

The Internet of Things

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Senior Vice President and Chief Innovation Officer,
Internet2

February 8, 2017



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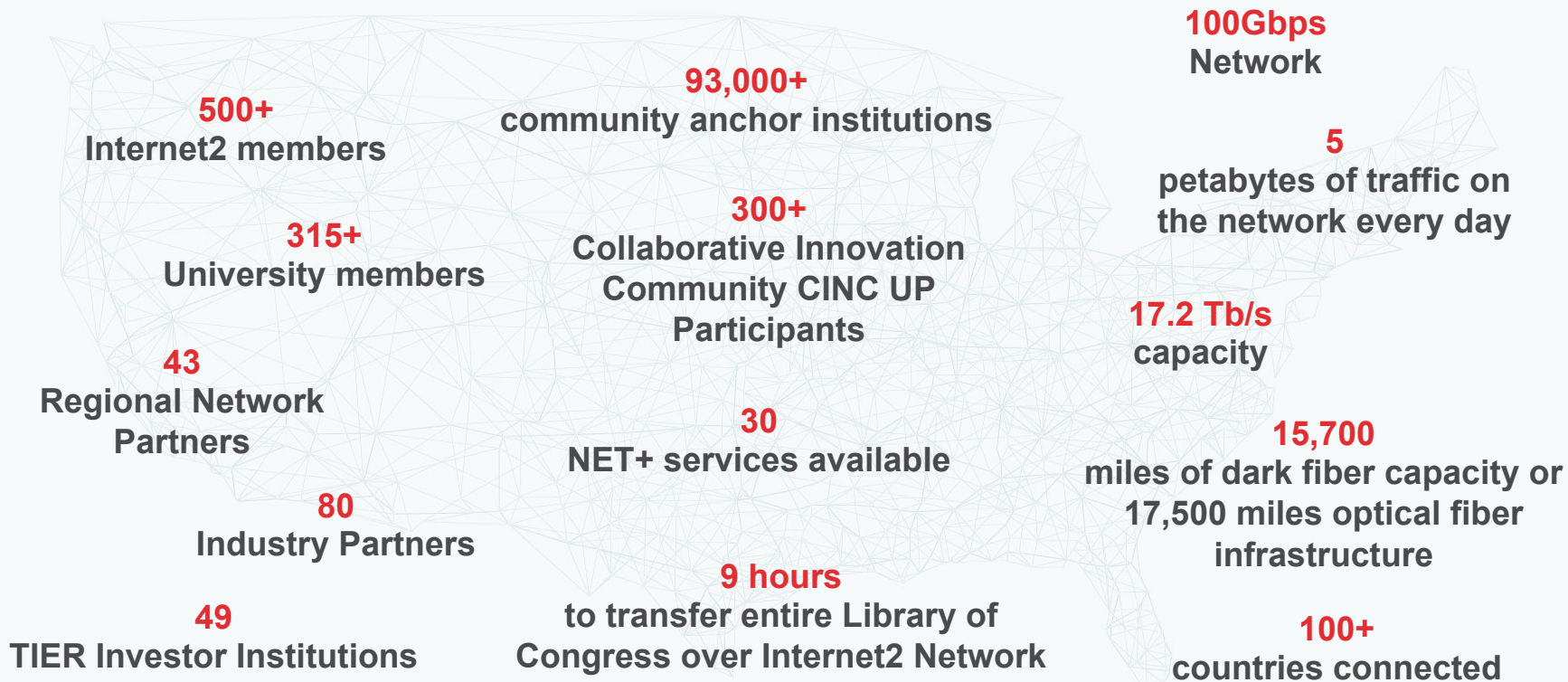


INTERNET2

- **Network Services** – 100Gbps network
- **Trust & Identity** – Federated Identity Management
- **NET+ Services** – 30 cloud services available
- **Community Engagement** – 500+ members in Higher Education, Regional Networks, Industry & Affiliates
- **Innovation Office** – Community-led innovations
- **US UCAN** – 93,000 community anchor institutions



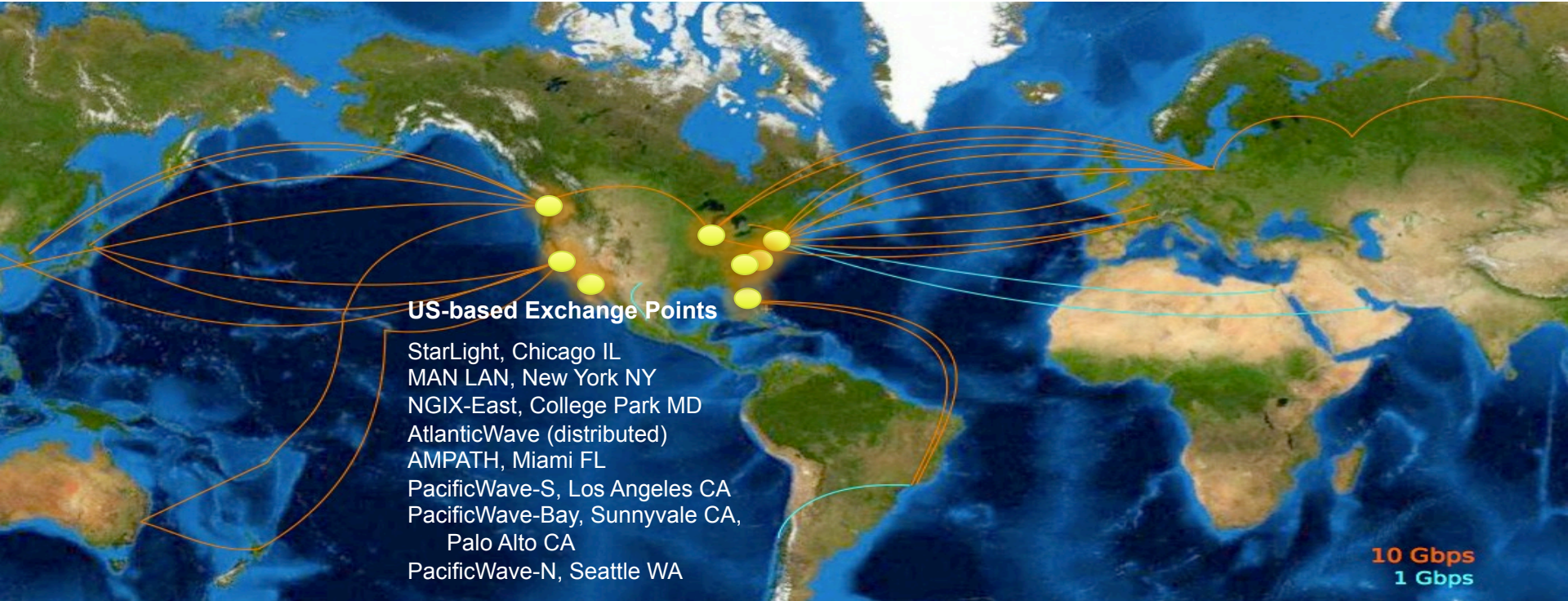
INTERNET2 BY THE NUMBERS



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International reach with 100+ Research and Education Networking partners Globally



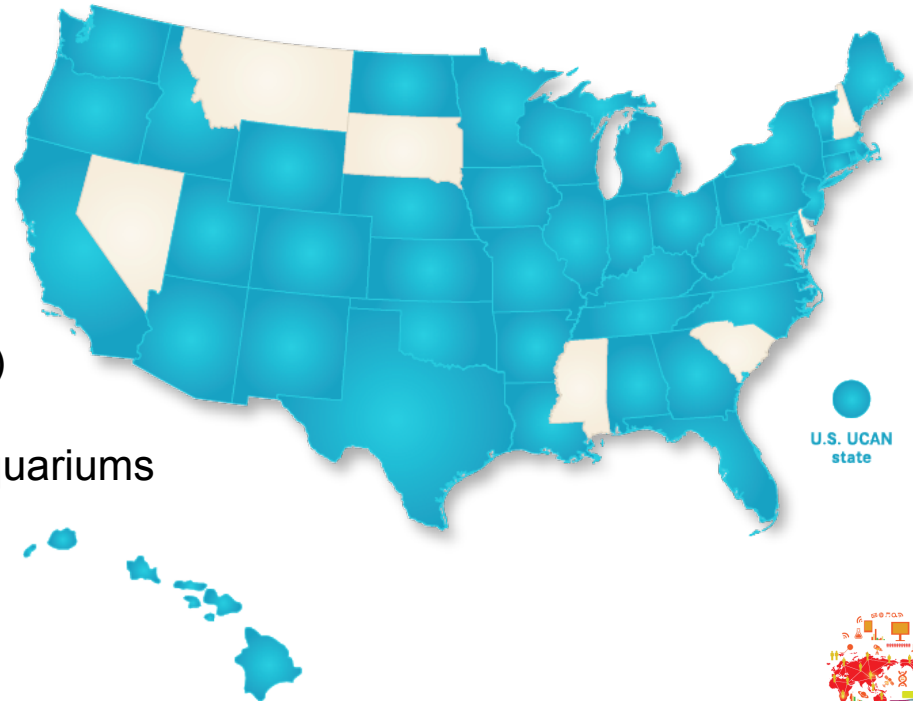
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U.S. Unified Community Anchor Network Program connects 93,000 institutions

Connectivity Statistics

- **84,146** K–12 Schools (60%)
- **4,203** Public Libraries (25%)
- **1,491** Colleges and Universities
- **799** Community or Vocational Colleges (50%)
- **2,237** Health Care Organizations
- **200** Museums, Science Centers, Zoo, and Aquariums
- **43** States



Extending Federated Identity Management services to K-14 through the InCommon Steward Program



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<http://bit.ly/2eN8S9z>

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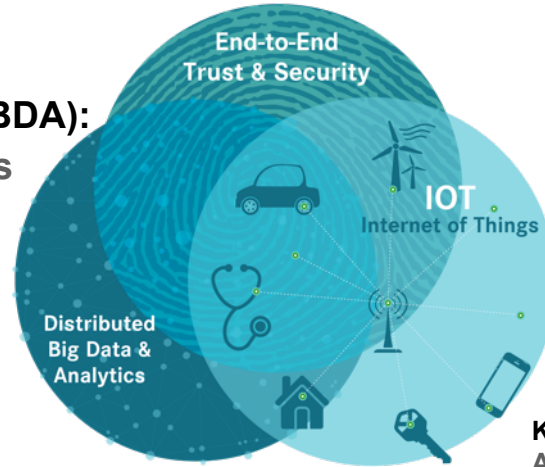
Internet2 Collaborative Innovation Community is the combination of three innovation working groups, focused on areas related to advanced networking plus trust & identity.

E2E Trust & Security (E2ET&S):

- End to End Trust and Security for the Internet of Things (IoT)
- TIPPSS – Trust, Identity, Privacy, Protection, Safety, Security
- *SDP (Software Defined Perimeter), Network Segmentation for IoT*

Distributed Big Data & Analytics (DBDA):

- Health & Life Sciences / Genomics
- Smart Campuses and Cities
- Digital Humanities



Internet of Things (IoT):

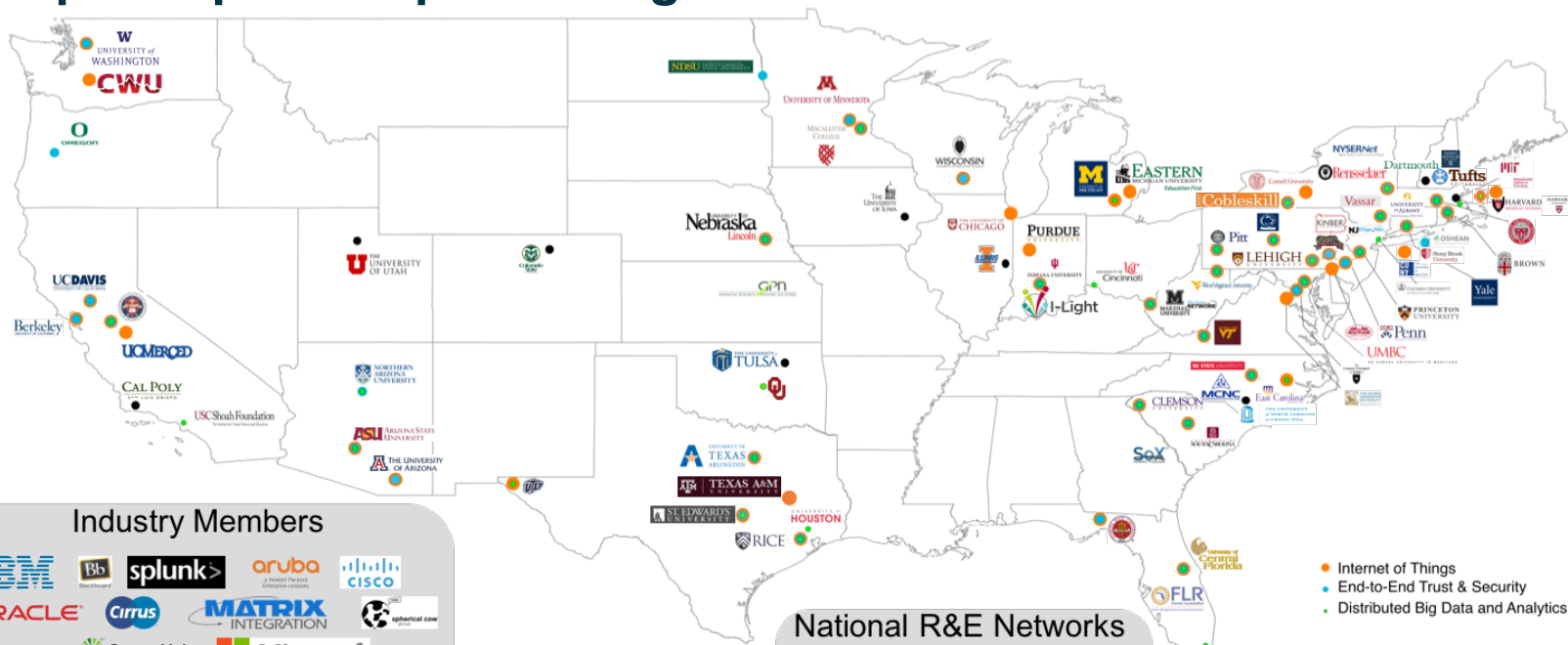
- IoT Sandbox
- Smart Campuses and Cities
- Smart Grid Testbed

Key:

Advanced Networking plus Trust & Identity
Advanced Networking focus only



Internet2 Collaborative Innovation Community Working Group Members: 300+ participants representing 125+ member institutions.



- Internet of Things
- End-to-End Trust & Security
- Distributed Big Data and Analytics

Industry Members

IBM | **Bb** | **splunk** | **aruba** | **cisco**
ORACLE | **Cirrus** | **MATRIX INTEGRATION** | **spahrlicol.com**
BROCADE | **CenturyLink** | **Microsoft**
INSTITUTE FOR DISEASE MODELING | **NORTHROP GRUMMAN**
Phybridge | **ciena** | **rackspace**
abbvie | **en@ Education Networks of America**

National R&E Networks

UNINETT | **NORDUnet**
HEAnet | **GEANT** | **ASREN**
aarnet | **20** | **CESENET** | **FIU**

Additional Organizations

HIMSS | **Argonne** | **Pacific Northwest**
Internet Society | **renCI** | **Trinity College** | **Universidad Nacional Autónoma de México**
ESnet | **IEEE** | **NIST** | **National Institute of Standards and Technology**
WICHE | **USignite** | **EDUCAUSE**

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As of January 29, 2017

NSF EAGER: Cybersecurity Transition To Practice (TTP) Acceleration

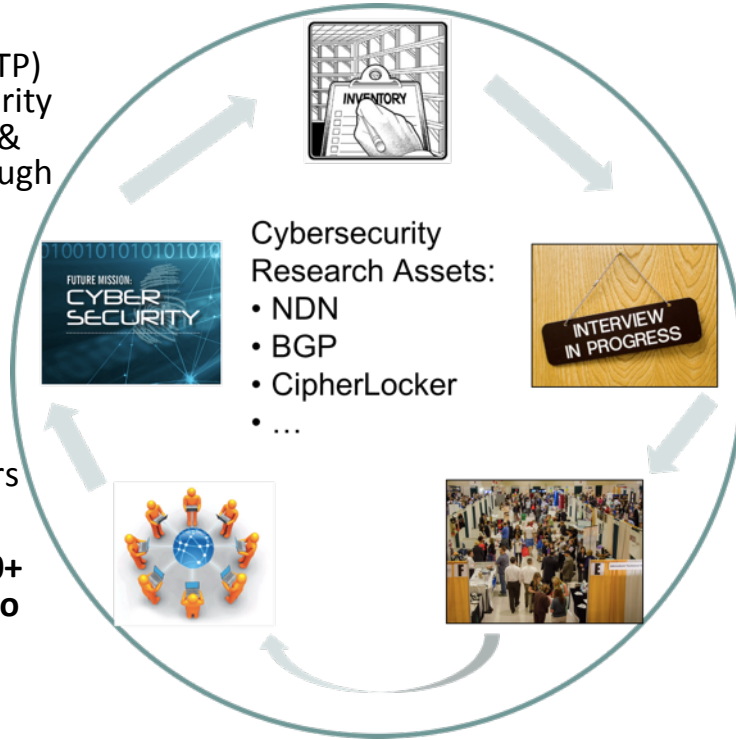


Challenge:

- Accelerate Transition To Practice (TTP) of NSF funded later stage cybersecurity research into operational Research & Education (R&E) environments through applied research pilot deployments

Solution:

- Identify & assess **inventory** of NSF cybersecurity research assets ready for applied research pilot phase
- **Interview** researchers & practitioners for needs/learnings/best practices
- **Leverage Internet2 community (300+ universities, 40+ regional network) to enable “matchmaking”** between researchers and academia IT/NW operations for pilots/testing
- Deploy webinars, portal, in person **events for researcher/IT matchmaking**
- Identify cybersecurity **needs/gaps**



Scientific Impact:

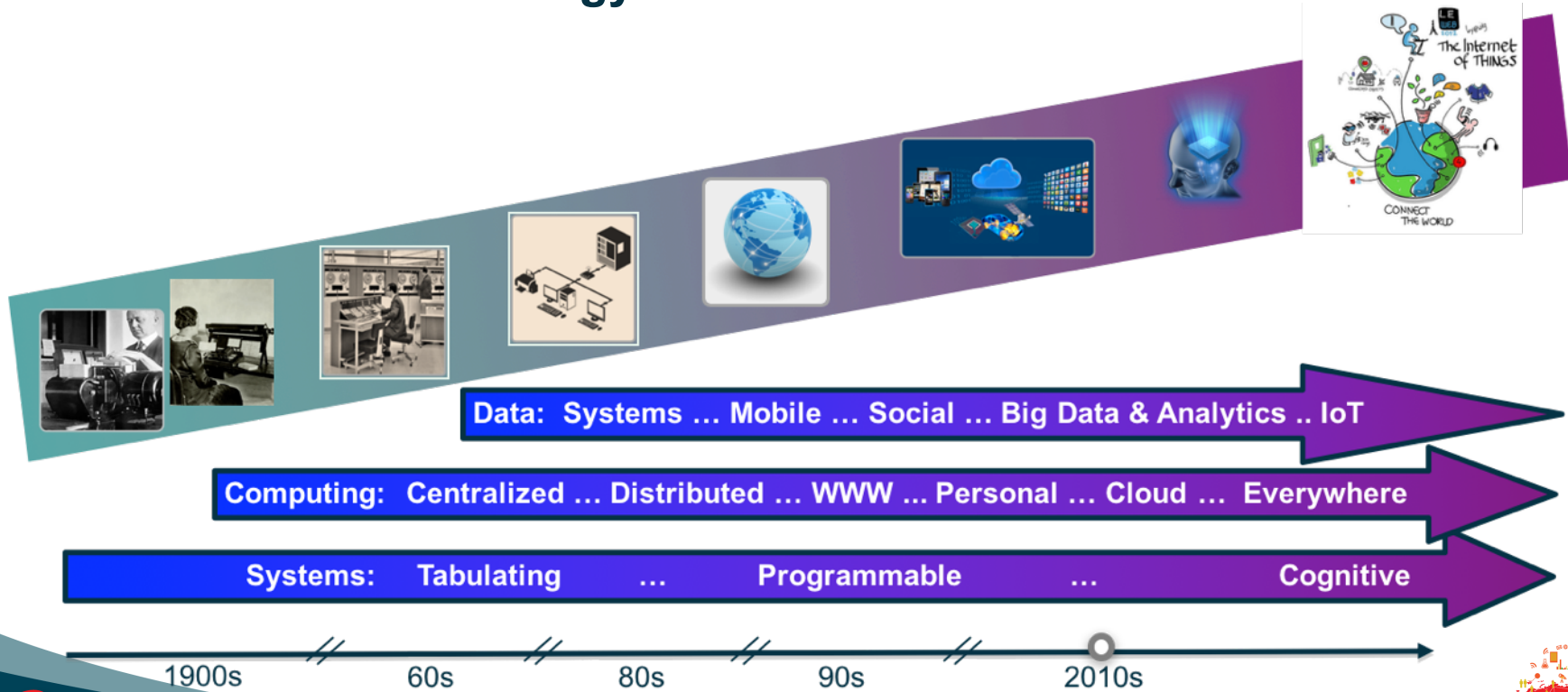
- Increase awareness of cybersecurity research & capabilities
- Accelerate cybersecurity transition to practice in the near to mid term to make cyberspace safer
- Identify cybersecurity needs to inform future NSF solicitations

Broader Impact:

- Enable partnership for NSF TTP with other Federal agency programs, including DHS, SBIR, etc. to accelerate and streamline the TTP pipeline
- Enable a more diverse research and education pipeline partnering with Society of Women Engineers and others

Award Number: 1650445
Internet2
PI: Florence Hudson, SVP/Chief Innovation Officer

The Innovation Office keeps an eye on the future Information & Communications Technology trends for research & education.

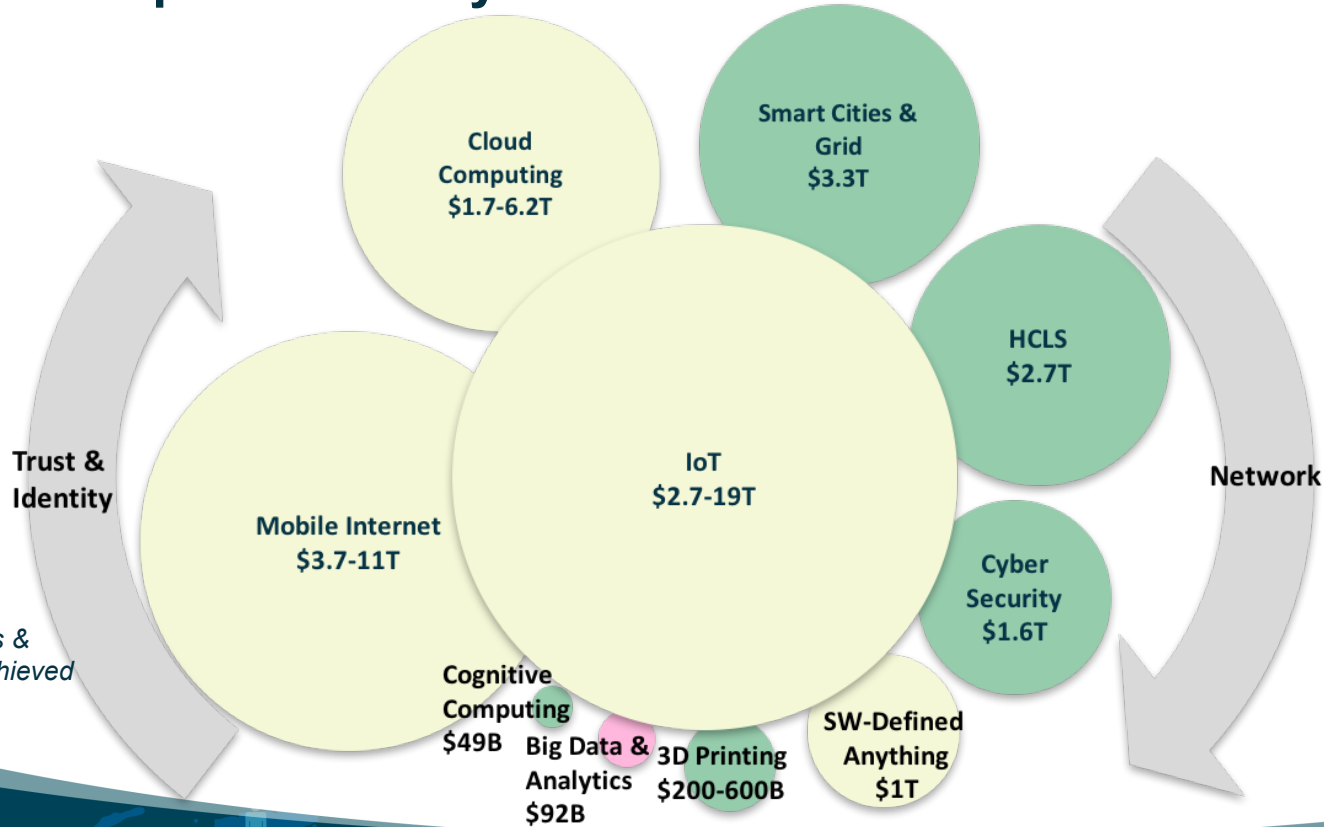


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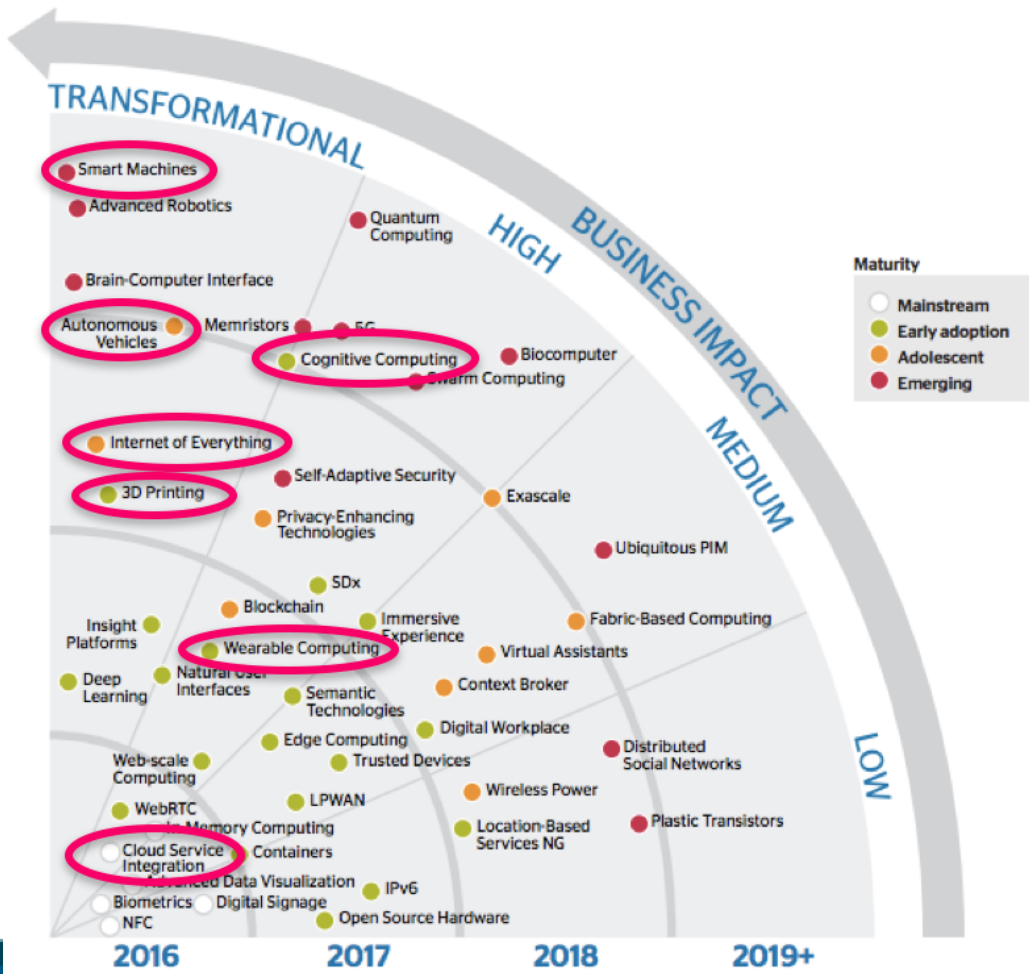
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The Internet of Things could represent \$19T in economic value by 2025, a significant component of key ICT trends for Research & Education.



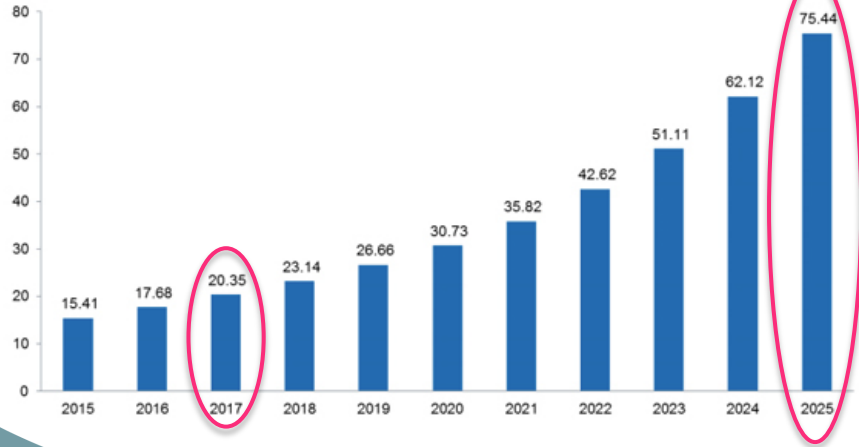
Supporting technologies for key ICT trends are already having significant business impact, with IoT applications & devices at the top of the transformation curve.



The Internet of Things will generate the majority of new data on the back of explosive device growth.

Data of the Internet of Things

IoT installed base, global market, billions



BrontoByte
The digital universe of tomorrow



ZettaByte
In 2016 1.3 ZB will cross our digital networks daily

10^{21}

PetaByte
The CERN LHC generates 1 PB per second

10^{15}

GigaByte
 10^9

MegaByte
 10^6

10^{12}

TeraByte - every day 500 TB of data is added on Facebook

10^{18}

ExaByte

At the moment, every day 1 EB of data is created on the internet. That is the equivalent of 250 million DVD's. The Square Kilometer Array Telescope will produce around 1 EB per day.

10^{24}

YottaByte
The digital universe today: 250 trillion DVD's

© - Big Data Startups

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Sources: What's The Big Data 2015; Datafloq 2016; GlobalSources 2016

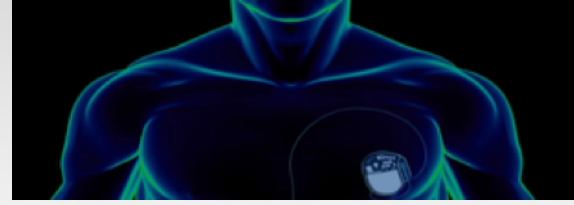


IoT risk and security awareness is increasing ... and highlighting the need for security research and development.



Vehicle Hacking

<https://www.youtube.com/watch?v=MK0SrxBC1xs>



Healthcare Device Hacking

<https://www.youtube.com/watch?v=YThj0Nh40KQ>
<https://www.youtube.com/watch?v=THpcAd2nWJ8>



Smart Home Devices Hacking Other Devices

<http://usat.ly/2eB5RZA>



Research & Education activities are growing in IoT, end to end trust & security, big data & analytics, Smart Campus / Communities.



Smart Campus operations & data analytics research



Advanced Networking / Cybersecurity Research



Smart Grid research



Smart Grid research network testbed



IoT Lab for Research and Pedagogy



Smart transportation / IoT ethics [research](#)



Smart Grid research



Smart Grid research and data sharing



IoT Security, Privacy & Ethics



Trust, Identity, Protection, Privacy, Safety, Security



IoT Systems Risk Management & Security



[Smart Campus operations](#), trust and security

- Grey = IoT security, privacy, ethics
- Yellow = IoT Smart grid research
- White = IoT research and pedagogy



THE VISION FOR A CONNECTED CAMPUS AT ASU



- Anomaly Detection
- Targeted Promotions
- Driverless Shuttles
- Space Utilization
- Seamless Messaging Tools
- Automated Attendance Tracking
- In-Seat Ordering
- Classmate Collaboration
- Crowd Monitoring
- Estimated Wait Times
- Campus Wayfinding
- Predictive Building Maintenance
- Smart Lighting
- Targeted Emergency Notifications



Connecting devices campus-wide to make more informed decisions and offer a more personalized experience



Academic, Government & Private Partnerships

Project Wing partners with Virginia Tech to test delivery by unmanned aircraft

September 8, 2016



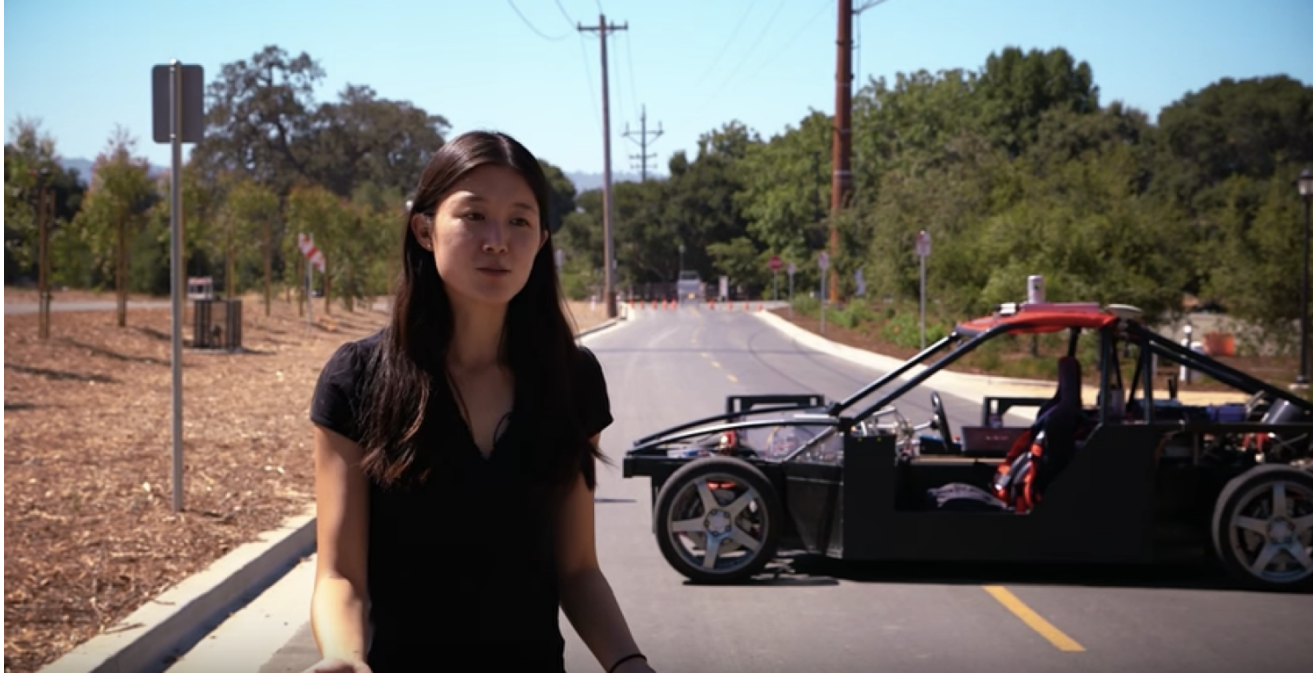
<http://vtnews.vt.edu/articles/2016/09/ictas-maaprojectwing.html>

Project Wing will be conducting research flights with Virginia Tech's Mid-Atlantic Aviation Partnership to explore food delivery by unmanned aerial vehicles. They will gather data on these operations to share with the Federal Aviation Administration as a step towards safely integrating deliveries by unmanned aircraft into everyday life.

The Virginia Tech Mid-Atlantic Aviation Partnership and X's Project Wing will conduct research flights this fall at Virginia Tech, delivering food using unmanned aerial vehicles.

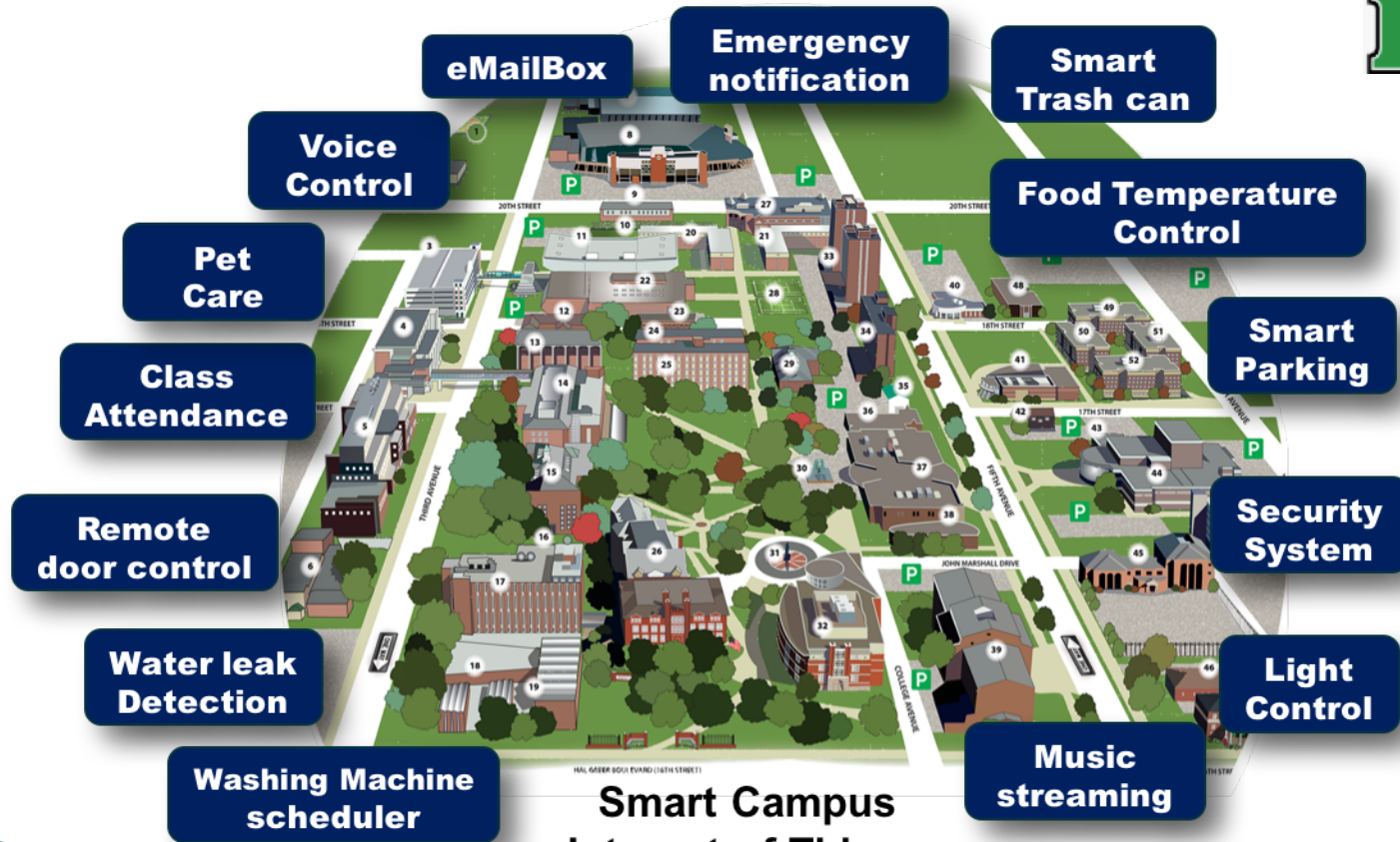


IoT Research & Education at Stanford University – Autonomous Vehicles and Ethics



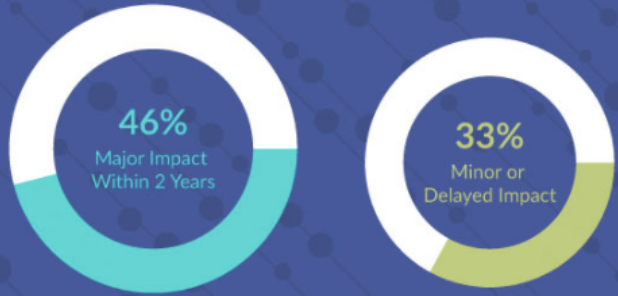
<http://stanford.io/2bhgp23>





IoT is having an impact in Higher education and K-12

What impact do you anticipate from the Internet of Things?



What concerns and drawbacks do you see to the technology?

1. Security
2. May be expensive
3. Privacy
4. Lack of interoperability among different smart technologies
5. Distractions
6. May be hard to manage

What are the benefits of smart school technology?

1. Increases student engagement
2. Takes advantage of mobile learning
3. Enables a more personalized education
4. Eases the learning process for students
5. Improves efficiency or reduces costs
6. Improves measurement of student success
7. Helps teach creativity
8. Provides a safer learning environment
9. Enhances control and responsiveness



Top 10 Currently-Implemented Smart Technologies

1. Interactive whiteboards
 2. Cameras and video
 3. Tablets and eBooks
 4. Student ID cards
 5. 3-D printers
 6. Smart HVAC system
 7. Electric lighting/maintenance
 8. Temperature sensors
 9. Attendance tracking
 10. Wireless doorlocks
-

*N=612 IT Managers;
K-12 (65%) & Higher Ed (35%)*



TIPPSS for IoT is a growing need with device, data, & application growth.

- **Trust** – ensuring only designated people or services have device access
- **Identity** – ensuring identity of people, services, or “things”
- **Privacy** – ensuring device data is kept safely private
- **Protection** – ensuring device users protected from harm
- **Safety** – ensuring safety of devices, infrastructure and people
- **Security** – maintaining security of data, devices, people, etc.



Flo's top concerns: TIPSS in an interconnected IoT world.

Top concerns:

- Connected vehicles
- Connected healthcare devices

Protection needed :

- Physical Health and safety risk
- Financial risk
- Reputational harm
- Loss of privacy
- Data theft
- Hack in / Hack out

How The Internet Of Things Is The Perfect Target For DDoS Attacks And Data Breaches

14 January 2017, 12:00 pm EST By Athena Chan Tech Times

COMPUTERWORLD
FROM IDG

NEWS

DDoS attack on Dyn came from 100,000 infected devices

TechRepublic.

SEARCH

Q

CXO Cloud Big Data Security Innovation More - Newsletters Forums Resource Library Tech

SECURITY

49% of businesses fell victim to cyber ransom attacks in 2016

Ransom is the top motivation behind cyber attacks, according to a report from Radware, and IT professionals are most concerned about data loss. Here's what you need to know.

By Alison DeNisco | January 10, 2017, 3:00 AM PST

xconomy

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Our
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Cybersecurity in 2017: Goal, Illusion, or Oxymoron?

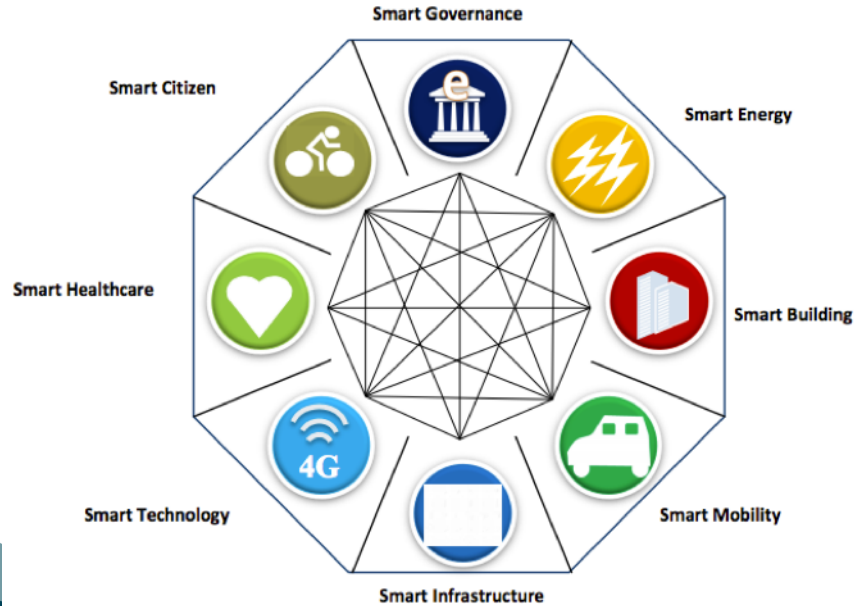
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Sources: IHS 2016; McKinsey 2016

Smart Cities, Campuses, & Communities will be built on a foundation of Internet of Things technologies.

Smart Cities Defined



White House Smart Cities MetroLab Network tackling key community challenges.

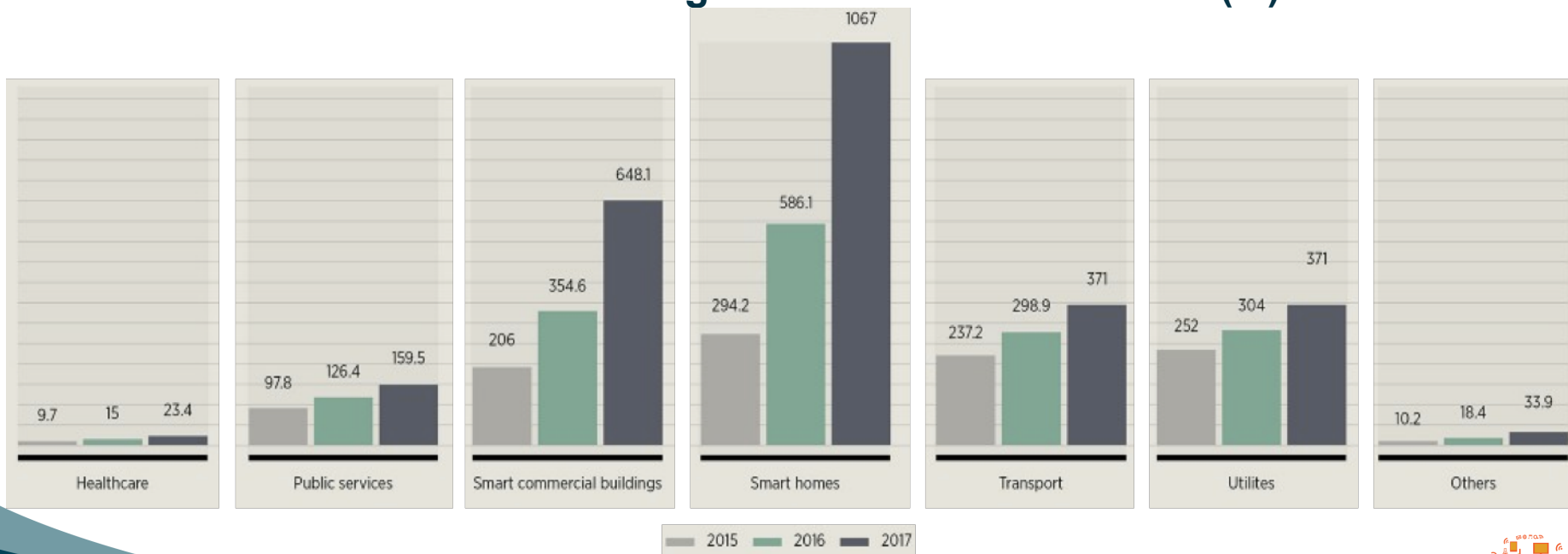
- 35 city-university partnerships including 50+ Internet2 university members
- Multi-sector, intercity collaborative models
- “Internet of Things” applications testbeds

NSF Smart and Connected Communities Solicitation 16-610



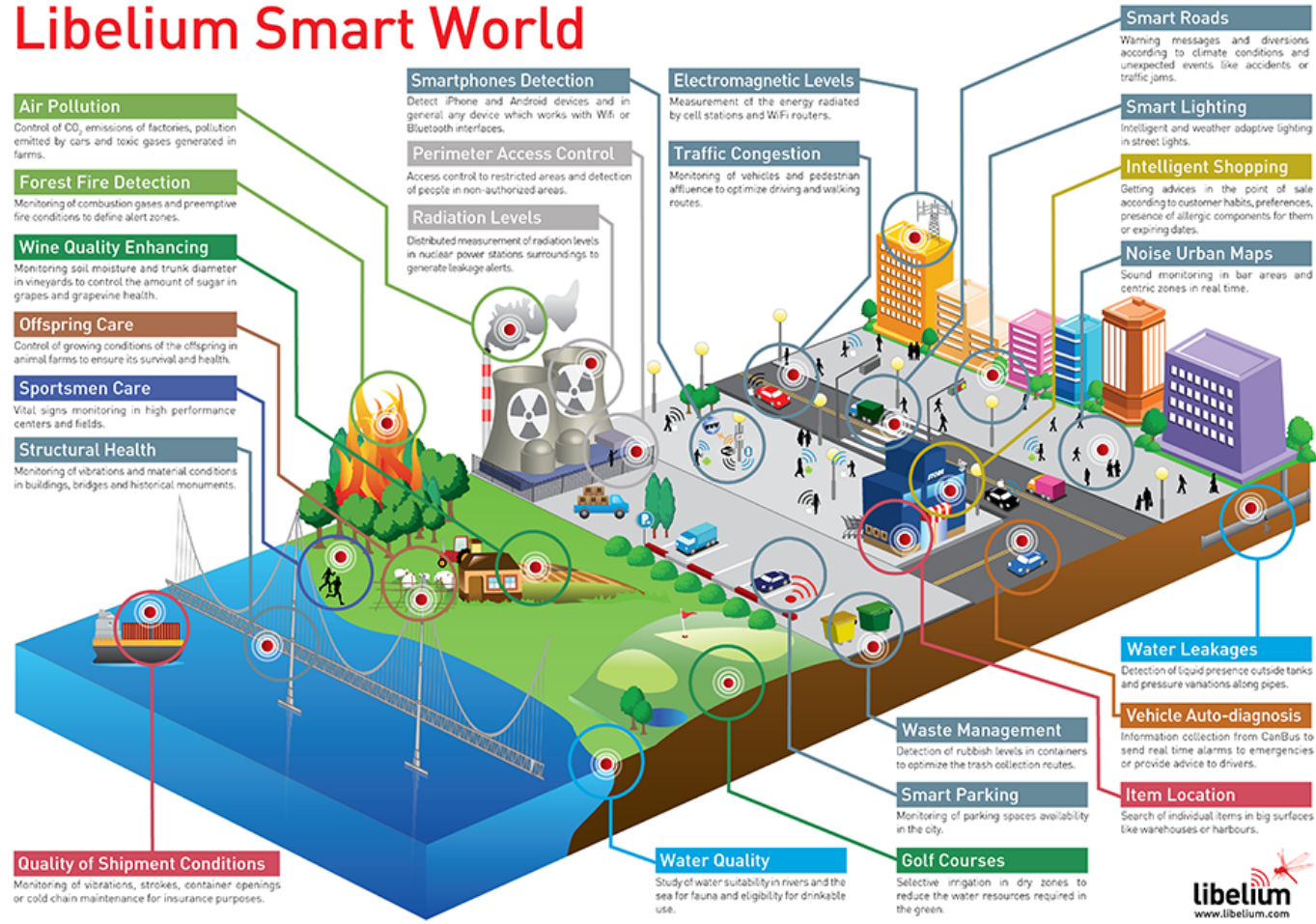
IoT devices are proliferating in homes, commercial buildings, and city infrastructure...and more...

Connected Things Installed in Smart Cities (M)



An interconnected city measures everything: traffic, lighting, water, waste

Libelium Smart World



Smart Campus Initiative created based on member input & innovation working group use cases, with kickoff meeting at Global Summit 2016.

- Share best practices and recommendations to deploy Smart Campus capabilities
- Guided by a Smart Campus CIO Advisory Council
- Next event: Microsoft Campus Connections Summit, 100+ enrollees, Feb 14-16
- NSF Smart & Connected Communities Research Coordination Network Proposal “TIPPSS for IoT in Smart & Connected Communities”

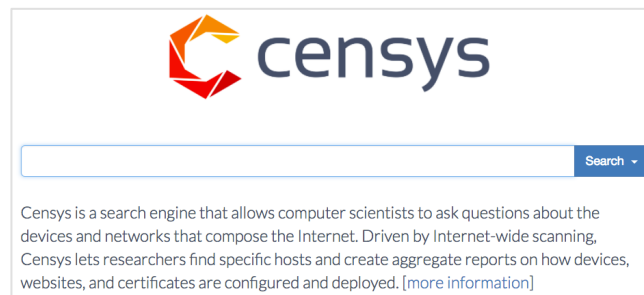
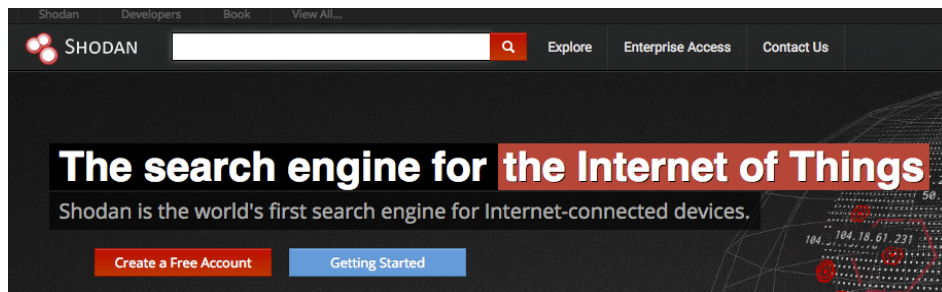
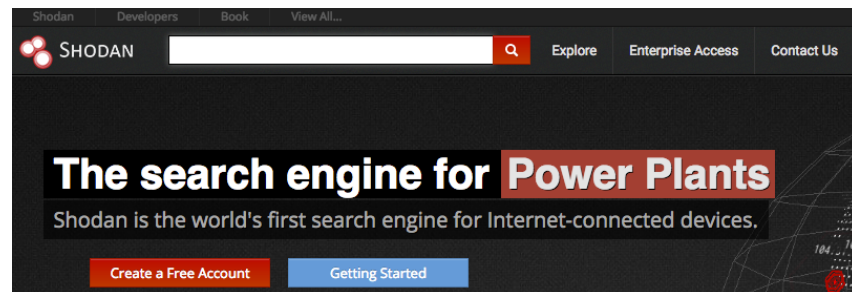
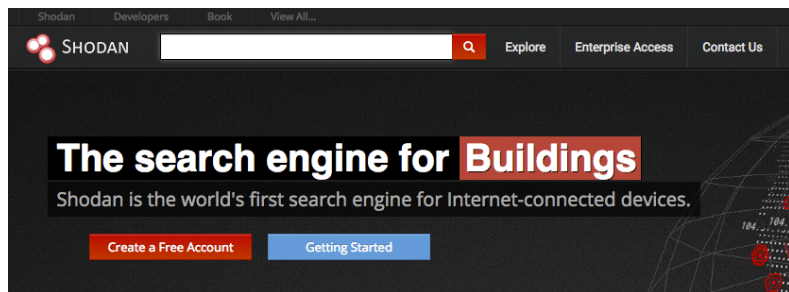


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Internet2 IoT Systems Risk Management Task Force: Recommend Initial Exposure Benchmarking/Baselining via Shodan & Censys.io tools.

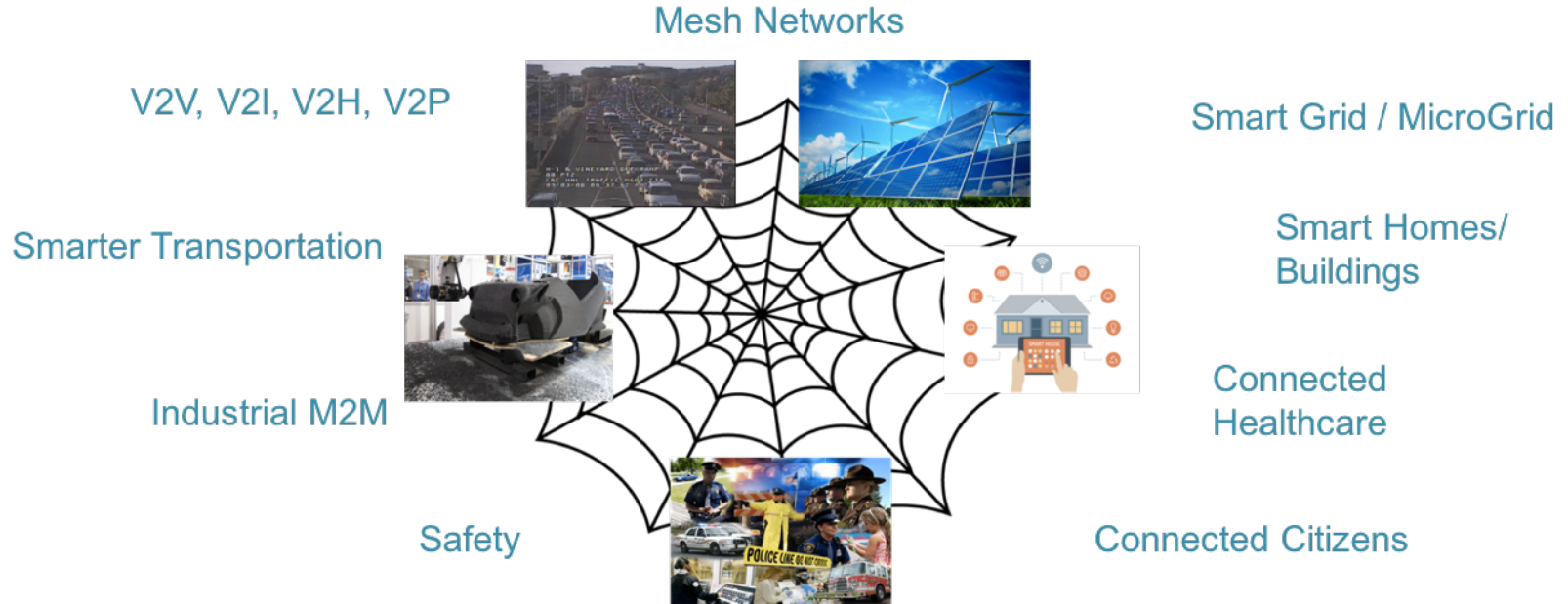


Internet2 Smart Campus Initiative Next Steps

- Enable IoT exploration, collaboration, and knowledge transfer across campuses
- Increase IoT systems risk awareness leveraging Shodan and Censys.io
- Develop IoT Systems Vendor Requirements Document
- In person workshop at Microsoft Campus Connections Summit, February 2017
- Demo Shodan and Censys.io tools at Internet2 Global Summit, April 2017
- TIPSS for Smart & Connected Communities



Future smart communities will be an inter-connected “system of systems” to improve efficiency, safety, quality of life, energy use, & environment.



What can we enable if we think across the system of systems?



Smart Grids are a key step in the development of Smart Cities/ Campuses, and require end-to-end trust and security.

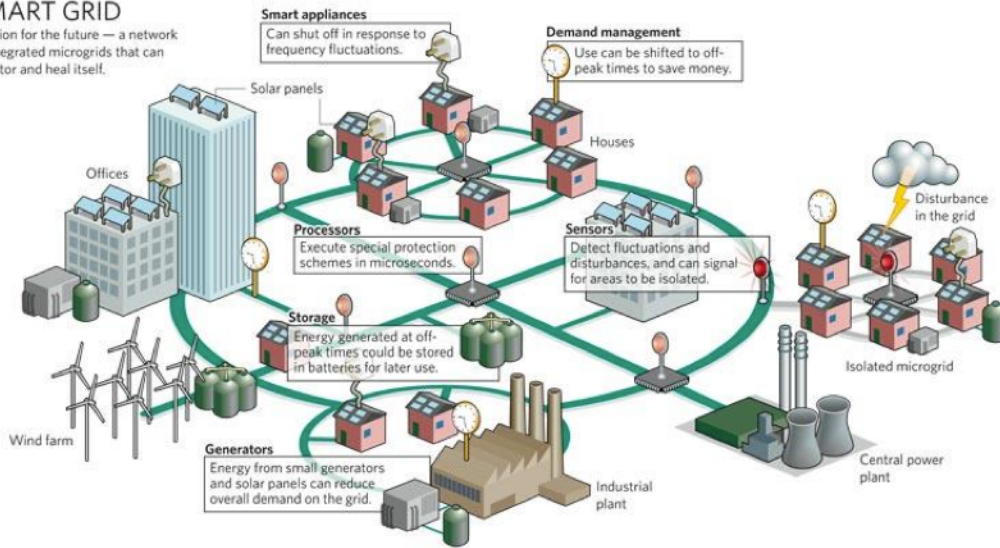
Smart Grid value is transformational and positively impacts:

- Transmission optimization
- Renewables integration
- Distribution automation
- Advanced metering infrastructure
- Analytics
- Cybersecurity

Universities and Regional Networks are leveraging the Internet2 network for Smart Grid testbeds

SMART GRID

A vision for the future — a network of integrated microgrids that can monitor and heal itself.



Mobile Internet is an enabler of IoT, Smart Cities/Campuses, and Healthcare transformation.

Internet-enabled portable devices are now a way of life:

- By 2020, 4 Internet-Connected devices for every human
- Mobile computing devices, high-speed wireless connectivity, and applications

Healthcare could benefit the most from Mobile Internet.

Consider a Connected Healthcare scenario:

<http://bit.ly/2eOcJBP>



Healthcare Leads Mobile Internet Potential in 2025

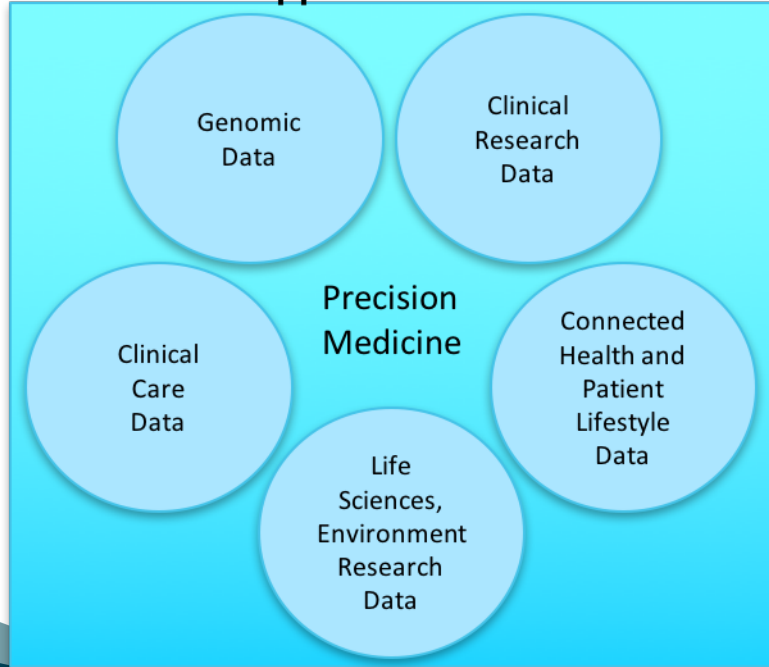


New technologies will play a role in Healthcare & Life Sciences in the future – building on current capabilities.



Healthcare & Life Sciences will increasingly leverage technology for analysis of volumes of data, improving insights and outcomes.

Data to Support Precision Medicine



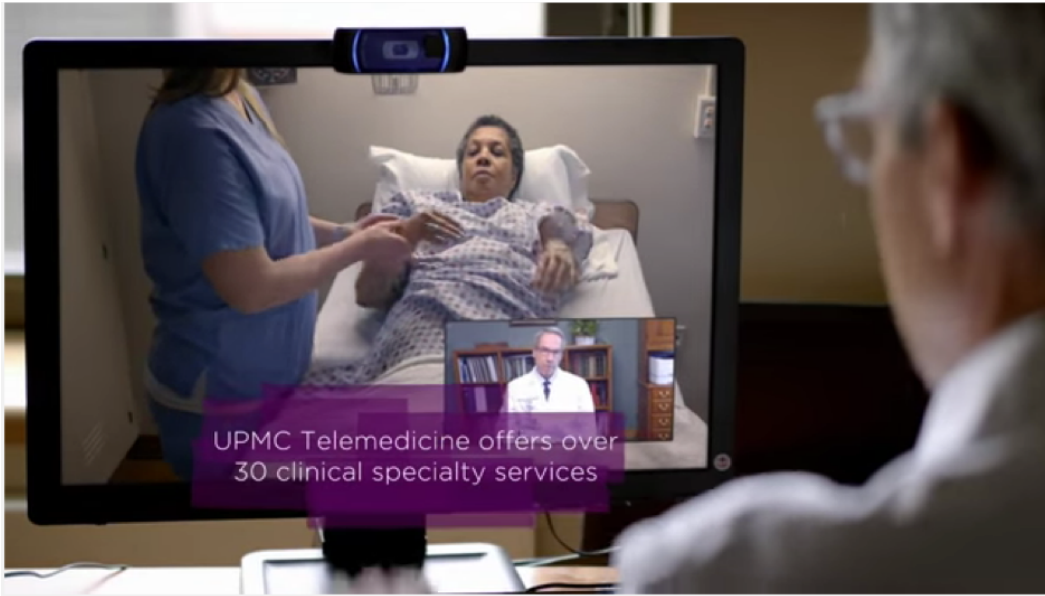
Large data volumes and analytics opportunity:

- Genomic data
- Clinical and fundamental research data
- Clinical care data and observations
- Patient input including lifestyle, travel

Creating a cognitive computing opportunity



Healthcare & Life Sciences advances – like Telemedicine – will be powered are enabled by broadband connectivity and IoT.

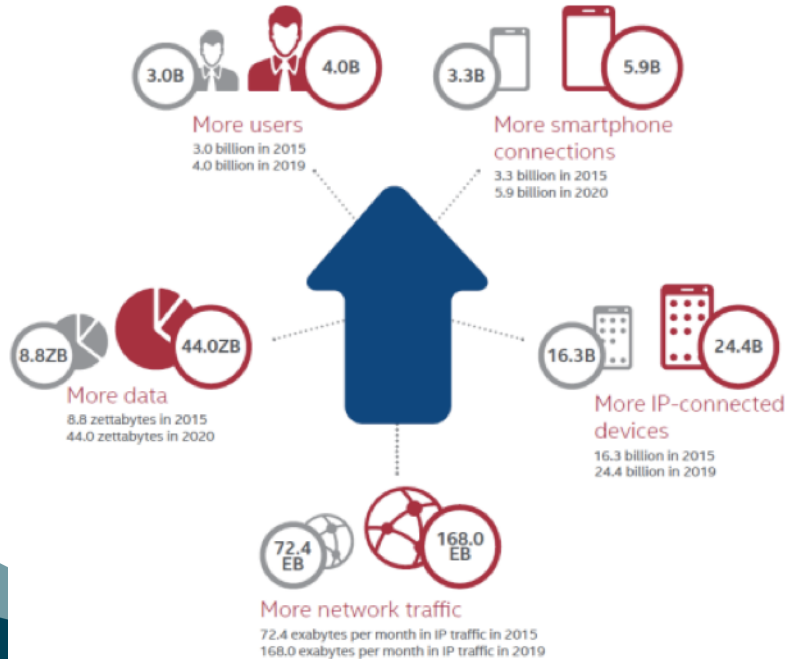


University of Pittsburgh Medical Center Telemedicine
<http://bit.ly/1SIVUhh>



Cybersecurity is required for IoT, Smart Cities, and Smart Grid to be successful.

The Growing Cyberattack Surface



Cyber Security grabbing headlines and will become increasingly important with more connected IoT devices.

- Distributed Denial of Service (DDoS) attacks increasingly more potent, and one of the most frequent types of incidents
- Key areas for innovation include: detection, response, defense, prediction, prevention
- Multiple aspects of risk: data, physical, and financial
- Critical applications of the Internet of Things require TIPSS: **Trust, Identity, Privacy, Protection, Safety, and Security**

“There are two kinds of big companies in the US. There are those who’ve been hacked, and those who don’t know they’ve been hacked.”

- FBI Director, James Comey



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Source: IDG 2015; IDC 2014; Intel 2016

Addressing TIPPSS is essential to achieving safe, secure, scalable future smart city and campus architectures.

Trust
Intity
Privacy
Protection
Safety
Security



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Opportunities for the Research & Education Community.



- **Develop curricula & labs to build the technical & business leaders of the future economy**
 - Curricula for TIPPSS, Internet of Things, Precision Medicine, Smart Campus/Cities/Grids, Informatics
 - Develop new business models, technologies, process
- **Create technology innovation through research and testbed programs**
 - Testbeds leveraging Internet2, international & regional networks: Smart Campus/Smart City/Smart Grid, HCLS
 - Collaborative research and application development
 - Innovations for device, chip, app, network, architecture, security, communications, etc.
- **Develop new models for improved operation & sustainability of a campus, city, community**
 - IoT to measure, monitor, model, and manage campus / city / community / health / safety operations
 - Cross-functional collaboration for improved outcomes, e.g., IT / facilities / administration / students
- **Internet2 and its members can guide health & life sciences to the next frontier**
 - Enable leverage of various data sets for precision medicine
 - Connect across multiple new technologies for strategic areas/use cases
- **Attract funding to support member research in strategic domains**
 - Potential funding sources could include agencies, industry, foundations
 - Opportunity for singular or multi-university funding proposals





Questions & Answers...
Thank You
fhudson@Internet2.edu
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