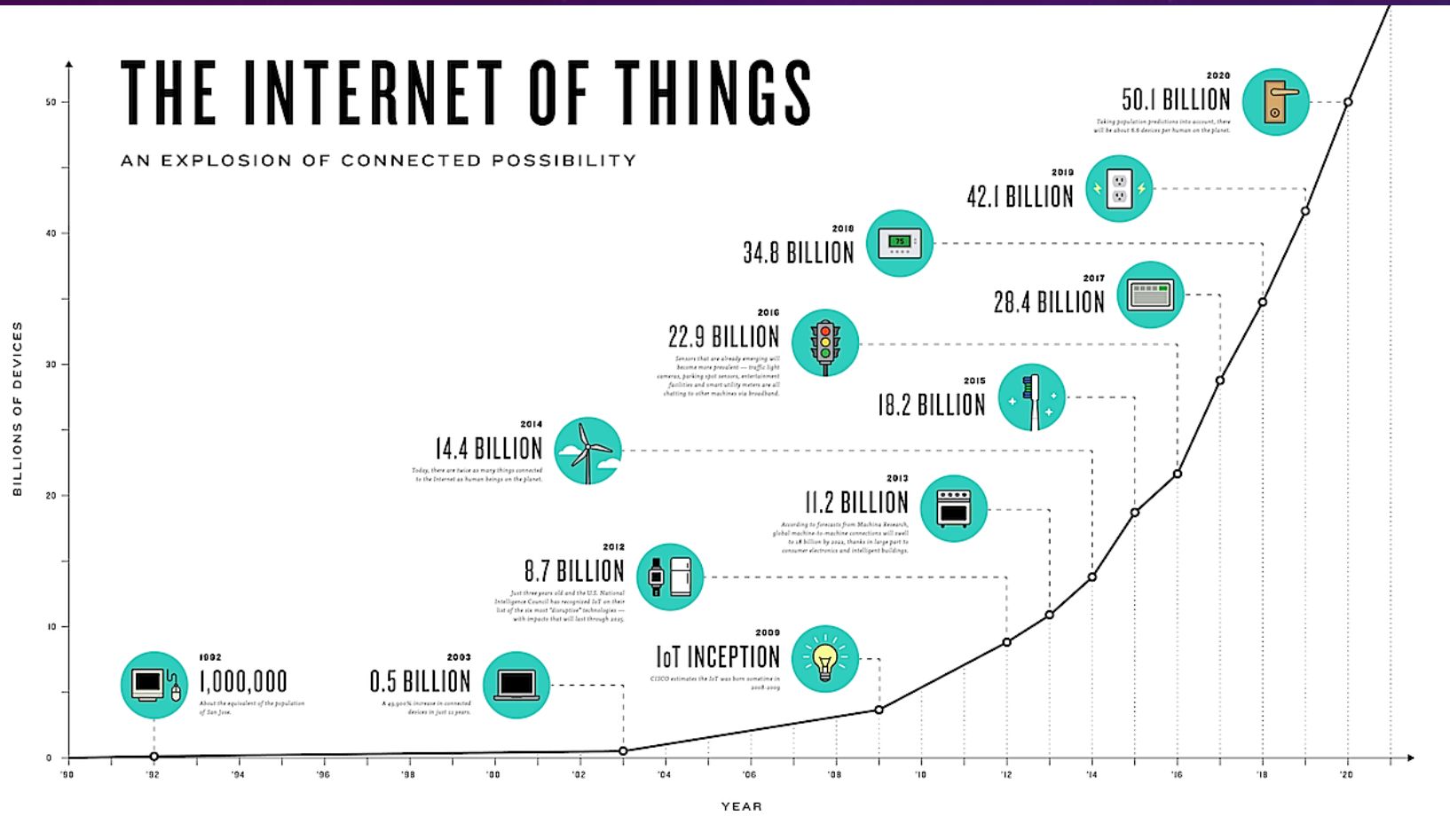
<http://qz.com/327326>

INTERNET OF THINGS



THE INTERNET OF THINGS

AN EXPLOSION OF CONNECTED POSSIBILITY



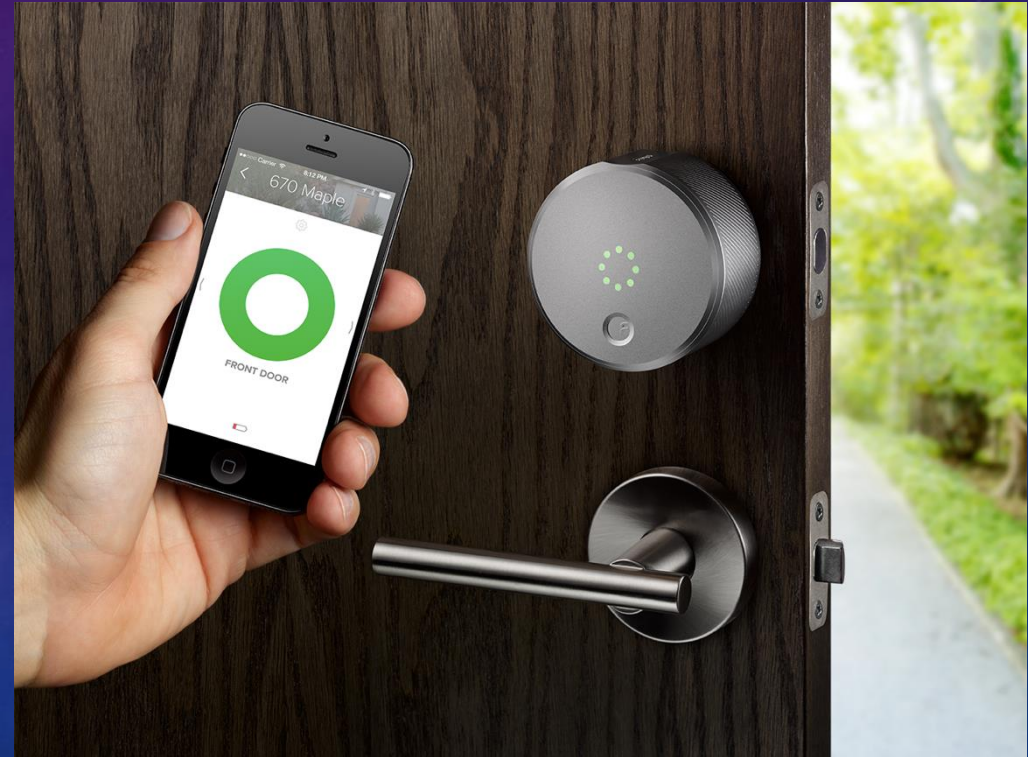
Where
do all
these
devices
go?

DOOR KNOBS

Manual



IoT Enabled



TRASH

Manual



IoT Enabled



“Philadelphia...has been able to reduce the number of weekly garbage-collecting shifts from 17 to just three, and realize \$1 million a year in savings on fuel, maintenance and labour costs” – Globe & Mail

YOUR HOME

Living Room...



...voice enabled.



DELIVERY

Truck



Truck + Drone



MEDICAL

Manual



Automatic



UTILITY METER

Manual



Digital / Wireless



LIGHT BULBS

Incandescent bulb + 120V



LED + Sensor + UPOE (+LiFi?)



AUTOMOBILES

Old



New

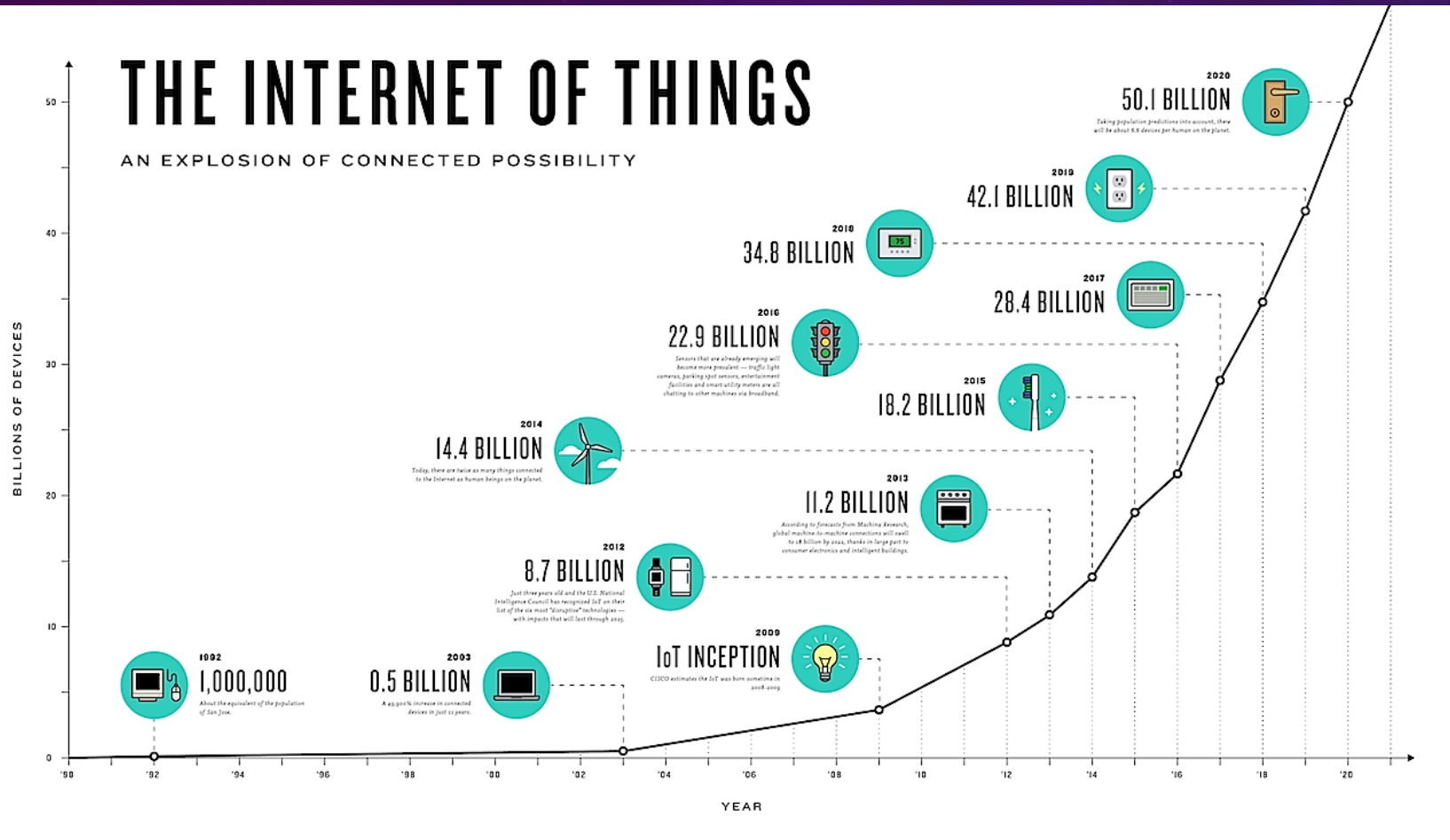


AGRICULTURE



THE INTERNET OF THINGS

AN EXPLOSION OF CONNECTED POSSIBILITY



Where
do all
these
devices
go?

WHAT IoT IS



- Relatively small
- Battery/Solar powered
- Sensor-based
- Remotely administered
- No User interface
- Limited network comms

UBIQUITOUS COMPUTING

“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”

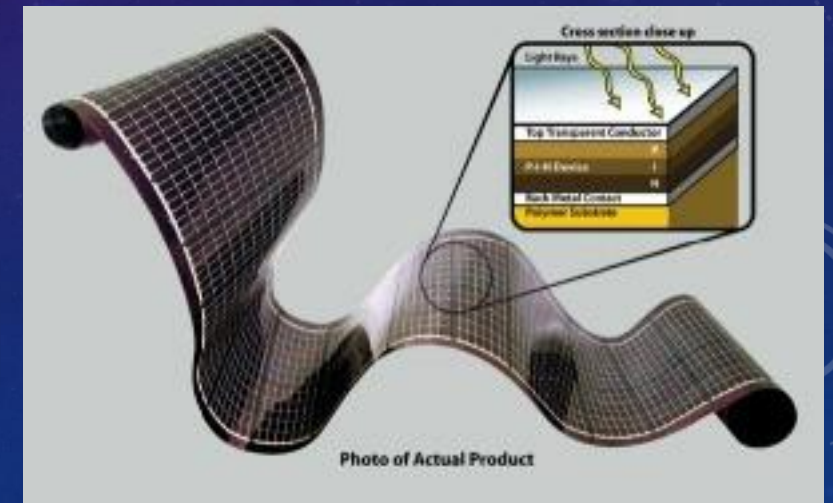
-Marc Weiser, CTO Xerox PARC 1991

...ARE THOSE THAT DISAPPEAR.



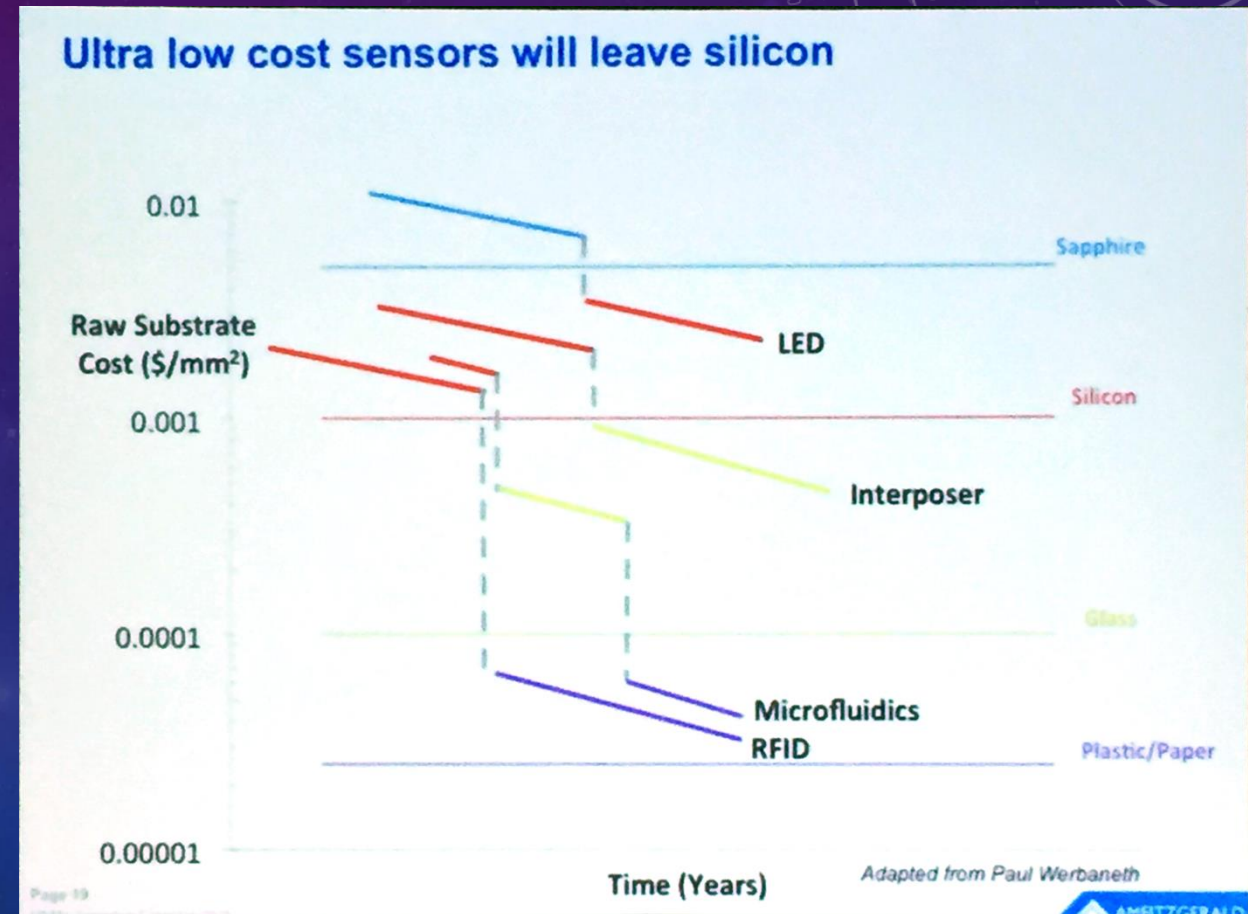
MANUFACTURING REVOLUTION

Decreasing cost and size. New devices can go everywhere.

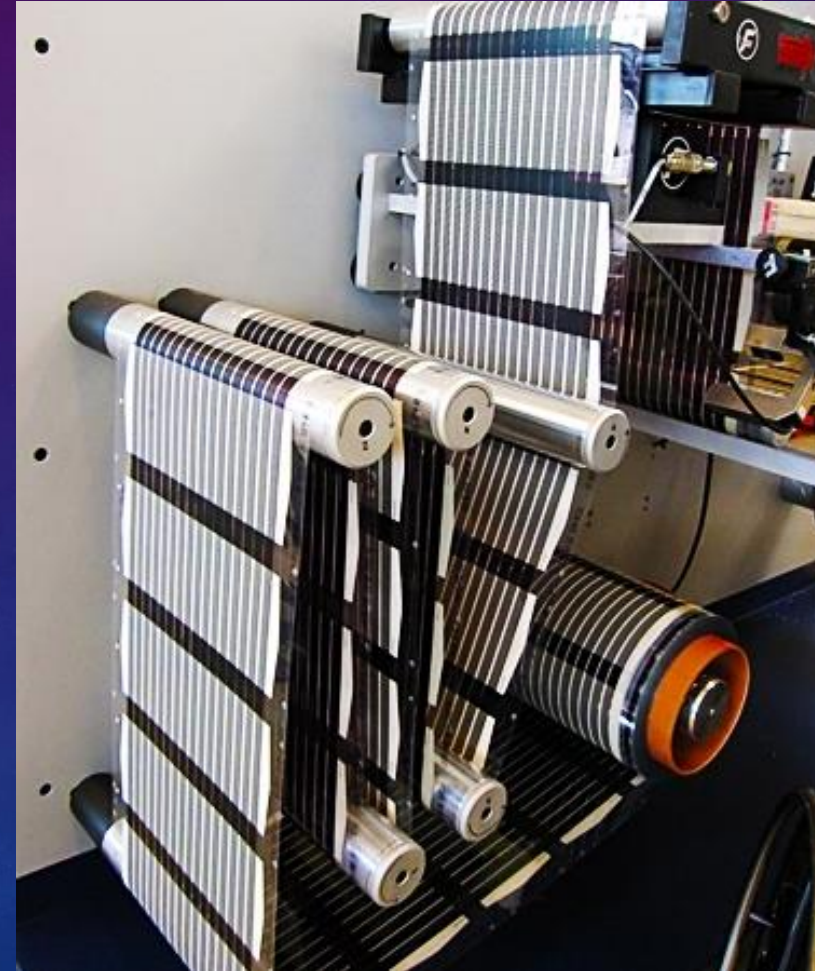
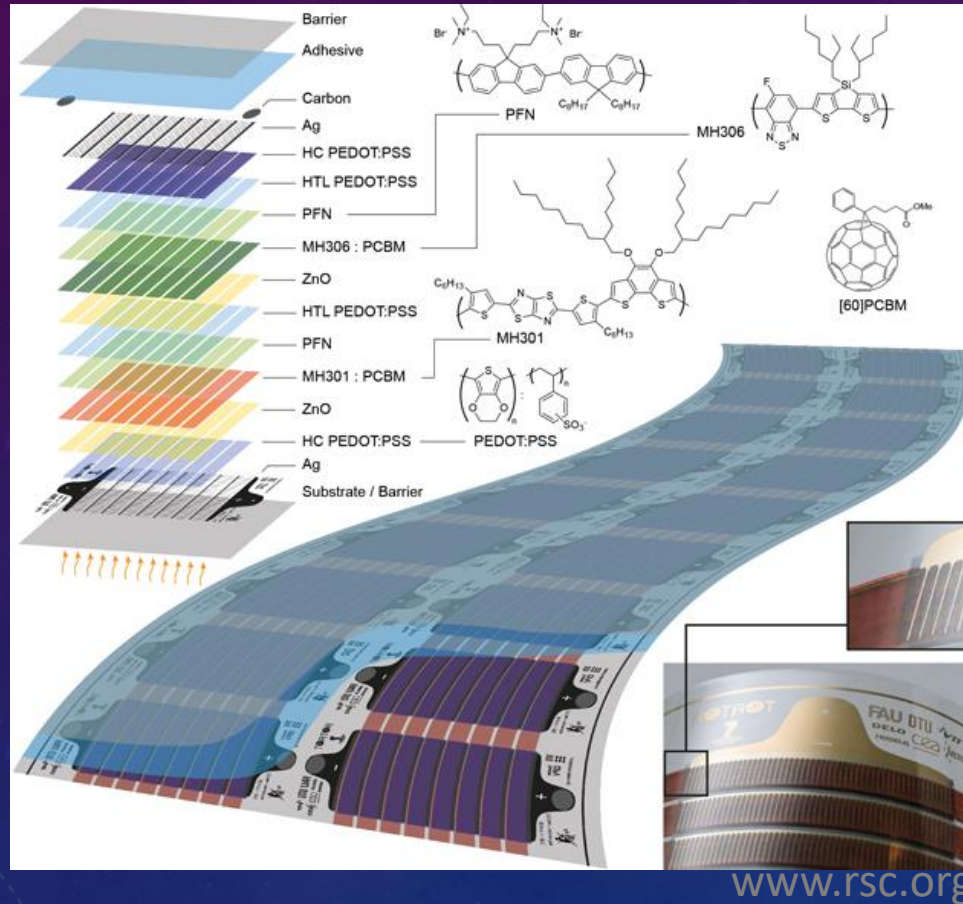


MANUFACTURING REVOLUTION

- Silicon is dominant for performance, but not cost
- Major efforts for Paper/Plastic substrates
- Requires new manufacturing infrastructure

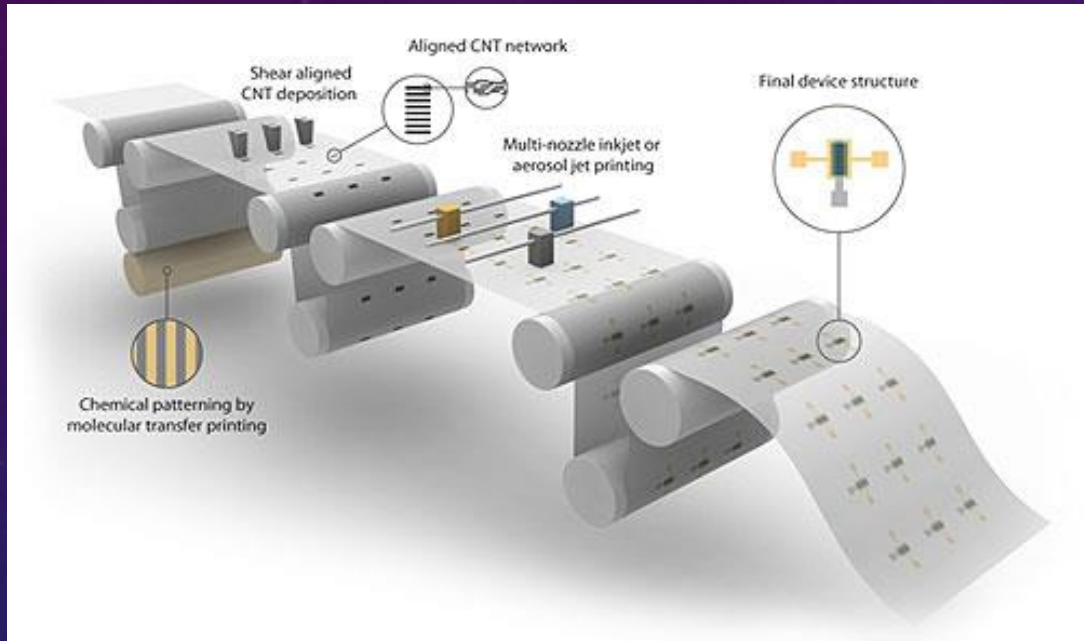


MANUFACTURING REVOLUTION

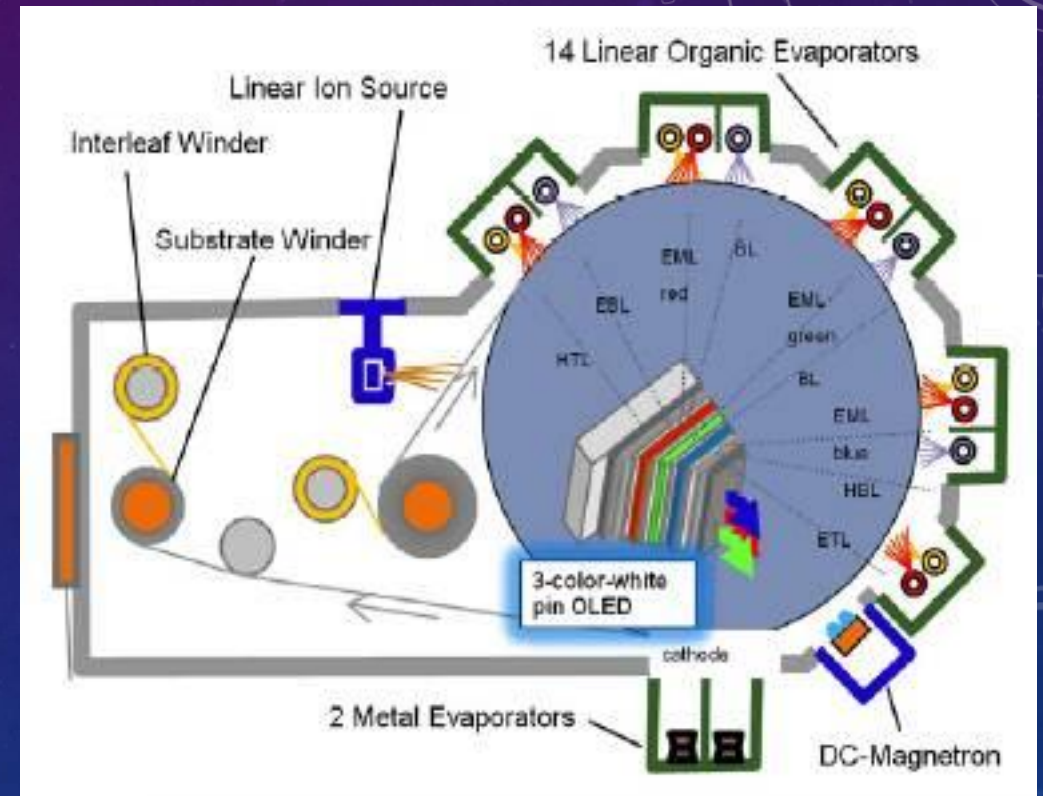


Organic Solar Cells using Roll-to-Roll mfrg

MANUFACTURING REVOLUTION



Ink Jet printed electronics



OLED evaporators

MANUFACTURING REVOLUTION

- Roll-to-Roll electronics poised for use in consumer packaging
 - OLED labels that illuminate only when a bottle is open.
 - Paper soda cups that light up when filled (“Coca-cola!”)



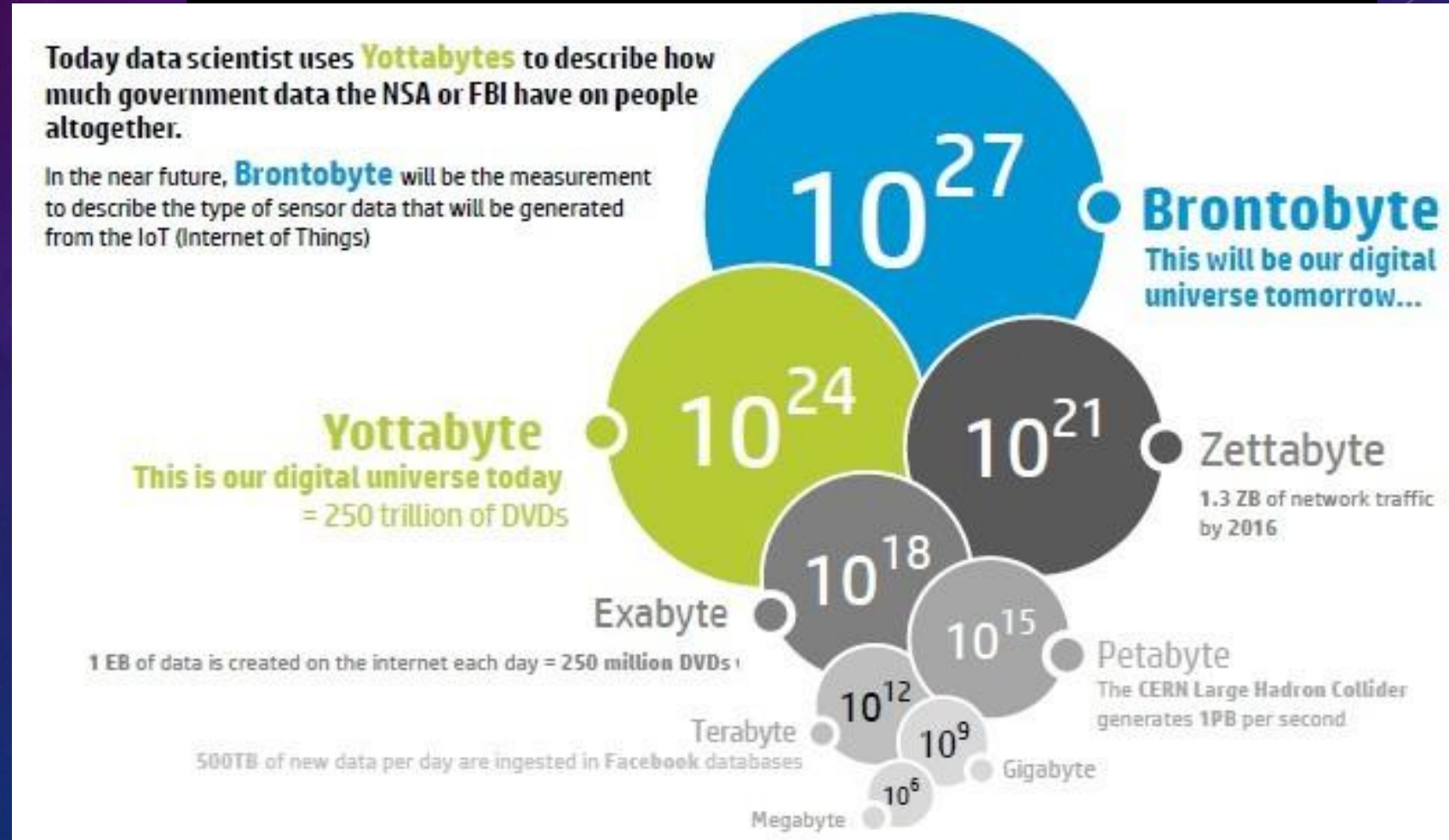
MANUFACTURING REVOLUTION

- Traditional Silicon technology is good for performance, not cheap enough for packaging and bottling
- New roll-to-roll technologies will reduce cost one or two orders of magnitude
- Packaging, signage and labelling could see major changes

MACHINE LEARNING REVOLUTION

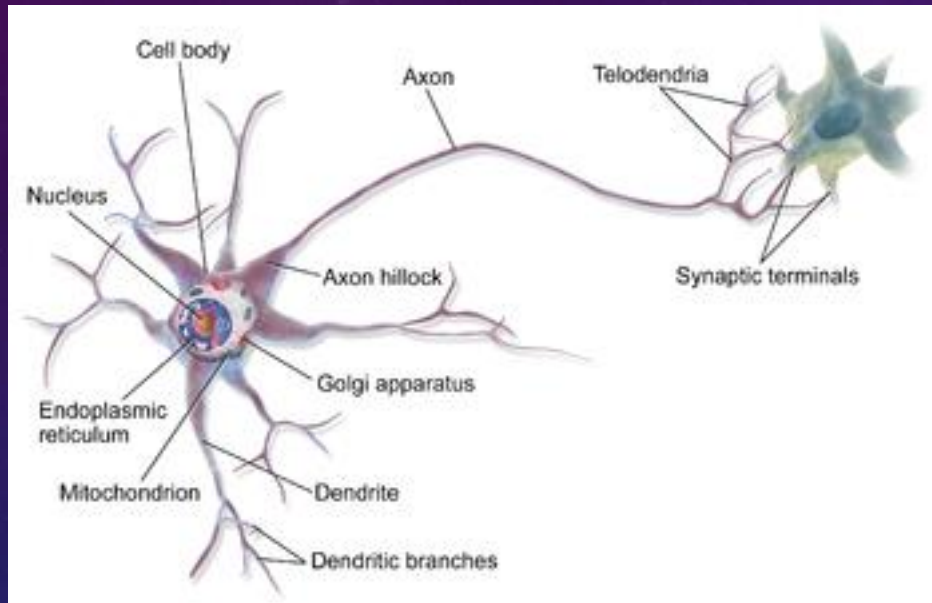
SO WHAT'S THE PROBLEM?

- We've got data.
A lot of data!
- No, really a
lot of data!

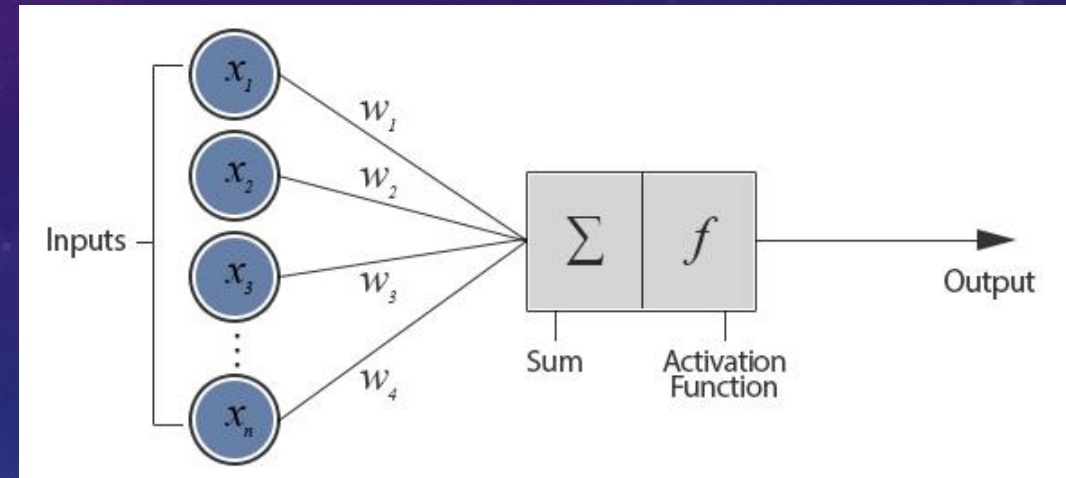


MACHINE LEARNING REVOLUTION

Biological Neuron

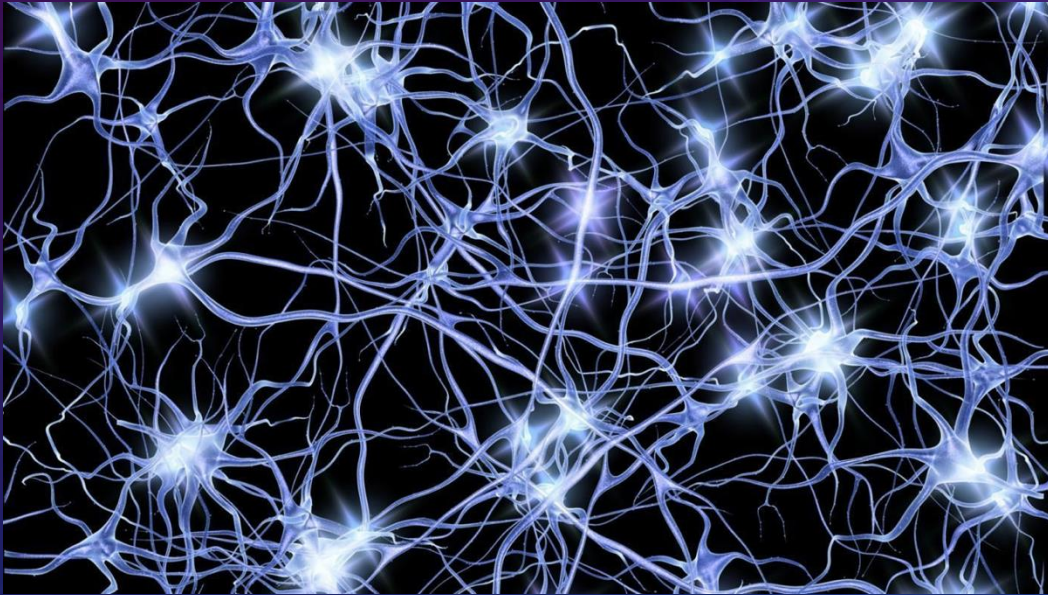


Artificial Neuron

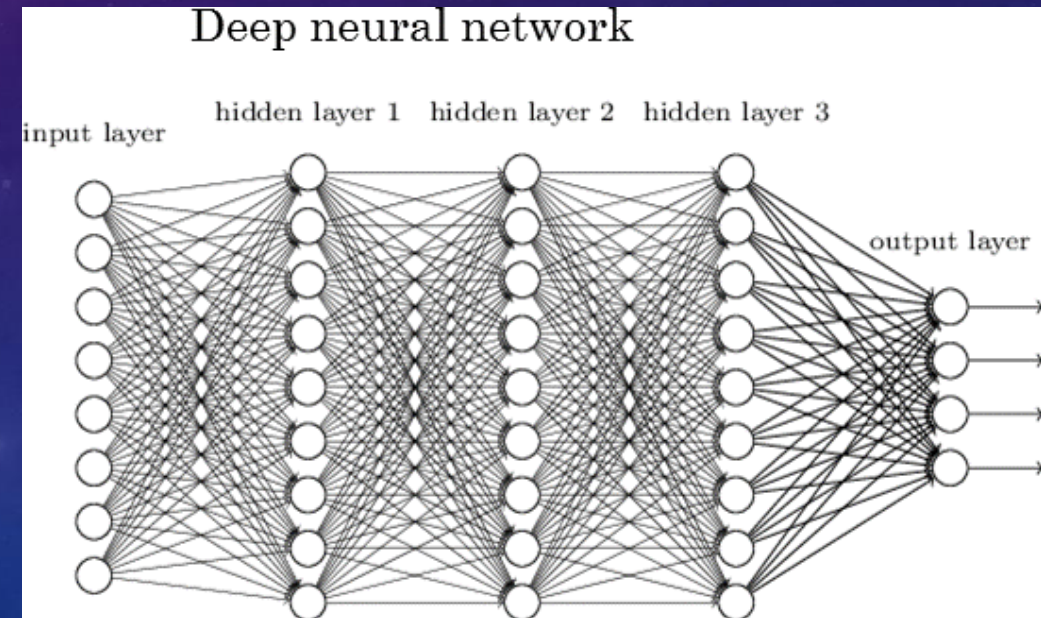


MACHINE LEARNING REVOLUTION

Biological Deep Neural Net



Artificial Deep Neural Net (DNN)



MACHINE LEARNING REVOLUTION

Training a DNN with War And Peace by Tolstoy. First 100 iterations. ([Karpathy](#), RNNs)

```
tyntd-iafhatawiaoighrdemot lytdws e ,tfti, astai f ogoh eoase rrranbyne 'nhthnee e  
plia tklrqd t o idoe ns,smtt h ne etie h,hregtrs nigtkie,aoaenns lng
```

At 300 iterations.

```
"Tmont thithey" fomesscerliund  
Keushey. Thom here  
sheulke, anmerenith ol sivh I lalterthend Bleipile shuw y fil on aseterlome  
coaniogennc Phe lism thond hon at. MeiDimorotion in ther thize."
```

At 500 iterations.

```
we counter. He stutn co des. His stanted out one ofler that concossions and was  
to gearang reay Jotrets and with fre colt of f paitt thin wall. Which das stimn
```

MACHINE LEARNING REVOLUTION

- Tolstoy training (cont)

At 1200 iterations.

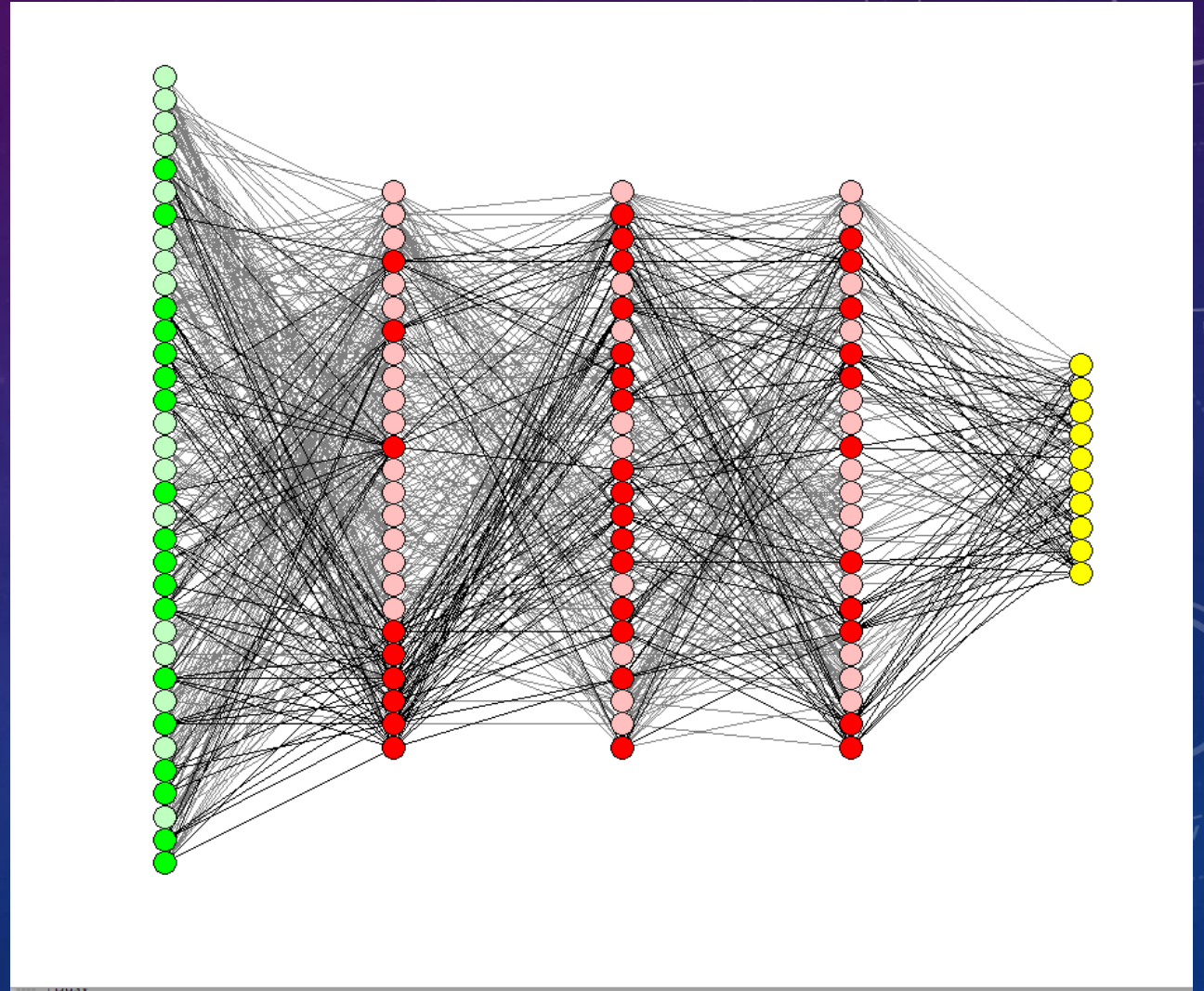
"Kite vouch!" he repeated by her door. "But I would be done and quarts, feeling, then, son is people...."

At 2000 iterations.

"Why do what that day," replied Natasha, and wishing to himself the fact the princess, Princess Mary was easier, fed in had oftended him. Pierre aking his soul came to the packs and drove up his father-in-law women.

MACHINE LEARNING REVOLUTION

- Is there any magic here?
 - Any soul? Or consciousness?
- No! Just some mathematics
 - Optimizations and matrix math



REVOLUTION IN ALGORITHMS



+

DATA



Traditional Programming
Methodology



+



+



+



Machine Learning
Methodology

EXPONENTIAL DISRUPTION



Robotics



Virtual Reality



Books



Medicine



Delivery / Fast Food



Self-driving cars

Industrial
Manufacturing



Language Translation

MACHINE LEARNING

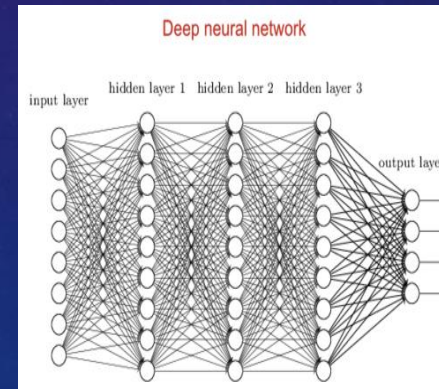
- Why now?
- The Perfect Storm of factors:
 - Dense chips + cloud compute + ML algo + large data sets



+



+



+

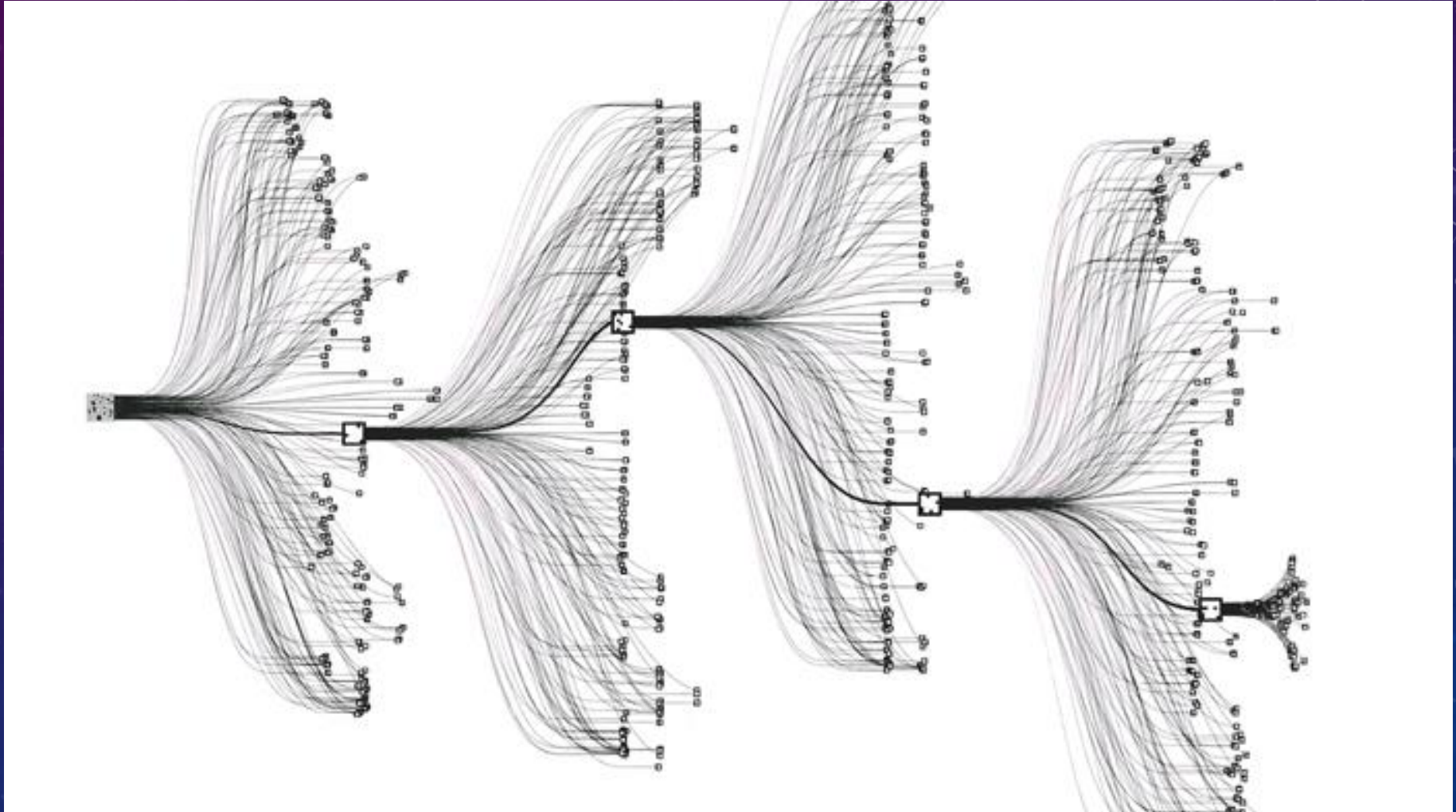


EXAMPLE: GAME OF GO



- Go is a 2,500 year old game
- Board is 19x19 (= 361)
- Time to master the game is 20-30 years.
- Expected to take 20 more years before computers can solve the game

EXAMPLE: GAME OF GO



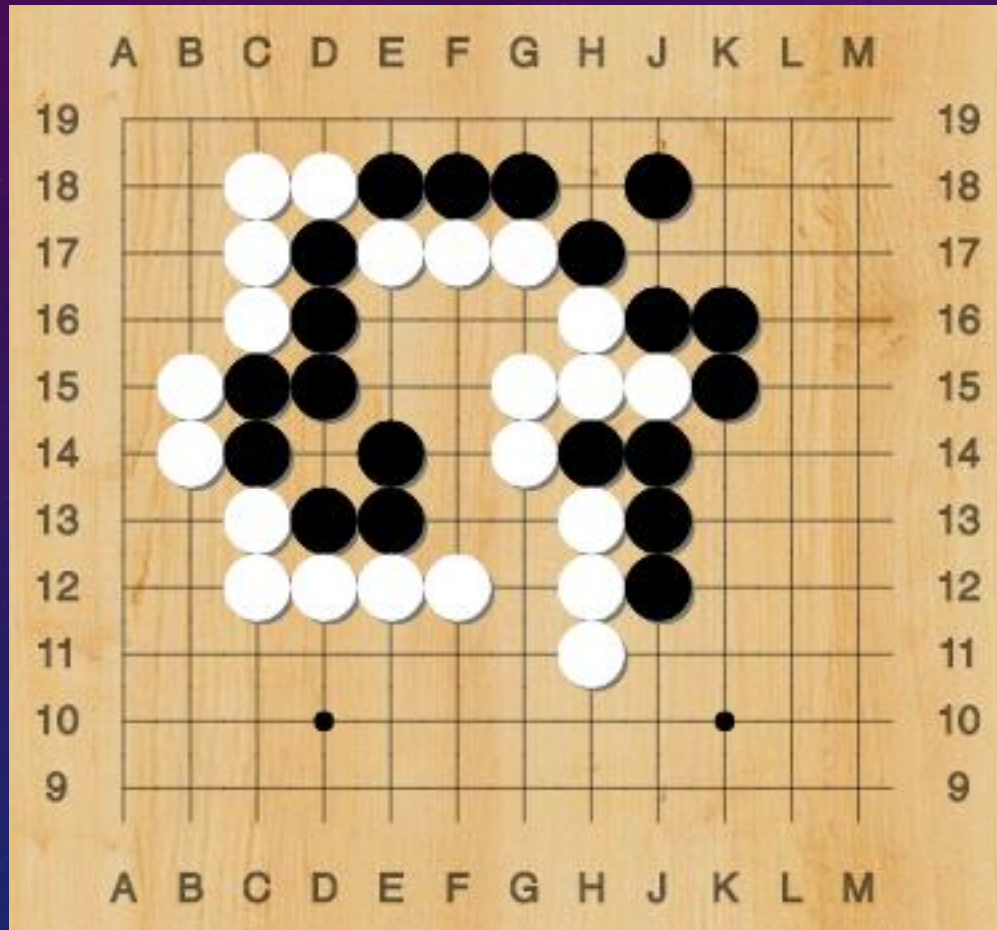
EXAMPLE: GAME OF GO

- # of moves = 2.0×10^{170}
- =2081681993819799846994
78633344862770286522453
88453054842563945682092
74196127380153785256484
51698519643907259916015
62812854608988831442712
97153193175577366203972
47064840935 moves
- Computationally impossible



Aside: there are 10^{80} atoms on the universe

EXAMPLE: GAME OF GO



- We see patterns & shapes
 - Called “good shape”
- Humans just see the answer...
 - ...and then rationalize why we think its right.

EXAMPLE: GAME OF GO

- The Team from Google trained an algorithm to see patterns
 - Using new Machine Learning algo
 - Library of 150,000 games and 30 Million moves
 - 2000 Processors + 280 GPUs
- Results: In March, AlphaGo won 4 of 5 games



Google's AlphaGo vs Korea's Lee Sedol

”I see AlphaGo not as a revolutionary breakthrough in itself, but rather as the leading edge of an extremely important development: the ability to build systems that can capture intuition and learn to recognize patterns.” - Michael Nielsen



THE NEW BEGINNING

THE NEW BEGINNING



THE NEW BEGINNING

- 5 Billion phones
- 7 Billion people → 9 Billion
- 20 Billion devices → 50 Billion
- 5-10 Million cell towers/stations
 - Soon to have satellite internet
- 100,000,000,000 web clicks per day
- 10,000,000,000,000,000,000,000 or 10^{21} transistors
- We are now connected every minute of every day



THE NEW BEGINNING

*The Internet is
the largest structure in
the history of mankind*



JOBS WILL BE DIFFERENT



SKILLS WILL BE DIFFERENT



THE NEW BEGINNING

The Second Machine Age

- New playing field
- New machines
- New jobs
- New opportunities



OPPORTUNITIES FOR PANAMA

EDUCATION

Old



Old World Education

New



Learn Anywhere; anytime; any topic
Tynker; CodeAcademy; Coursera
StackOverflow/StackExchange

SOFTWARE/APP DEVELOPMENT

Old



Code Farm



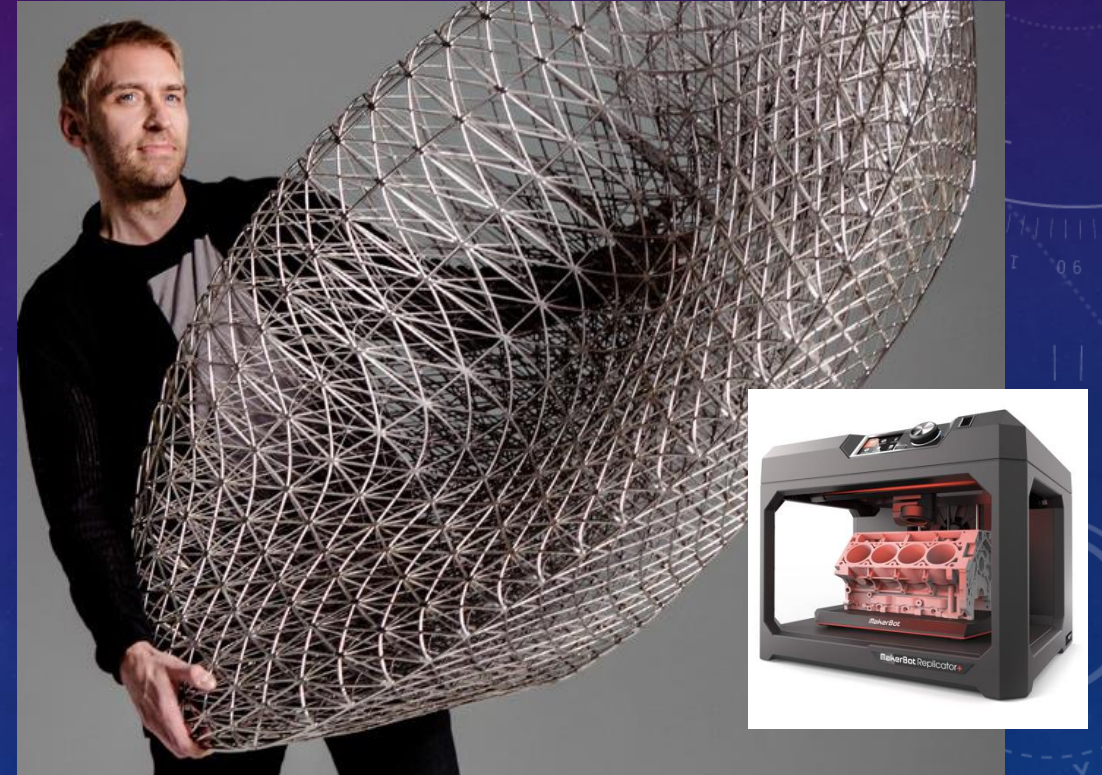
Small team startup; new apps
Code Cafe

3D PRINTING

Old



Expensive manufacturing



Novel designs; low cost

IoT: INTERNET OF THINGS

Old

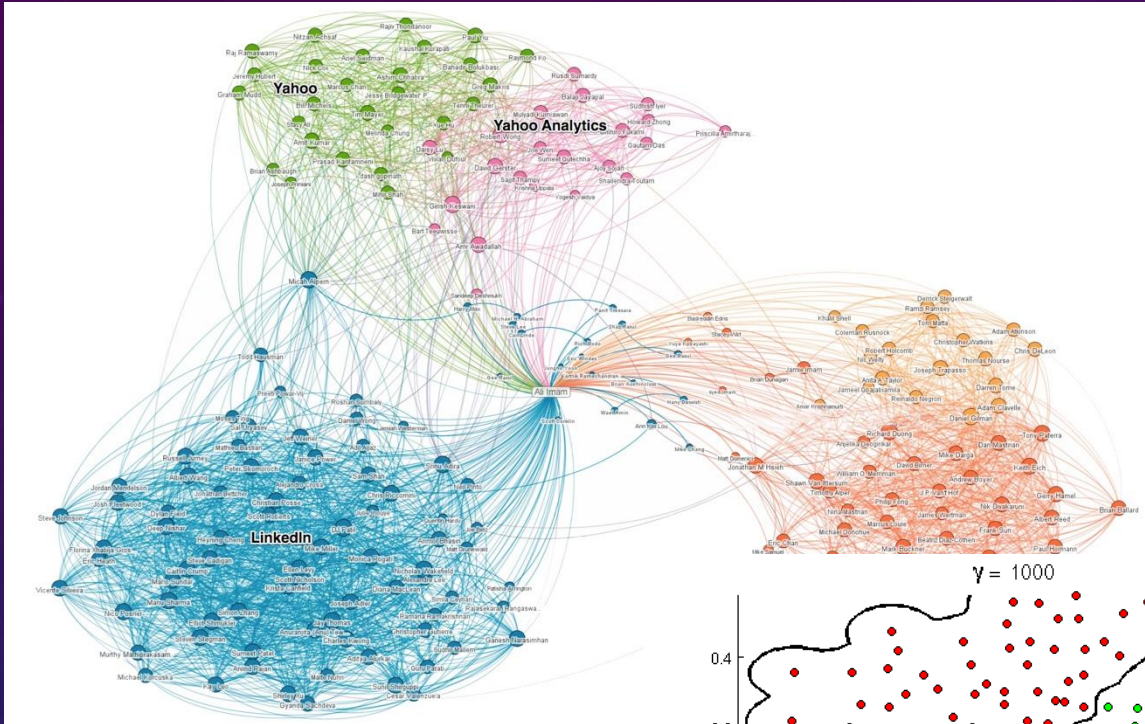


Appliances; established markets

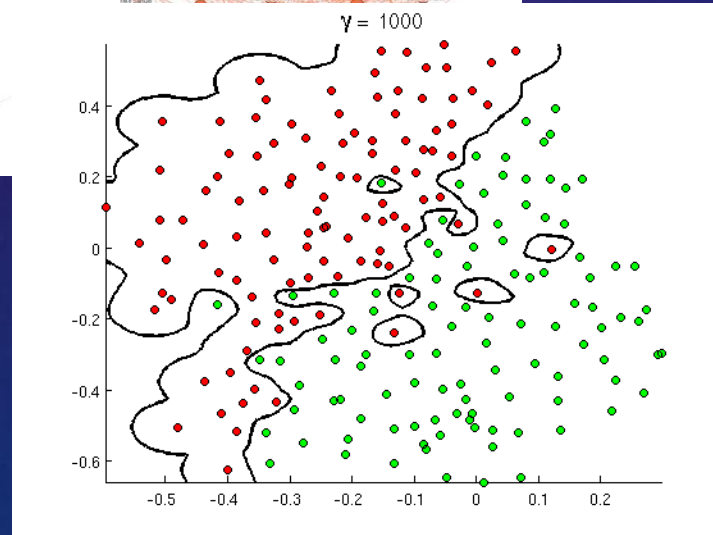


Novel devices; new markets

MACHINE LEARNING / ARTIFICIAL INTELLIGENCE



Data shown in 3D Cluster map



Machine Learning Library



Python Programming Language

OPPORTUNITIES

- Opportunity goes to
 - Who want to learn
 - Who want to building something (Makers)
 - With fast internet and computers
 - With Support infrastructure
 - Startup incubators; hacker spaces; Hack-a-thons
 - With like-minded teams

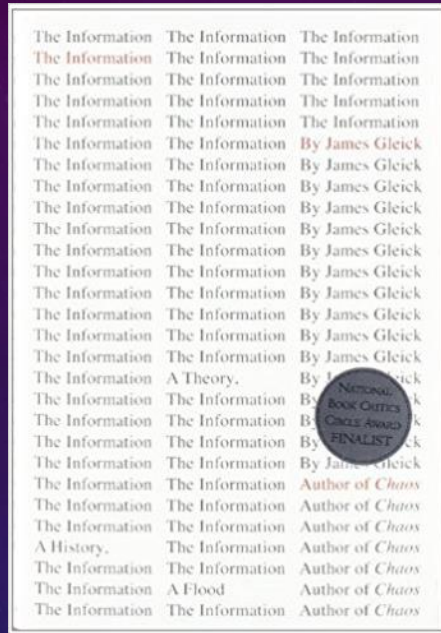
A high-angle, wide shot of a mountain valley. In the foreground, a winding asphalt road curves through a lush green field. To the right, a small cluster of traditional European-style houses with dark roofs and light-colored walls is nestled among trees. The middle ground is dominated by dense, vibrant green forests covering the steep slopes of the valley. In the background, majestic, rugged mountain peaks rise sharply, their upper reaches covered in patches of snow and partially shrouded in a light mist. The sky is a clear, deep blue.

WHERE IS TECHNOLOGY GOING?

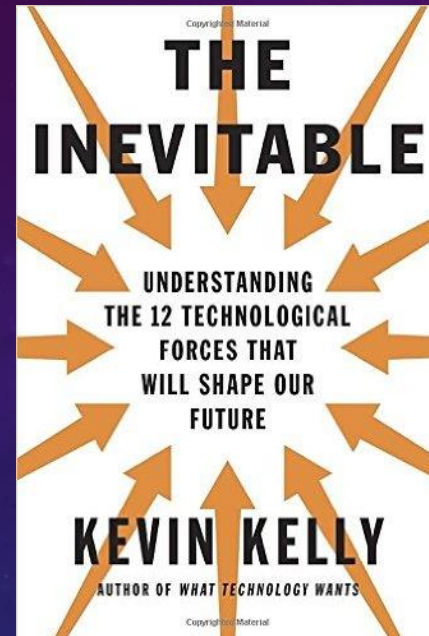


WHERE IS TECHNOLOGY GOING?

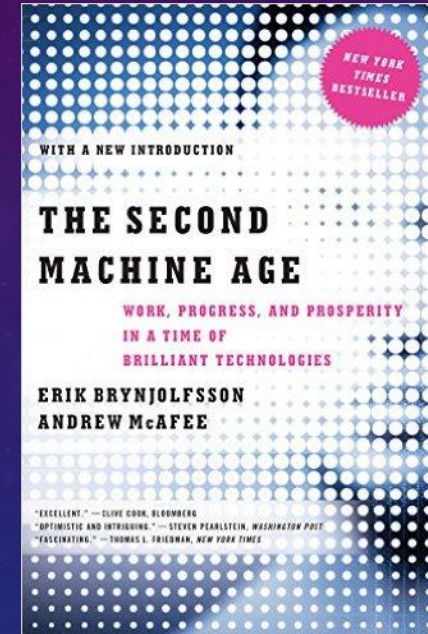
INTERESTING BOOKS



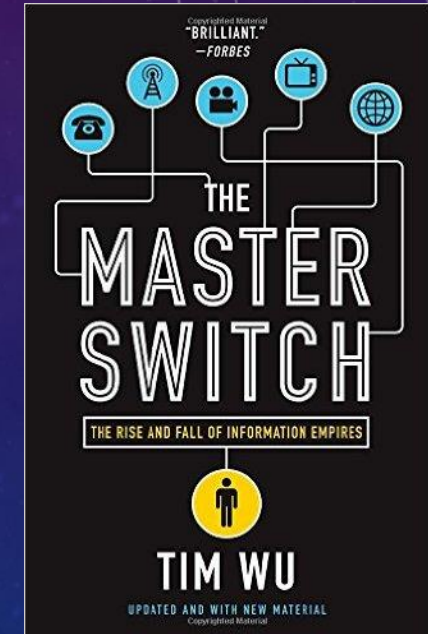
“The Information”
by James Gleick



“The Inevitable”
by Kevin Kelly



“The Second
Machine Age”
by Erik Brynjolfsson

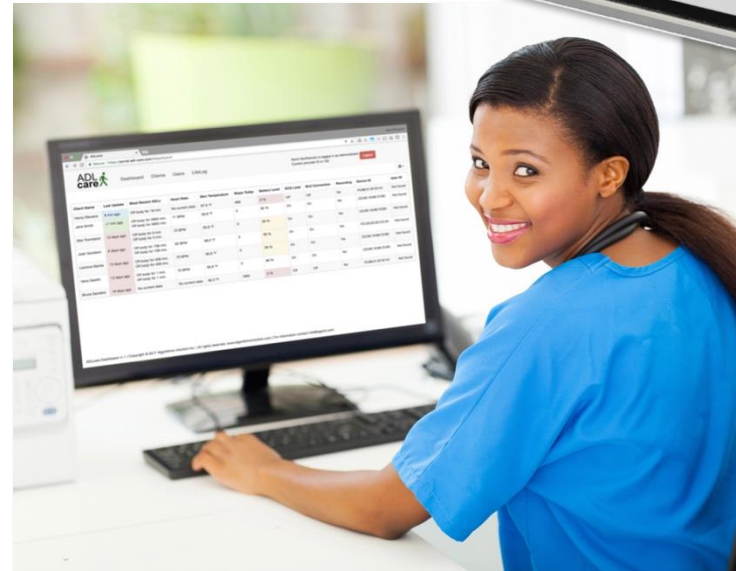
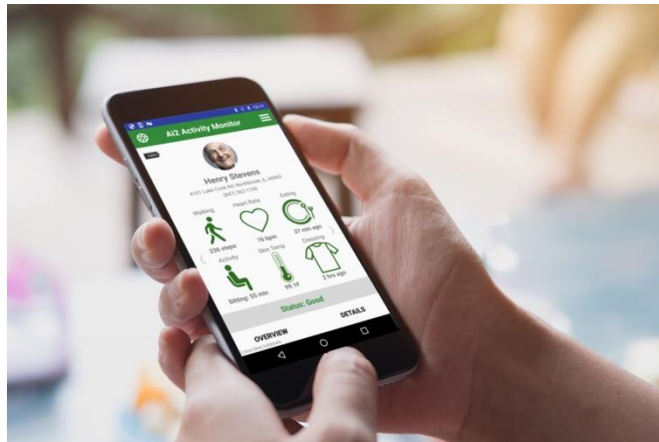


“The Master Switch”
by Tim Wu



There when you can't be™

Connected monitoring of
Vitals, Daily Activity and Falls
for elderly adults.



PANAMA NATIONAL COMPETITIVENESS FORUM 2017

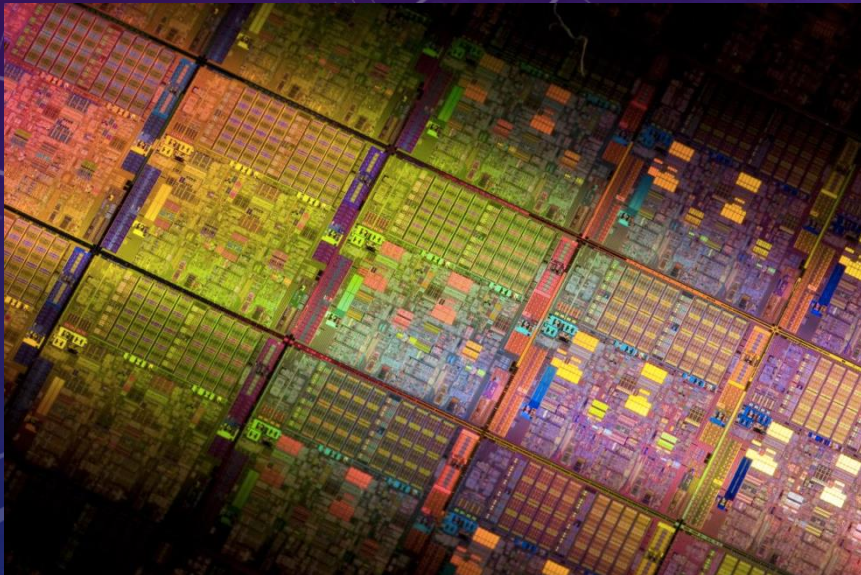
EXPONENTIAL TECHNOLOGIES

Leading Change in the World

KEVIN A. SHAW, PH.D.

CTO / Co-FOUNDER | ALGORITHMIC INTUITION INC.

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Silicon Wafer