2018 Annual INCOSE
Great Lakes Regional Conference
SYSTEMS AT THE CROSSROADS
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Mike Celentano

The Future of Healthcare with IoT
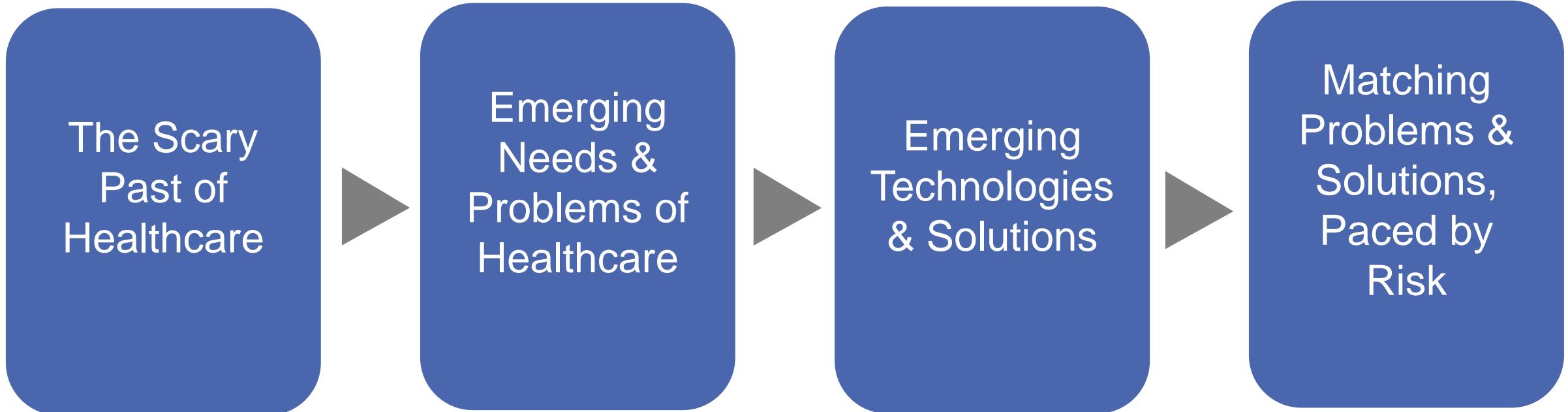
The Future of Healthcare with IoT

Abstract:

Healthcare changes in the future will primarily be driven by cost & quality. A view of the past may be helpful to predict the future. Patient outcomes must improve while costs continue to be contained. One of the highest costs with lowest outcomes come from patients with chronic diseases who do not improve their lifestyle choices. Examples of poor lifestyle behaviors include smoking, overeating, under-exercising, drug and alcohol abuse.

While IoT sensors and Apps have been conceived to help with these issues, at least three major challenges remain: convincing the patient to change behavior, managing the risk of IoT errors enough to satisfy the healthcare regulatory bodies, convincing the insurance companies that the IoT gadget is worth reimbursement. Many technical options are available, so many that it adds to the complexity of this emerging system of system. Many fitness devices are already connected and collecting valuable health information.

A mindset change for all parties in the healthcare ecosystem may be required to successfully cross the IoT threshold from consumer electronics to healthcare. This presentation uses Systems Thinking to thread all of these topics together into a prediction of where we will likely find ourselves.
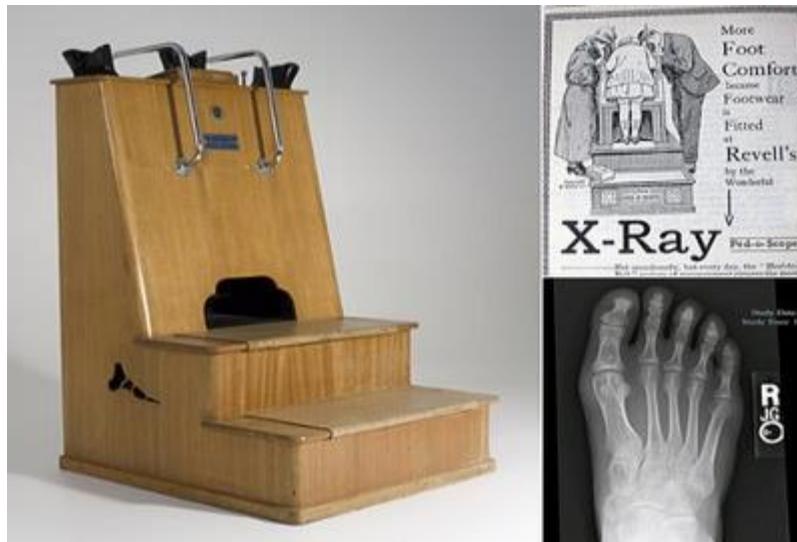
The Future of Healthcare with IoT
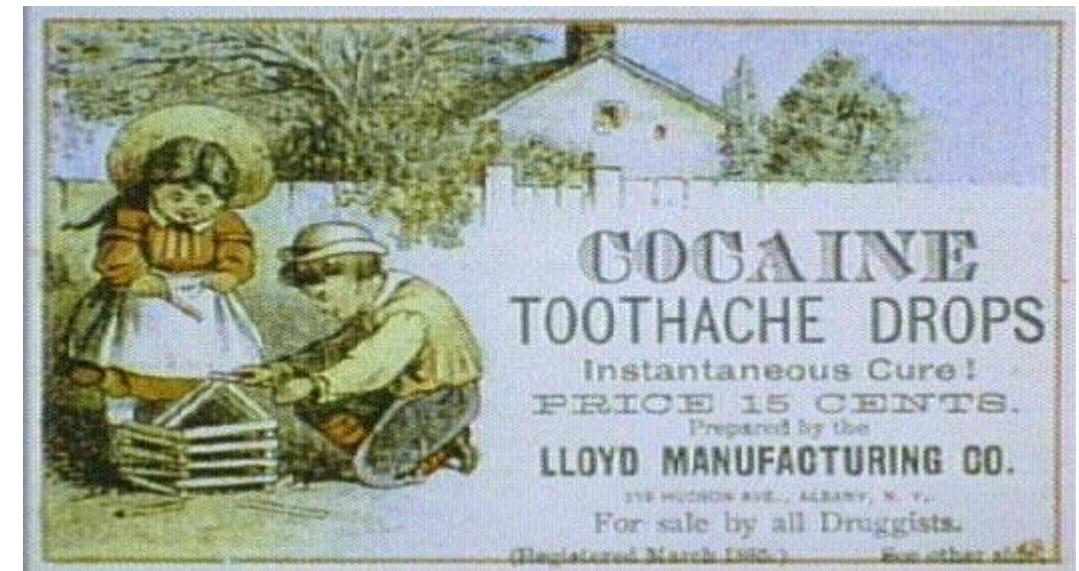
The Scary Past of Healthcare	→	Emerging Needs & Problems of Healthcare	→	Emerging Technologies & Solutions	→	Matching Problems & Solutions, Paced by Risk

Known Risk Levels Set the Pace of Evolution

From Sickcare to Healthcare

IoT, Wearbles, Big Data, DNA, Sensors

The Future of Healthcare with IoT is Selfcare

http://thegriffincollection.com/273.html

MR. & MRS. BESE,
CUPPERS & LEECHERS,
Nº 177 Grant St.
Cor. Strawberry Alley,
PITTSBURGH, PA.

ridiculouslyinteresting.wordpress.com

THE SCARY PAST OF HEALTHCARE

More Foot Comfort
Because Footwear is Fitted at Revell's by the Wonderful

X-Ray Ped-o-Scope

COCAINE
TOOTHACHE DROPS
Instantaneous Cure!
PRICE 15 CENTS.
Prepared by the
LLOYD MANUFACTURING CO.
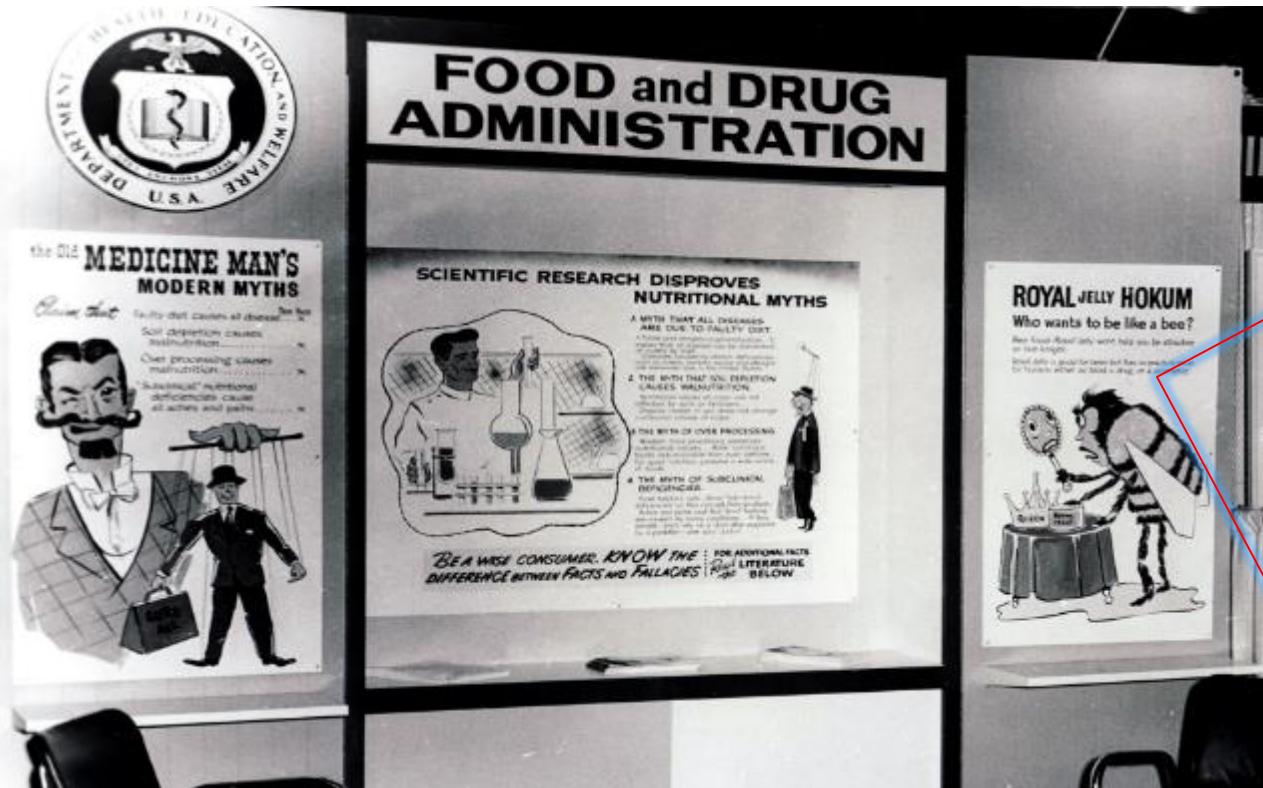For sale by all Druggists.

www.rsna.org

wings.buffalo.edu/aru/preprohibition.htm

FDA Regulation Starts to Protect US in the 1930s

- Efficacy (safe and effective) must be proven
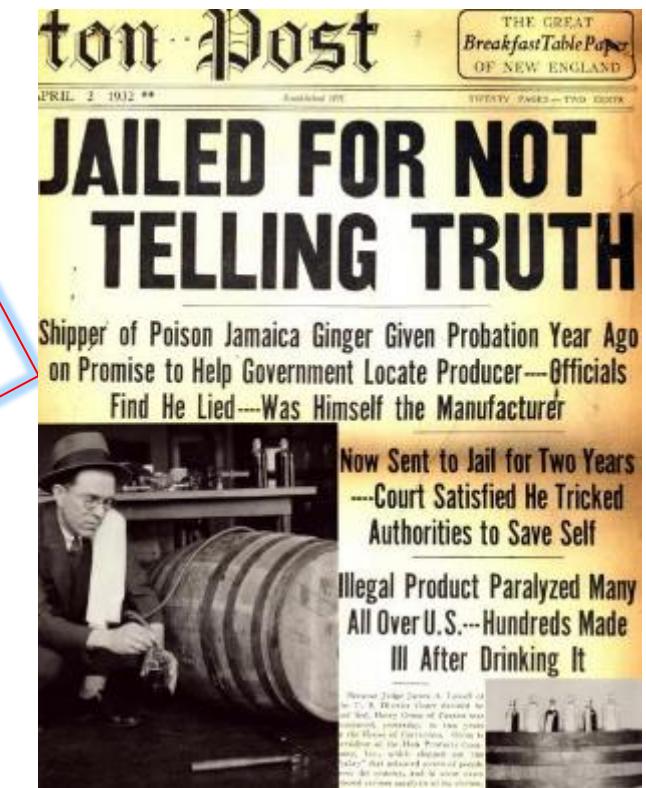- Claims must be proven

The Benefit Must Outweigh The Risk

flickr.com/photos/fdaphotos/sets

flickr.com/photos/fdaphotos/sets

Today…   *Higher Efficacy …*   *More Effort …*   *Slower to Market*

Today US Healthcare is …

"Sickcare"

- *I see my doctor when I'm sick*
- *I get treatment (drugs, procedure, etc) to fix me*
- *I do pretty much whatever the doctor says*
- *Costs continue to rise and are the Highest in the World*
- *Outcomes are not anywhere close to the best (~ median)*
- *Now more people have insurance than ever*
- *So the doctor-to-patient ratio is shrinking quicker than ever*
- *Incentives are based more on volume than outcome*

Life expectancy in years

US Spends ~ 2.5 x Avg Country per capita, Quality of Care ~ Avg!

EMERGING NEEDS OF HEALTHCARE

$R^2 = 0.5$

Health spending per capita (USD PPP)

Source: OECD Health Statistics 2017.

StatLink http://dx.doi.org/10.1787/888933602272
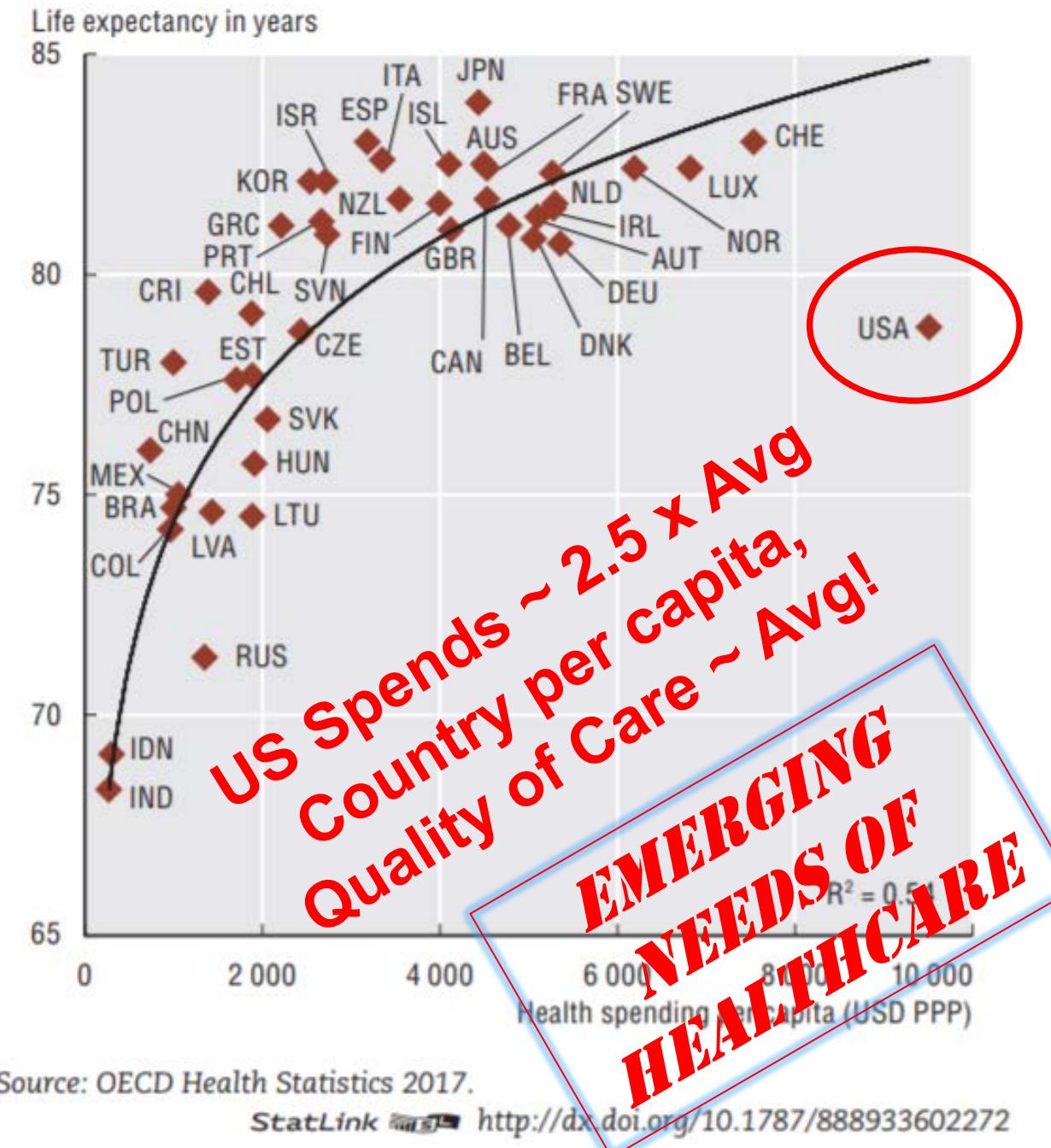
May 29, 2014

PCAST Report to then President Obama

Better Health Care and Lower Costs:

Accelerating Improvement through Systems Engineering

1) reform payment systems,
2) build the Nation's health-data infrastructure,
3) provide technical assistance to providers,
4) increase community collaboration,
5) share best practices, and
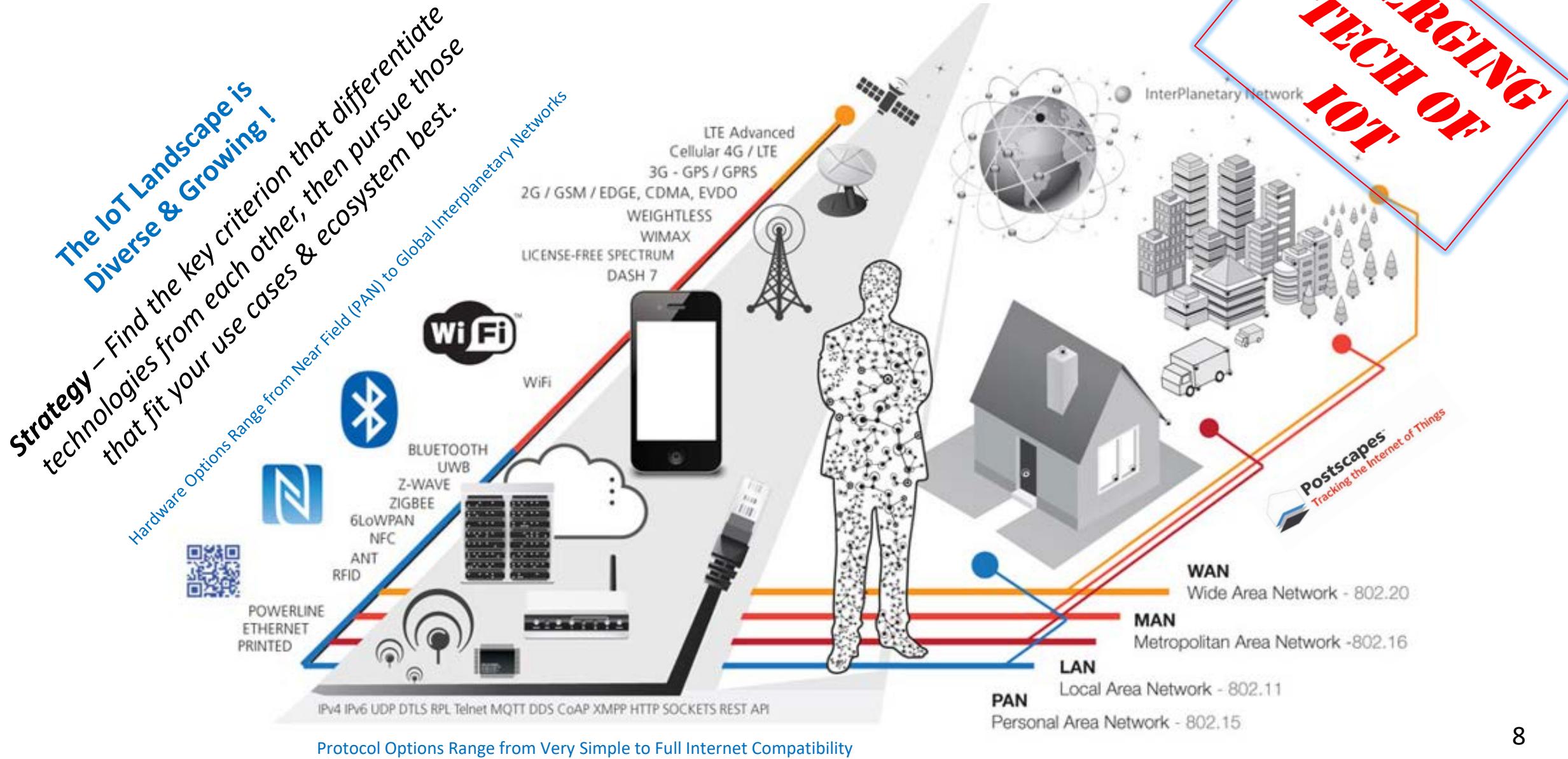6) train health professionals in systems engineering approaches.

REPORT TO THE PRESIDENT
BETTER HEALTH CARE AND LOWER COSTS:
ACCELERATING IMPROVEMENT THROUGH
SYSTEMS ENGINEERING

Executive Office of the President
President's Council of Advisors on
Science and Technology

May 2014

The US is Moving from Sickcare to Healthcare

- *I see my doctor to stay healthy*
- *I get instructions (diet, fitness, routines) to stay healthy*
- *We focus on prevention*
- *I discuss the treatment options & costs*
- *Incentives are becoming more outcome driven*
- *Electronic Medical Records are fully implemented*
  - Penalties started in 2015 for those choosing not to participate

EMERGING NEEDS OF HEALTHCARE

Potential Connectivity Technology Solutions

EMERGING TECH OF IOT

The IoT Landscape is Diverse & Growing !

Strategy – Find the key criterion that differentiate technologies from each other, then pursue those that fit your use cases & ecosystem best.

Hardware Options Range from Near Field (PAN) to Global Interplanetary Networks

InterPlanetary Network

LTE Advanced
Cellular 4G / LTE
3G - GPS / GPRS
2G / GSM / EDGE, CDMA, EVDO
WEIGHTLESS
WIMAX
LICENSE-FREE SPECTRUM
DASH 7

WiFi
WiFi

BLUETOOTH
UWB
Z-WAVE
ZIGBEE
6LoWPAN
NFC
ANT
RFID

POWERLINE
ETHERNET
PRINTED

Postscapes
Tracking the Internet of Things

WAN
Wide Area Network - 802.20

MAN
Metropolitan Area Network -802.16

LAN
Local Area Network - 802.11

PAN
Personal Area Network - 802.15

IPv4 IPv6 UDP DTLS RPL Telnet MQTT DDS CoAP XMPP HTTP SOCKETS REST API

Protocol Options Range from Very Simple to Full Internet Compatibility

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Example Use Cases

Often Home

Your Device

?? Mesh Smart Home

GSM Edge · LTE 2G 3G 4G

Wi Fi

Often Work/School

Your Device

GSM Edge · LTE 2G 3G 4G

Wi Fi ?

EMERGING TECH OF IOT

Note: Even the Best Connections are Not Always There!
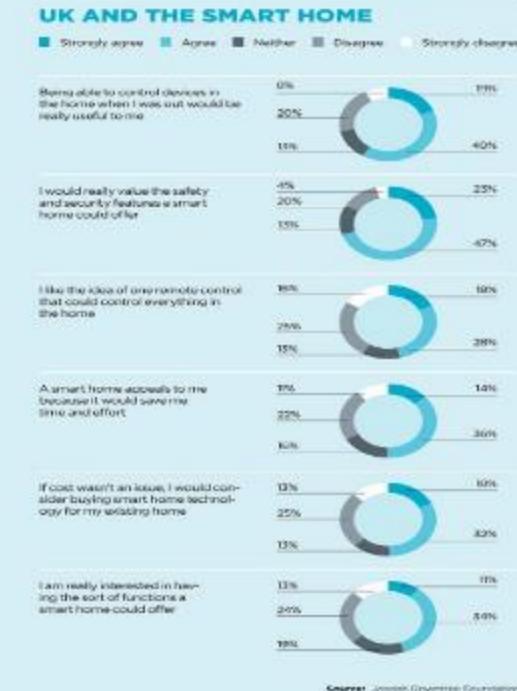
Sometimes Play

Your Device

GSM Edge · LTE 2G 3G 4G

?

Wi Fi ?

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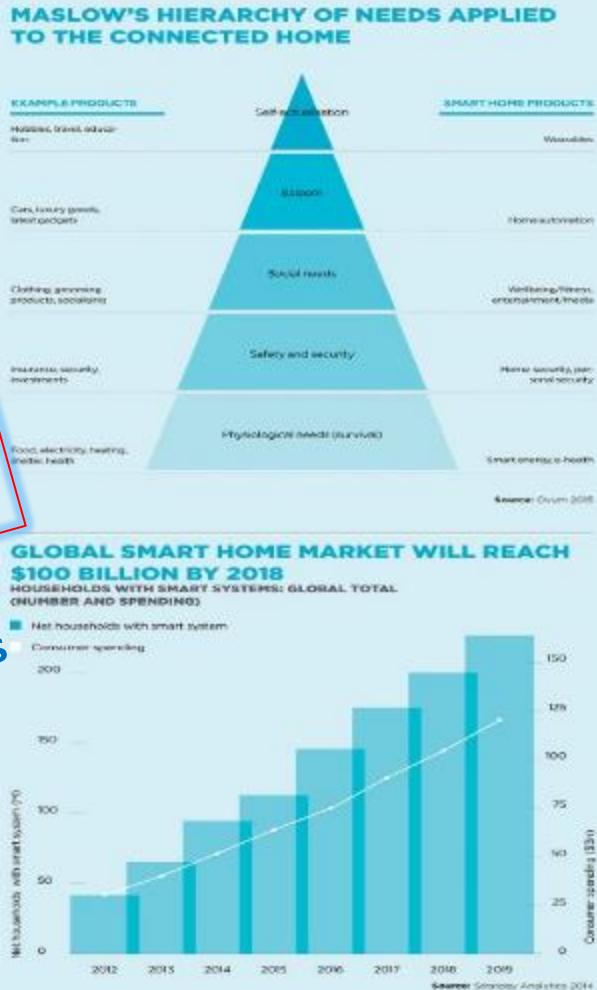# Example Ecosystems

Infrastructure Coverage – *Cellular Coverage (circa 2016)*

EMERGING TECH OF IOT

Cellular Infrastructure is nearly World-Wide with gaps depending on technology & country

4G LTE World Coverage map 2016
©WorldTimeZone.com All Rights reserved

4G (LTE / WiMAX / HSPA+)   3G (850 / 1900 / 2100)   GSM   850 / 1900 900 / 1800
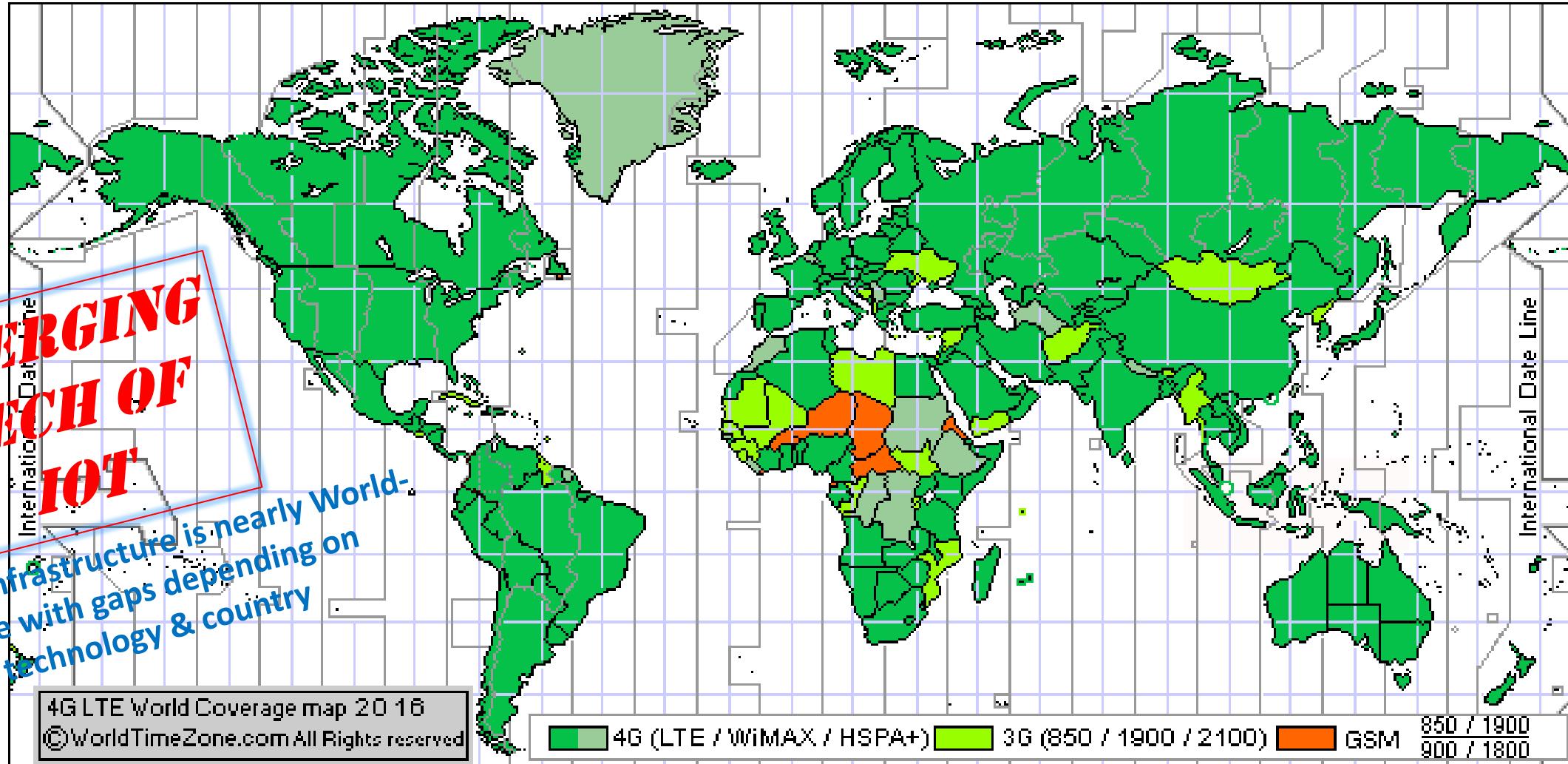
Example Ecosystems

Infrastructure Coverage – *WiFi Coverage* *(circa 2016)*

EMERGING TECH OF IOT

Wi-Fi Infrastructure is Not World-Wide, depends on owner of building, ships & planes
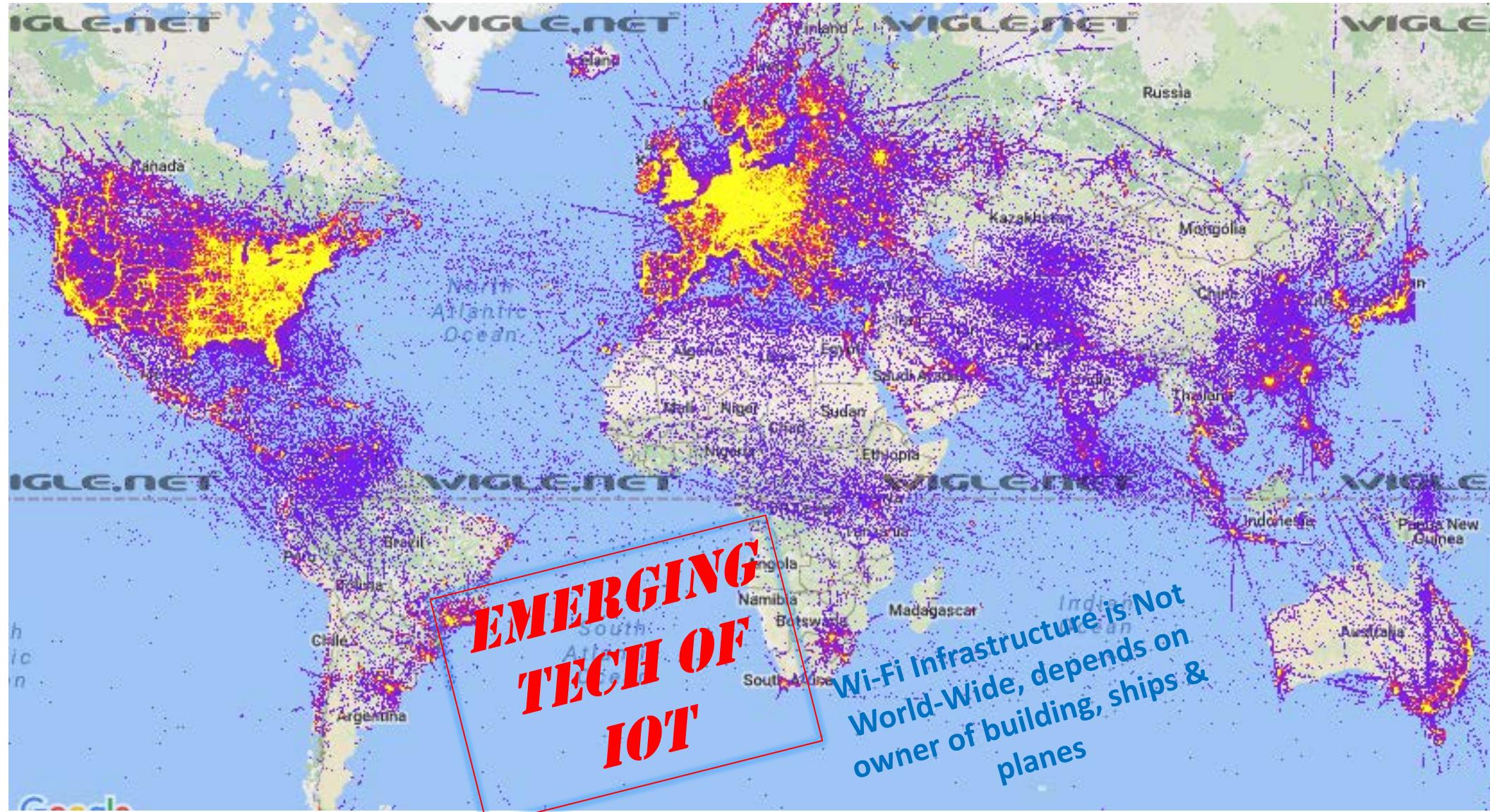
Example Ecosystems

Infrastructure Coverage – *Mesh/Smart Home Coverage (circa 2016)*

EMERGING TECH OF IOT

Mesh Infrastructure is Not World-Wide, depends on home owner.
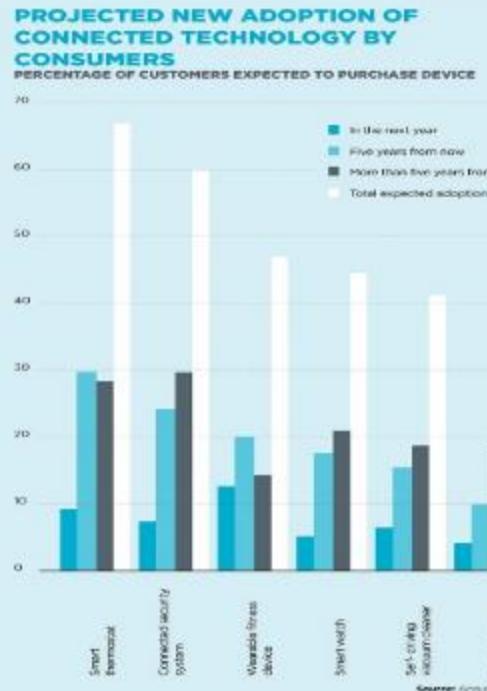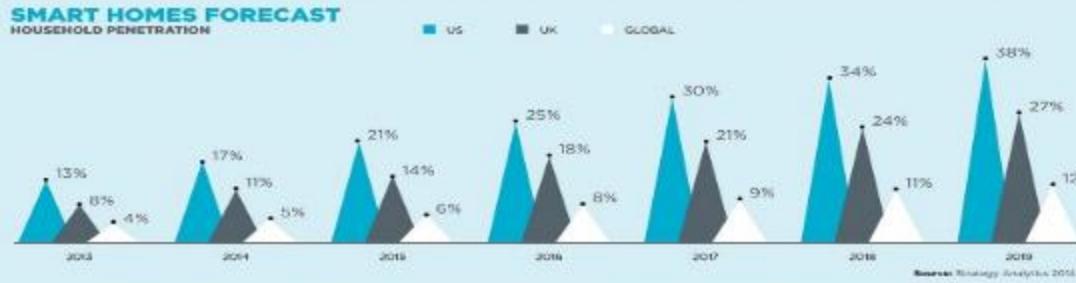
Example Ecosystems

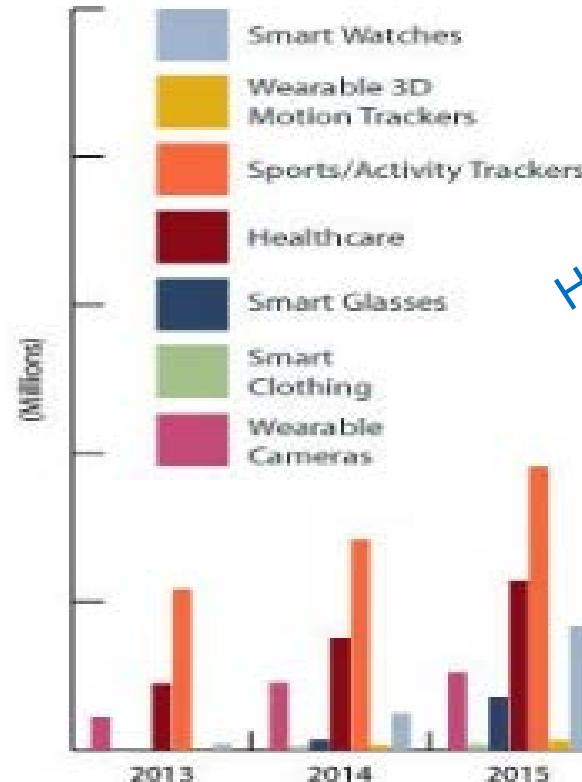Infrastructure Coverage – *SigFox Coverage (circa 2016)*

SigFox Coverage is Not World-Wide, depends on others for infrastructure.

■ Live coverage   ■ Country under roll-out

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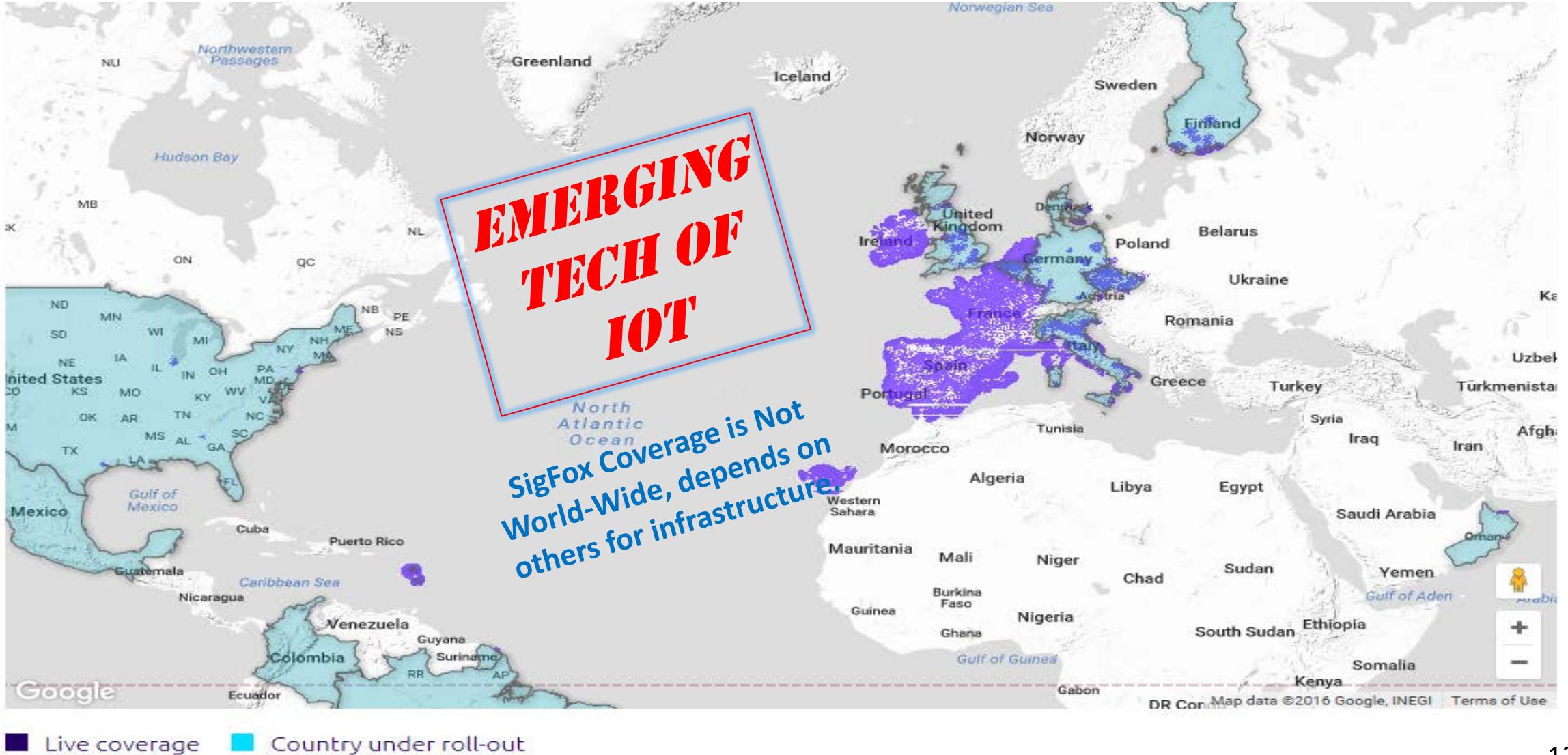
RF Technology Roadmap for RDC IoT

Infrastructure Coverage – *LoRa Coverage* (circa 2016)

EMERGING TECH OF IOT

LoRa Coverage is Not World-Wide, depends on others for infrastructure.
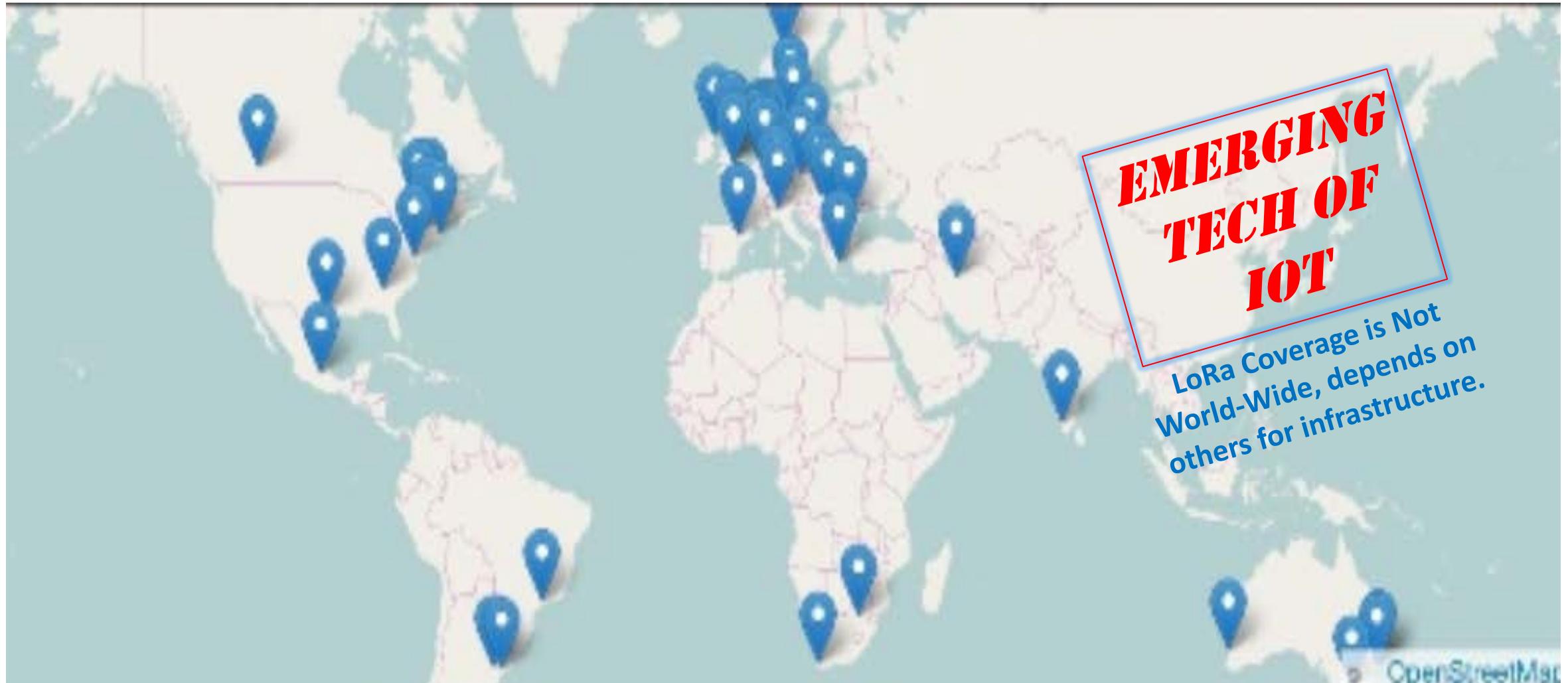
Global Wearable Computing Devices
World Market, Forecast: 2013-2019

Legend:
- Smart Watches
- Wearable 3D Motion Trackers
- Sports/Activity Trackers
- Healthcare
- Smart Glasses
- Smart Clothing
- Wearable Cameras

(Millions)

2013 2014 2015 2016 2017 20

Healthcare Wearables to Exceed Sports Wearables in Volumes!

EMERGING TECH OF HEALTHCARE

Continuous glucose monitor   Battery

Raspberry Pi

@DanaMLewis
#OpenAPS

Insulin pump

Carelink USB

)I(HEALBE   LOG IN

Automatically Measures Calorie Intake

GoBe calculates your calorie intake through your skin. Know exactly how many calories you're consuming with no manual logging, no estimates and no error-prone guesswork.

Learn more

healbe.com/us/GoBe

ECG Sensors   Temperature Sensors   Strain Gauges   LED   Wireless Power Coil

Wireless communication oscillator

EEG/EMG Sensors

Wireless antenna

Photo Detectors

Contact Lens Sensor - Google   Earbud Pulse/Ox - valencell.com   www.incose.org/glrc2018   Tattoo Sensors - Coleman Lab / UCSD
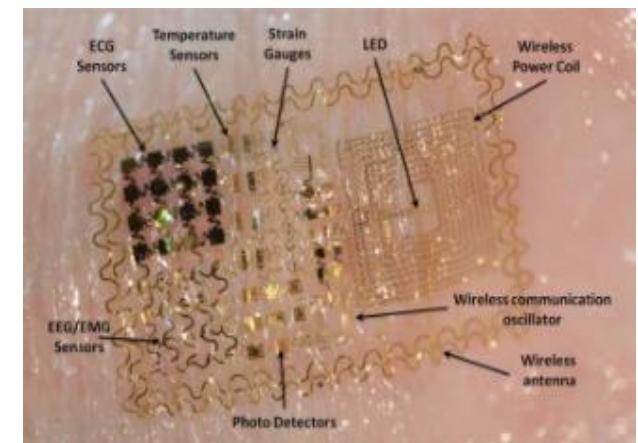
EMERGING TECH OF HEALTHCARE

CancerSelect™ Report

PATIENT NAME
John Doe

3D Printed Artificial Heart Valve - Cornell University

doctor-watson.mybluemix.net

mypersonalgenome.com

firstbuild.com/mylescaley/chillhub

Toto Intelligence II smart toilet

LUNA - Make your bed 'Smart' and Sleep better!

Lunasleep.com/

www.incose.org/glrc2018

Mapping Problems to Potential Solutions

www.incose.org/glrc2018
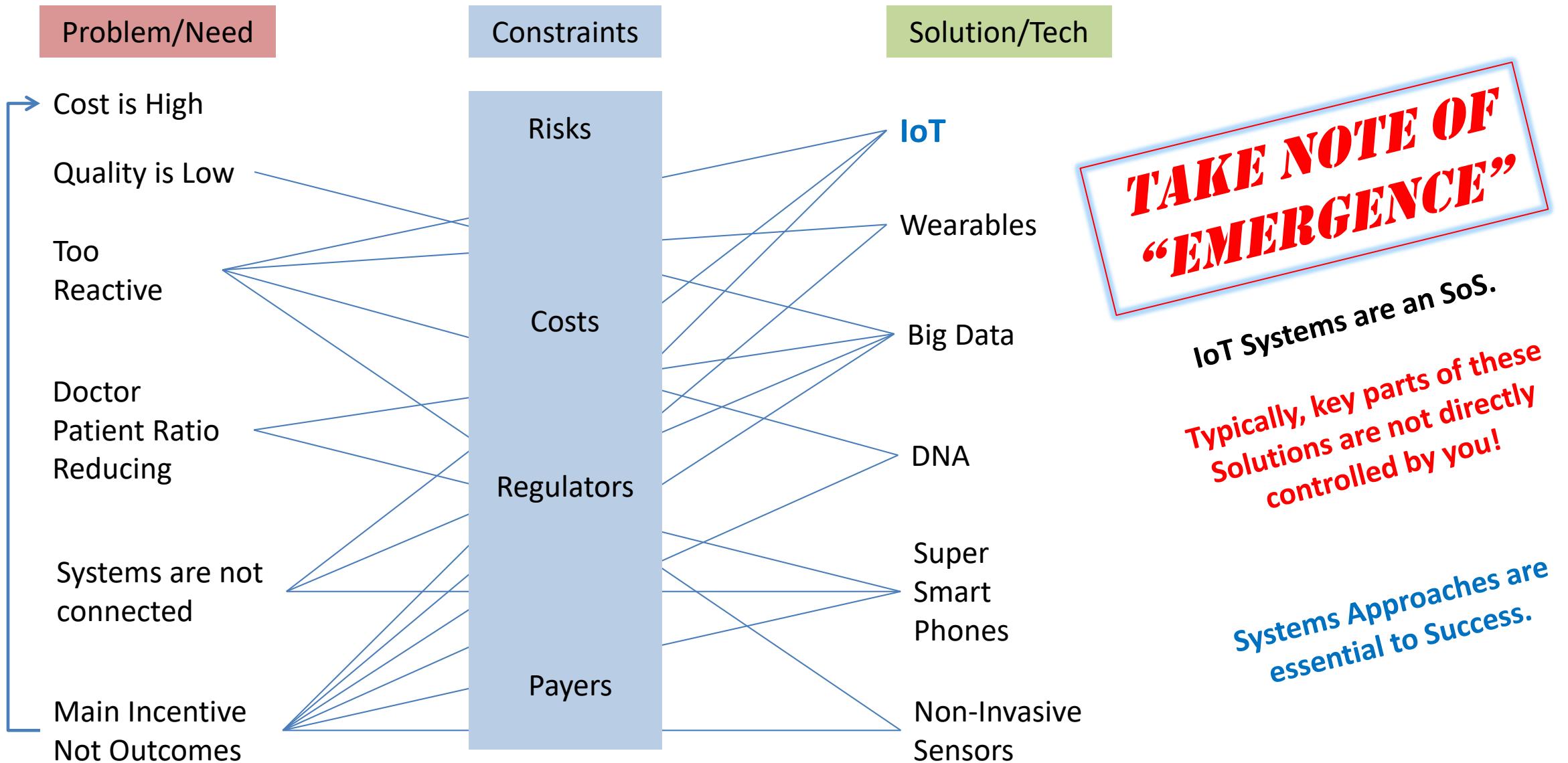
The Future of Healthcare with IoT

- **Expect Many More Low Risk Solutions**
  - *Wearable Health Sensors, Smart Appliances and Furniture, all Connected*
  - *Apps that Monitor, Motivate, Tattle-tell and help Change Behavior*
  - *Systems that are Better Connected to You, your Doctor and your Insurance*
- **Expect an Emergence of Automatic Advice for Low & Medium Risk Situations**
  - *Dr. Watson and other Big-Data systems will become World-Class Experts*
  - *Doctors, Patients & Payers will Use This Advice Often*
  - *Your Genome will be available to predict outcomes*
- **Expect More Early Adapters Who Just Can't Wait**
  - *Medium & High Risk Situations*
  - *Diabetes, Heart Disease, Cancer, etc*
- **Expect the Healthcare Costs to Go Down in a Transparent Way**
  - *They'll be Apps for Finding the Best Price & Doctor per Procedure*
  - *They'll be Apps for Many, Many Low Risk Diagnoses & Procedures*
  - *Doctors will be Prescribing Apps & Sensors and Presenting All Cost Options*
- **Expect an Explosion of Self-Care**

THE FUTURE OF HEALTHCARE

The Future of Healthcare with IoT

Risks & Barriers to the Future of Healthcare with IoT

- ***Regulation***
  - *Trending toward meeting the IoT needs (ie: The 21st Century Cures Act & MDDS*)*
  - *Not settled regulations, subject to variations with politics & current events*
- ***Security & Privacy***
  - *Many off-the-shelf IoT solutions need additional measures for healthcare (ie: HIPAA)*
  - *MDDS are much, much less risk than IoT that command & control systems*
- ***Costs & Reimbursement***
  - *Total cost of care needs to be considered (ie: less doctor visits)*
  - *Reimbursement from Insurance Companies will usually lag product launch*
- ***Generation Gap & Usability***
  - *New tech solutions often assume technical savviness*
  - *An ongoing challenge will be to make IoT solutions easily usable by our older generations*
- ***Self-Advocacy***
  - *Consider what habits you can add or change to help yourself (ie: count carbs)*
  - *Need to keep up with technology but be critical of incredible marketing claims*
  - *Medical opinions are, well, Opinions*

*Medical Device Data System: FDA lowered the risk of medical devices that only transfer, store or display data. These are categorized as MDDS.

Many Thanks!

Questions & Alternative Visions Welcomed

Contact for more info:
Mike.Celentano@INCOSE.Org
+1-317-521-7617

www.incose.org/glrc2018

Mike Celentano, ESEP

Roche Principal Systems Engineer
INCOSE Technical Director

Office: +1-317-521-7617
Mike.Celentano@incose.org
Mike.Celentano@roche.com
http://www.linkedin.com/in/indianamike

Mike Celentano has been influencing the Medical Diagnostics field since 1987. He has experience in systems engineering, advanced research, engineering management, product development, and technology management.

Mike has dedicated his career to developing multi-disciplined instrumentation used to diagnose & monitor disease to ultimately help improve the quality of healthcare globally. He has worked for Technicon, Miles, Bayer, Seradyn, UMM and Roche. Mike is currently the Program Leader for Global Adaptive Technologies at Roche Diagnostics Diabetes Care in Indianapolis. His charter is to evaluate and expedite new technologies and features that could benefit Roche's diabetes patients, caregivers, and payers.

Mike has a B.S. in Electrical Engineering from N.Y.I.T. He achieved SE certification at the highest level in 2017. Mike has been granted many global patents related to medical diagnostics. Through his involvement in INCOSE Mike is striving to make Systems Engineering practices more common-place in the Biomedical Industry. Mike founded the INCOSE International Healthcare Working Group. He currently serves on the Board of Directors for INCOSE at the international level.