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BOUNDLESS COLLABORATION.
COMMUNITY
CONNECTED RESEARCH. ACCELERATED DISCOVERY.

www.internet2.edu  [@internet2](https://twitter.com/internet2)

Smart Campuses

Florence D. Hudson, Senior VP and Chief Innovation Officer, Internet2

April 27, 2017

Georgia Tech, Atlanta, Georgia

Internet2 – Not for Profit, Member-Owned Consortium.

Network Services – 100 Gbps network

Trust & Identity – Federated Identity Management

Cloud Services (NET+) – 30 cloud services available

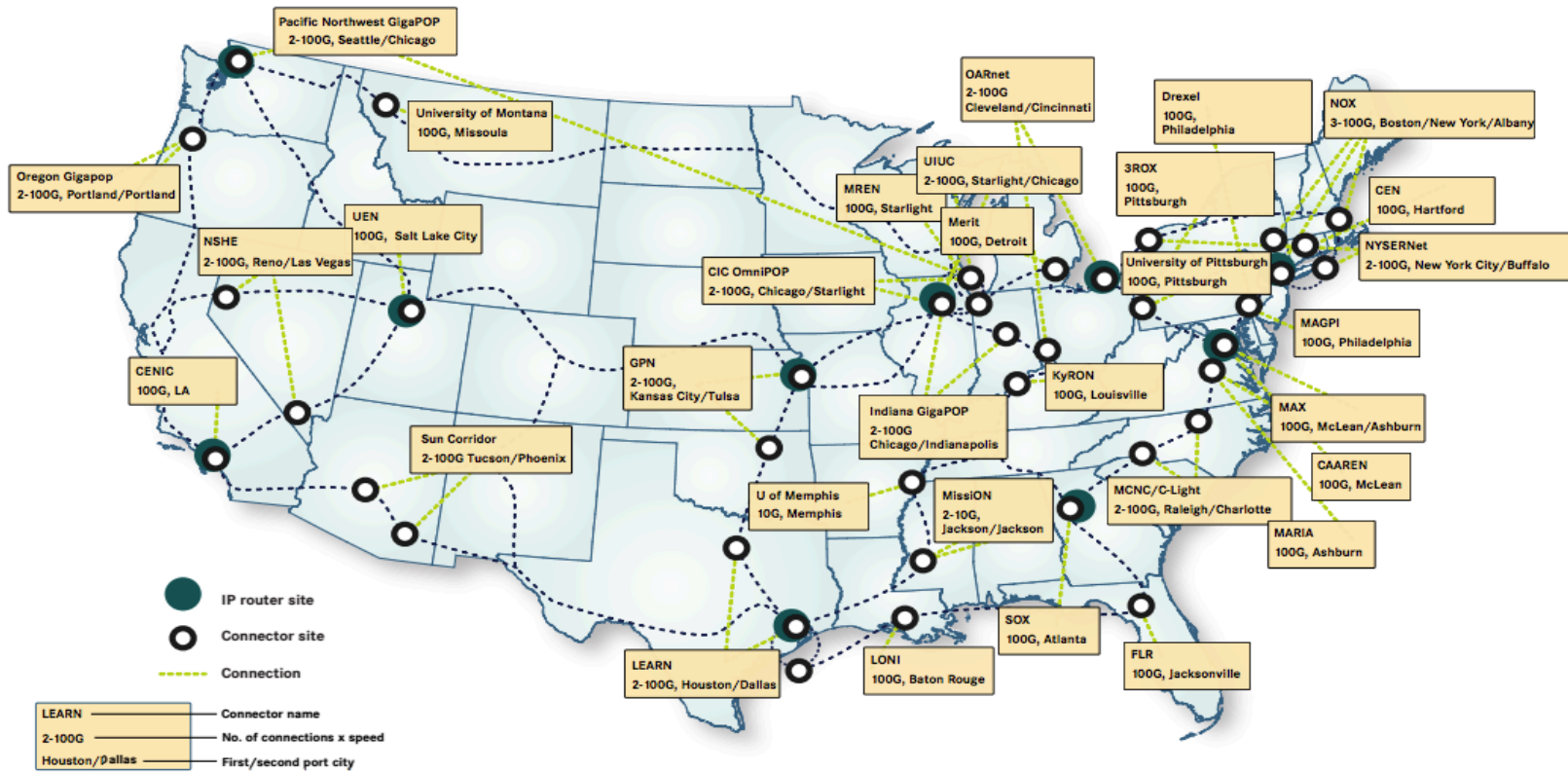
Community Engagement – 500+ members in Higher Education, Regional Networks, Industry & Affiliates

Innovation Office – Community-led innovations

US UCAN – 93,000 community anchor institutions



Internet2 NETWORK CONNECTIONS



NETWORK PARTNERS



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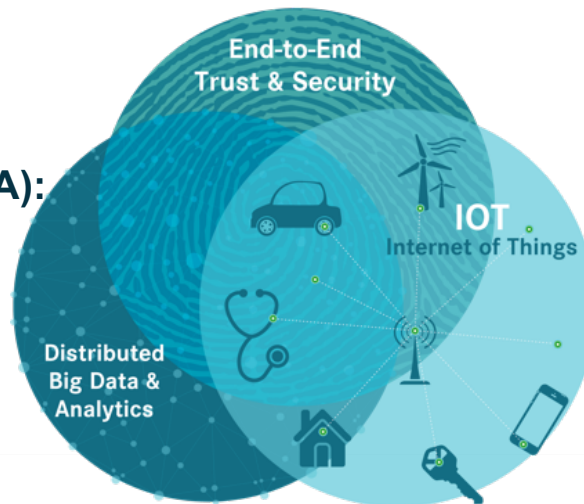
Smart Campuses and Cities was identified as a key area for collaborative innovation, stemming from focal areas in a May 2015 Internet2 member innovation survey.

E2E Trust & Security (E2ET&S):

- TIPSS for IoT – Trust, Identity, Privacy, Protection, Safety, Security
- NSF EAGER Cybersecurity Transition to Practice (TTP) Acceleration
- SDP (Software Defined Perimeter), Network Segmentation for IoT

Distributed Big Data & Analytics (DBDA):

- Health & Life Sciences / Genomics
- Smart Campuses and Cities
- NSF Big Data Hub Collaboration



Internet of Things (IoT):

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

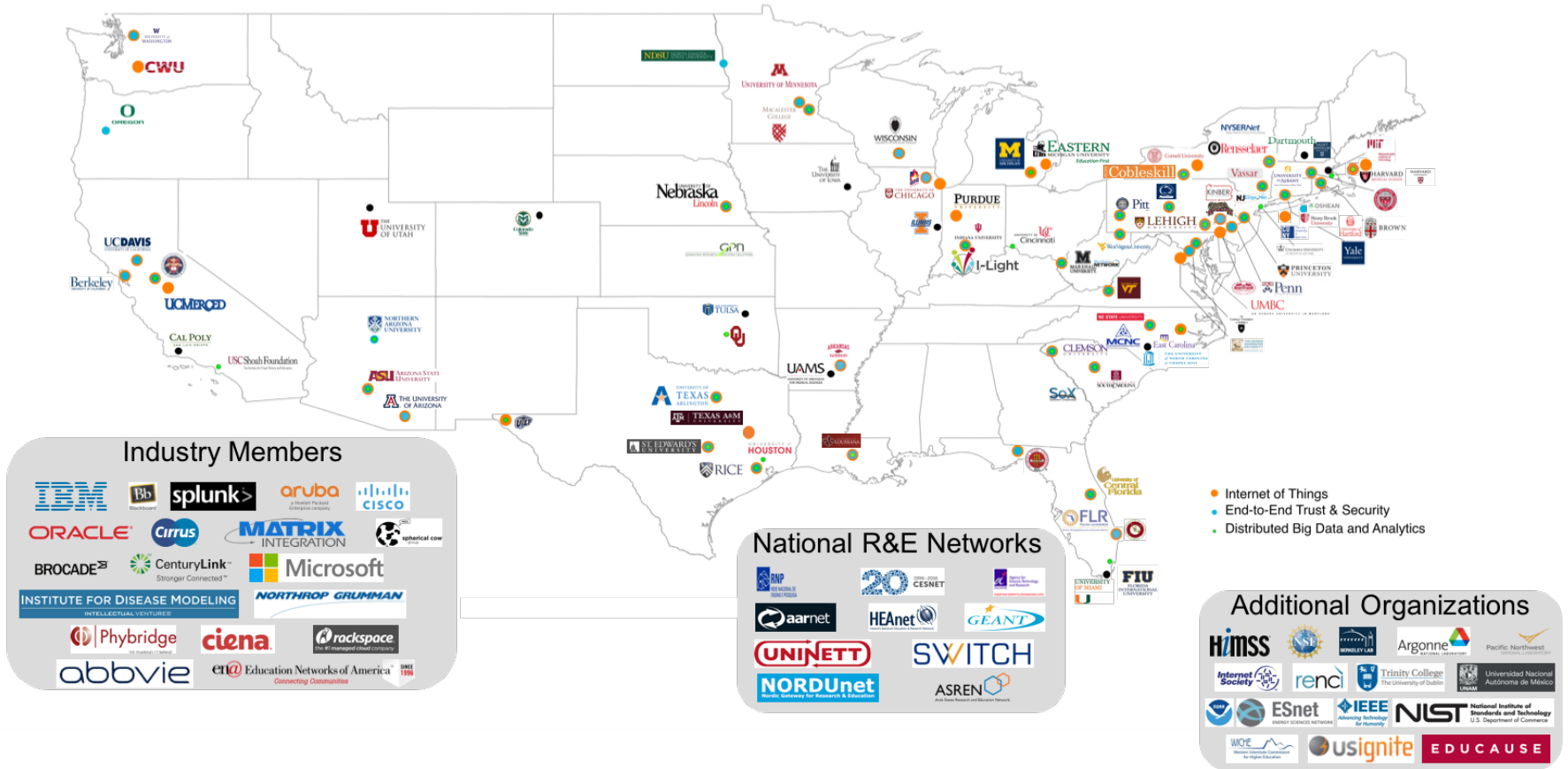
The Internet2 Collaborative Innovation Community (CINC UP) includes Special Interest Groups pertinent to use cases identified by members.

- Smart Campus
- Smart Grid
- IoT Ethics
- Cybersecurity TTP
- Healthcare & Life Sciences / Genomics



Join us! Email CINO@Internet2.edu

Internet2 Collaborative Innovation Community includes 335+ individuals representing 135 institutions.



As of April 12, 2017

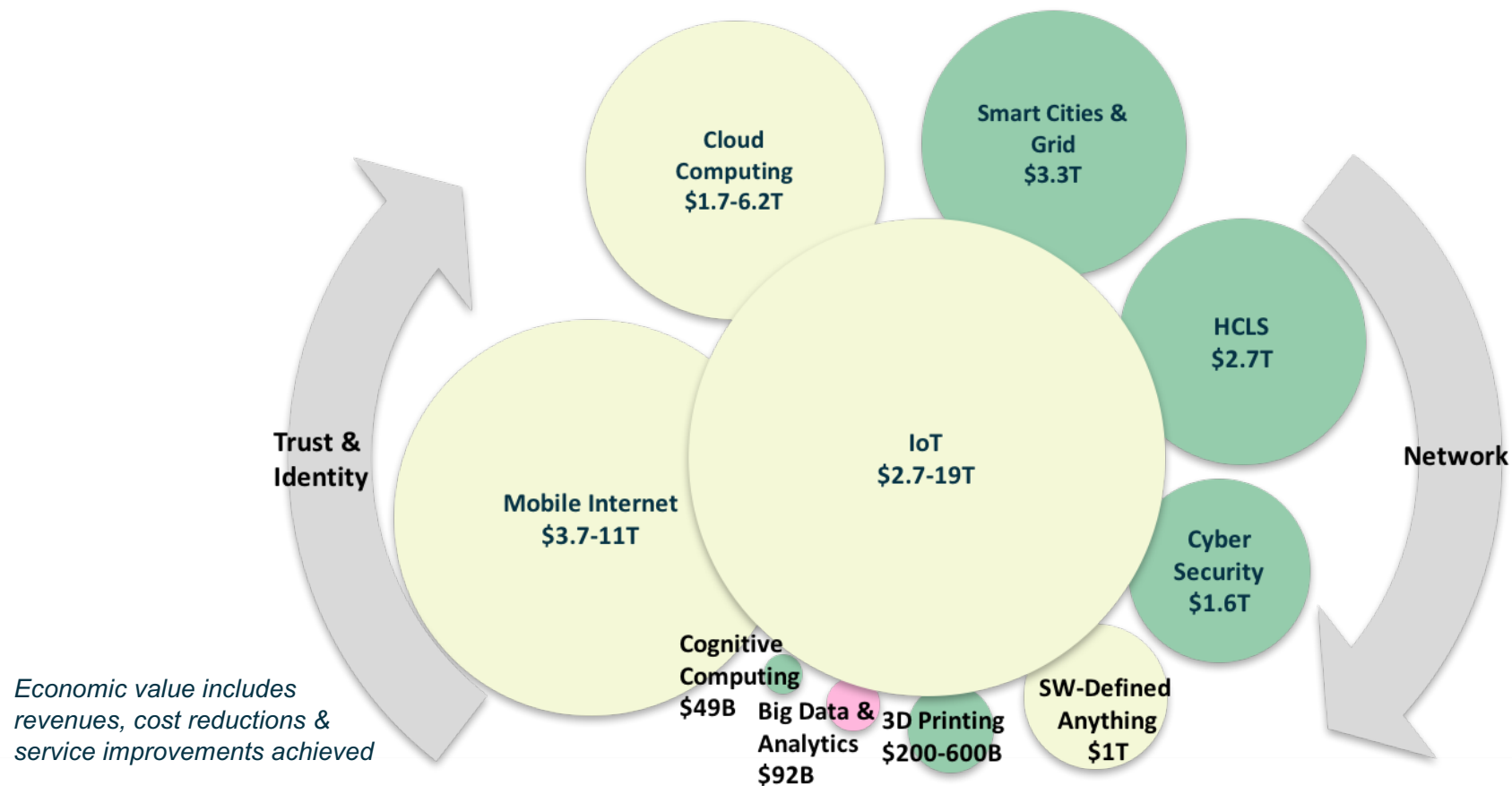


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Monthly Collaborative Innovation Community CINC UP Calls are held on a variety of topics, many pertinent to smart campuses

- Network Segmentation for IoT presented by Cisco
- OpenFog Consortium presented by Princeton University
- Best Practices for researcher engagement and cyber-infrastructure support presented by Penn State and University of Wisconsin-Madison
- Virtual and Augmented Reality presented by University of Cincinnati
- LoRa low-power wireless WAN pilot for IoT research presented by SURFnet (Netherlands)
- NSF Smart & Connected Communities, with US Ignite and The Quilt
- Internet of Things Security and Blockchain presented by IBM Blockchain Garage (Singapore)
- AWS Greengrass: Unlocking the Promise of IoT presented by Amazon Web Services
- IPv6 Myth vs. Reality presented by Virginia Tech and Malone University
- IoT Azure Suite presented by Microsoft
- IoT Pedagogy presented by Marshall University, SUNY Cobleskill, Syracuse University
- Privacy Decision Making and IoT presented by Clemson University
- **Interested in participating? Email CINO@Internet2.edu**

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



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Sources: McKinsey 2016; Frost & Sullivan 2016; CNBC 2016; Markets & Markets 2016; Morgan Stanley 2016; CMS Wire 2016; Business Wire 2016; Wikibon 2016; Yahoo! Finance 2017

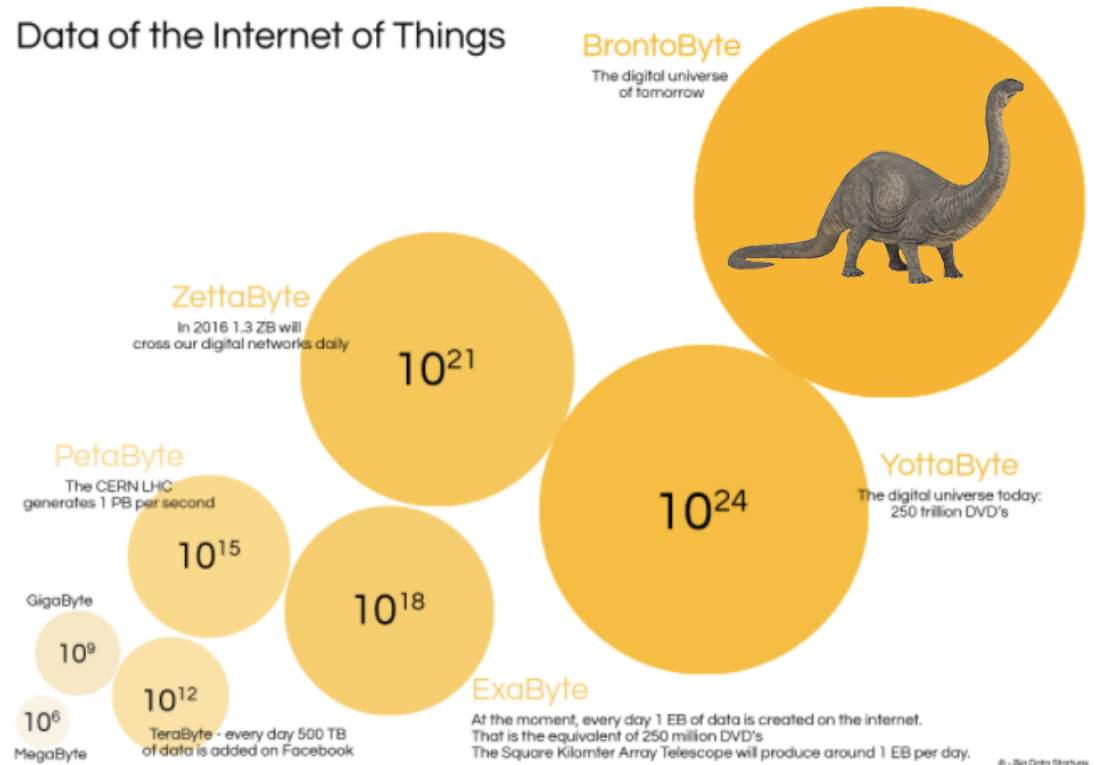
The Internet of Things will generate the majority of new data on the planet, generated by billions of new devices.

IoT installed base, global market, billions



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

Data of the Internet of Things



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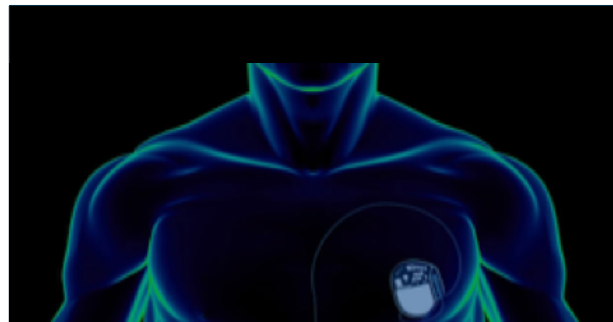
Sources: What's The Big Data 2015; Datafloq 2016; GlobalSources 2016

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



Vehicle Hacking

<http://bit.ly/jeephackwired>



Healthcare Device Hacking

<http://bit.ly/jnjinsulinpump>

<http://bit.ly/medtronicinsulinpump>



**Smart Home Devices
Hacking Other Devices**

<http://bit.ly/hackedhomedevices>

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
- Commissioned IoT Systems Risk Management Task Force
- Microsoft and Internet2 co-convened first annual Campus Connections Summit, Feb 2017, 140+ university “CIO + 1” attendees from around the world



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Research & Education activities in Smart Campus & Communities, IoT, end-to-end trust & security, big data & analytics, Smart Grid.



Smart Campus operations & data analytics research



Advanced Networking / Cybersecurity Research



Smart Grid research

NC STATE UNIVERSITY

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 research and pedagogy
- Blue - IoT Smart grid research
- Orange - IoT security, privacy, ethics



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ASU Smart Campus Journey began with a Smart Stadium



Gen 1: Game Day Experience

- Infrastructure upgrade
 - WiFi
 - DAS - Distributed Antenna Systems
- Real Time Parking
- Sensor Packs
- A smarter sound game
- Upgraded mobile app

Gen 2: Stadium Suite

- Water flow sensors
- Alexa skillset
- Sentiment analysis
- Indoor wayfinding
- AWS Dash



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Gen 3: Scaling to a Smart Campus

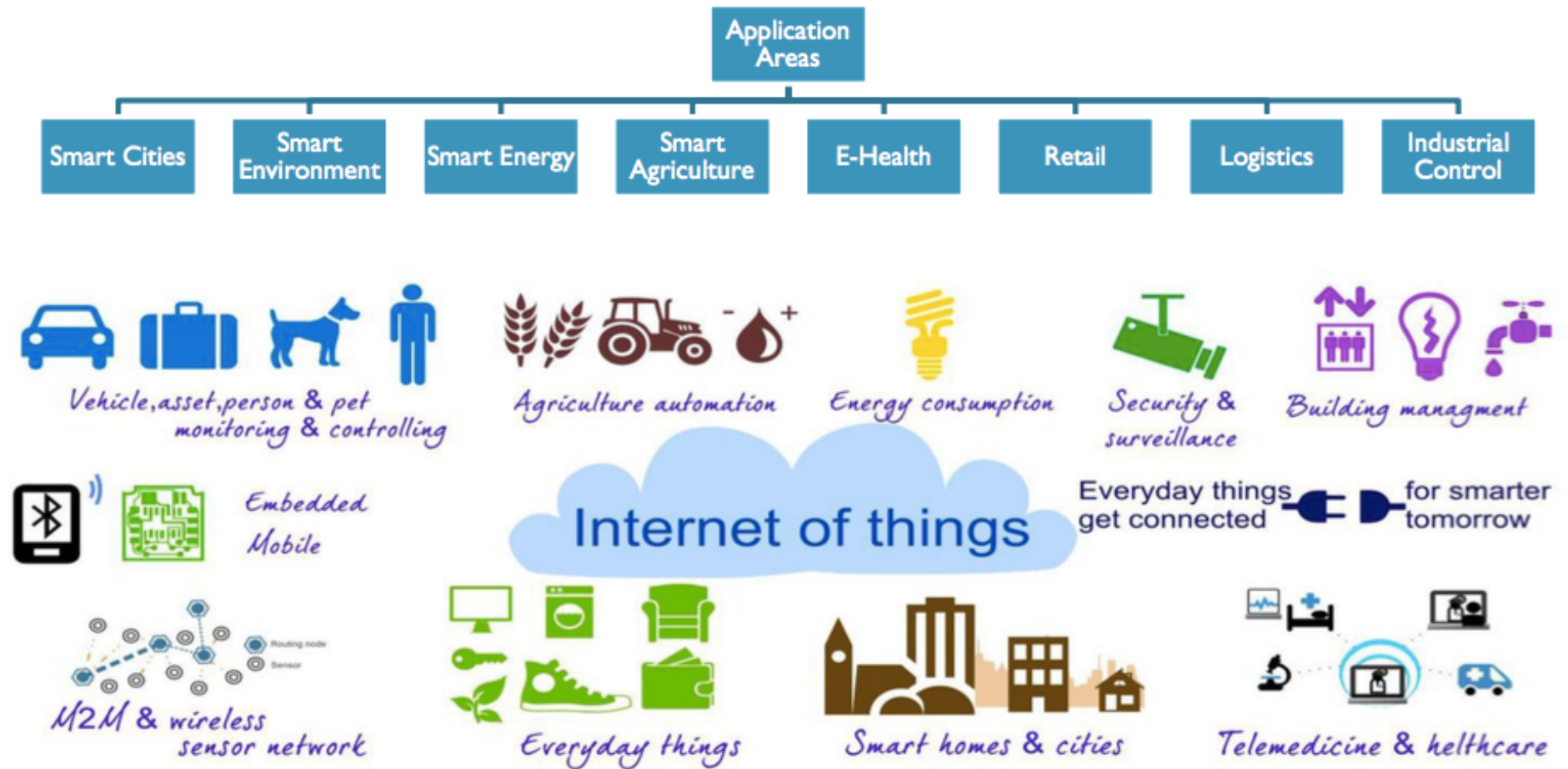
- Smart Fleet
 - Vehicle/Golf Cart Reservation tracking
- Smart Classroom
 - Automated attendance tracking
- Smart Assistant
 - Building out Alexa skillset
 - Integrating other information sources



ASU Smart
Culture



ASU's View of a Smart Campus



Arizona State University's Vision for a Connected Campus



A comprehensive connected campus blends both IoT-driven insights and digital engagement capabilities to deliver a leading higher education experience across university stakeholders.

Smart Campus

Implementing IoT technologies across multiple layers of the campus environment to help inform university decision making and improve the day-to-day life of students, faculty, administrators, and alumni

Digital Student

Delivering world-class on campus and digital experiences by looking at services from the outside-in putting students, faculty, administrators and alumni at the heart of design



- Student**
- Higher Student Retention
 - Higher Student to Teacher Ratio
 - Higher Student Engagement

- Faculty**
- Higher Student Interaction
 - Early Detection of Disengagement
 - More Personalized Attention

- Administration**
- Better Resource Utilization
 - Secured & Safe Infrastructure
 - Automated and Continuous Process Improvement
 - New Revenue Streams



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Academic, Government & Private Partnerships



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



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.



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

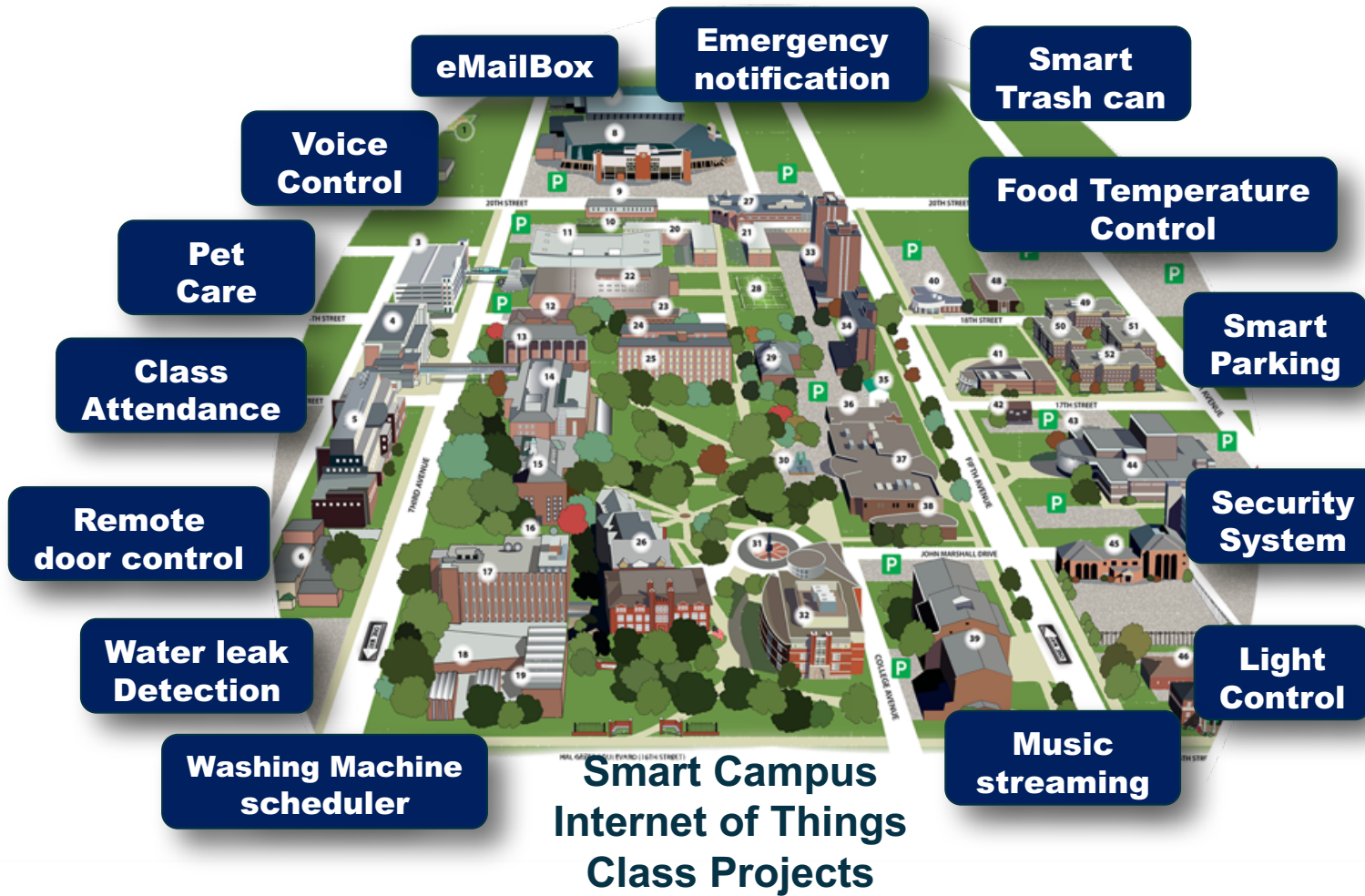
IoT Research & Education at Stanford University – Autonomous Vehicles and Ethics



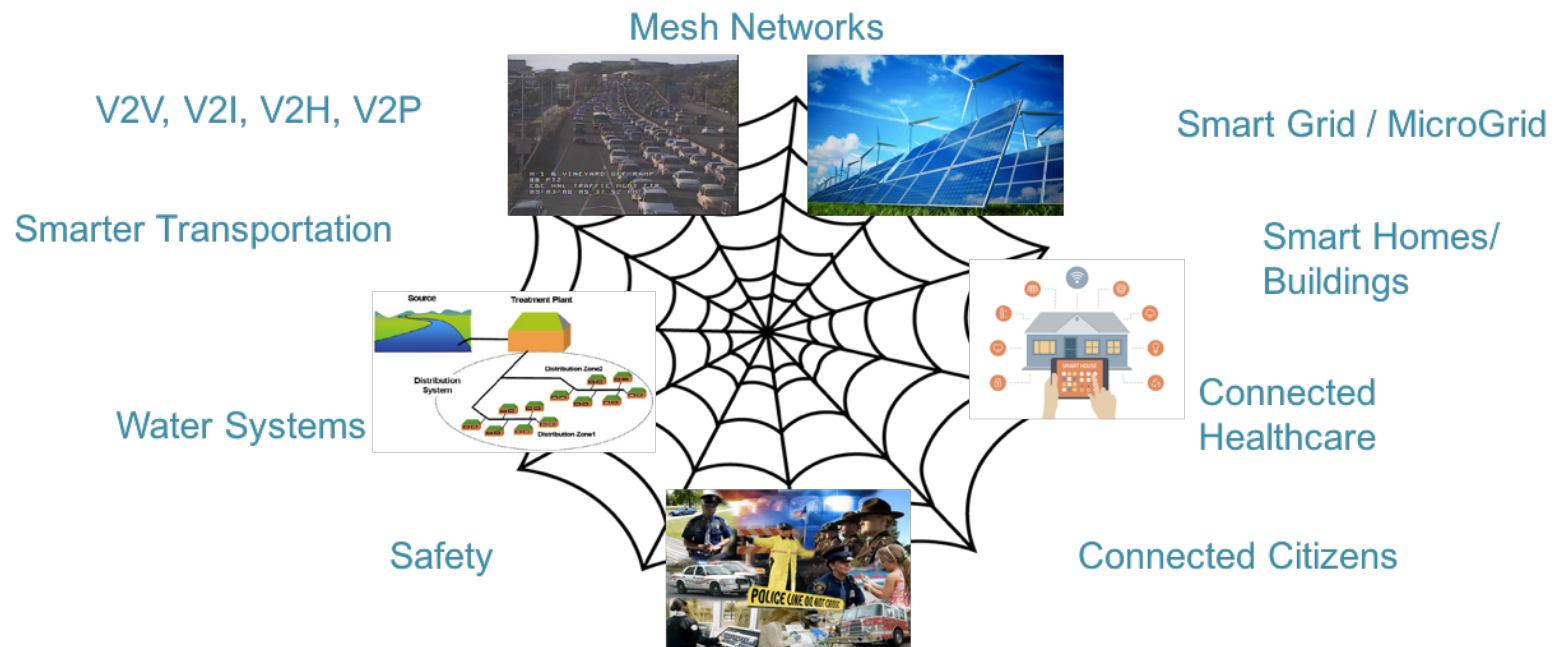
<http://bit.ly/autonomousvehiclesethics>



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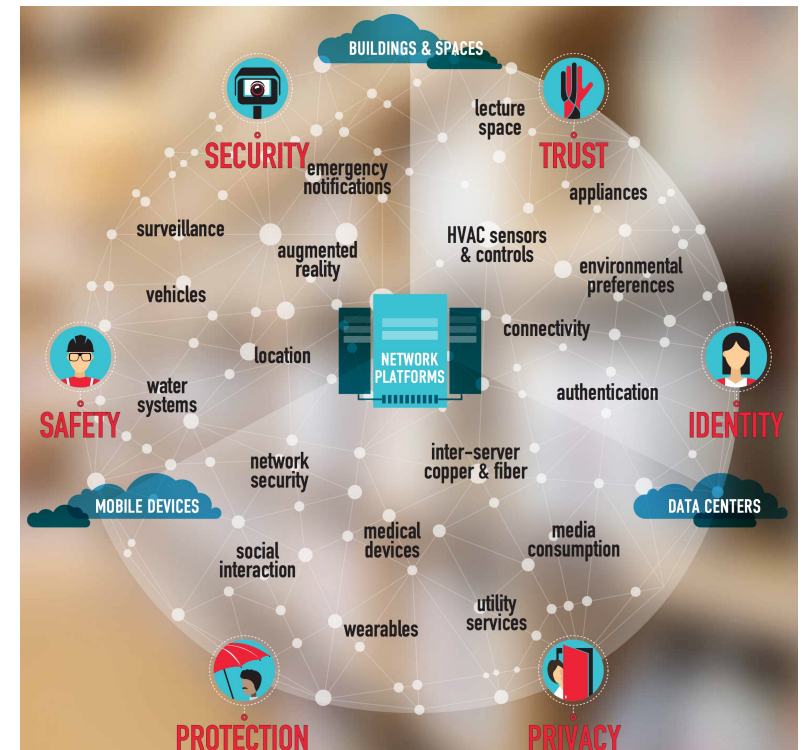
Smart communities will be an interconnected “system of systems” to improve efficiency, safety, quality of life, energy use, & environment.



*What can we enable if we think across the system of systems?
How do we safely and securely connect these systems?*

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

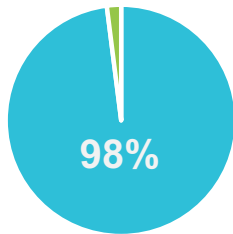
- **Trust:** Allow only designated people/services device access
- **Identity:** Validate identity of people, services, or “things”
- **Privacy:** Device, personal, sensitive data is kept private
- **Protection:** Device users protected from harm
- **Safety:** Safety of devices, infrastructure and people
- **Security:** Maintaining security of data, devices, people, etc.



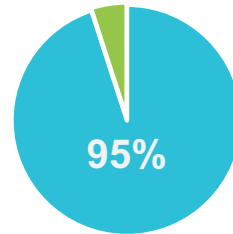
February 2017 Microsoft Campus Connections Summit participants identified initiatives to further the Smart Campus journey.

- **Student Success & Data Analytics**
 - The Agile University
 - Global Talent Profile
 - MentorBot Personal Tutor for Student Success
 - **Safety & Security**
 - Cybersecurity Learning Hub
 - Digital Literacy
 - **Energy & Sustainability**
 - Campus as a Living Lab Breaking Cultural Barriers
 - Achieving Carbon Neutrality SCOPE ME
 - **Collaborative Research**
 - Research Portal “1 Portal for All”
- The Agile University**
- Cybersecurity Learning Hub**
- IoT Lab Contest**
- Research Portal**

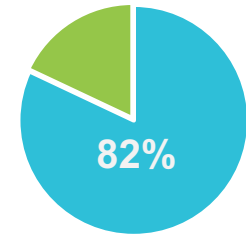
Survey finds that U.S. university students are comfortable sharing personal data with universities, but want an improved college experience in return.



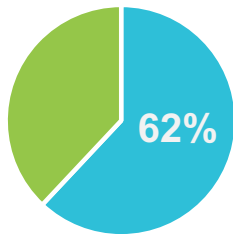
98% want school to use personal information to improve academic processes



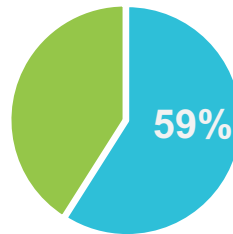
95% expect the personal data shared to improve college experience, student life



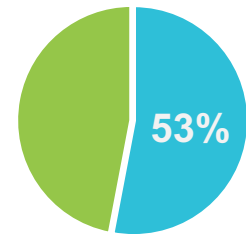
82% think personal data shared now will transform future college experiences



62% want school to track graduation requirements & progress



59% want school to use personal data to help select, register for classes



53% want school to use data for scheduling academic advising sessions

Internet2 IoT Systems Risk Management Task Force 2016-2017 Outcomes

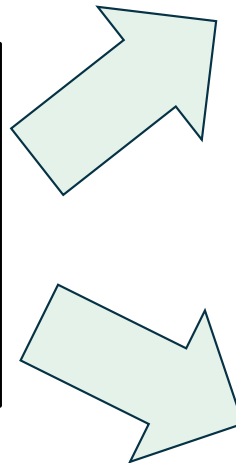
- Explored *lifecycle of IoT Systems risk & operational management* for Higher Ed
- **Developed 2 tools/practices as starting place:**
 - Higher Ed practice of using Shodan and Censys tools to develop a view of IoT Systems risk exposure for a Higher Education institution
 - IoT Systems Vendor Management document/checklist to guide departments/orgs within an Higher Ed institution on selection, procurement, management of IoT Systems

Developing an IoT Systems Risk Mitigation Life Cycle

Pre-IoT Systems Implementation -- Risk Mitigation

IoT Systems Vendor Management Guidance Document

- Questions to guide purchaser/
future owner of IoT Systems



Post-IoT Systems Implementation -- Operational Risk Management

Institutional leadership

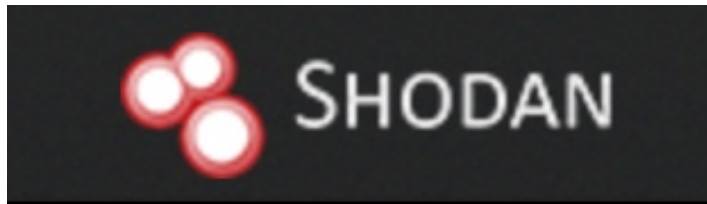
- Policy, process, oversight,
resourcing

Post-IoT Systems Implementation -- Cybersecurity Risk Management

Shodan/Censys/Other tools

- System / device identification
- Risk mitigation

IoT Systems Risk Management benchmarking activity – identify discoverable devices on campus



- Proprietary
- Developed by former UCSD student
- Used by private sector and academia






- Open source
- Developed at Univ of Michigan/Illinois
- Daily [ZMap](#) and [ZGrab](#) scans of IPv4 address space across important ports and protocols

Both do full text searching on protocol banners and other metadata on websites, servers, devices

WARNING: Consult your CISO office before using! Prior notice and authorization may be required.

Some identified devices on campus using Shodan and Censys

	Cameras	Building Automation	Sensors
		 device servers	 ICS/SCADA
Search terms	"camera"	"scada," "ICS," "HVAC," "Tridium Fox," "BACnet," "Modbus"	"AMQP" "RabbitMQ" "MQTT"
Potential Risk	Weak, hard-coded passwords	Components of building control systems exposed on Internet, protocols lacking authentication, encryption	Complex, layered systems with physical security issues, protocols lacking authentication

Cybersecurity Risks of EV Charging

Raju Gottumukkala, Ph.D

Director of Research, Informatics Research Institute
Site Director, NSF Center for Visual and Decision Info
Assistant Professor, College of Engineering



[2017 Internet2 Global Summit \(04/25/2017\)](#)

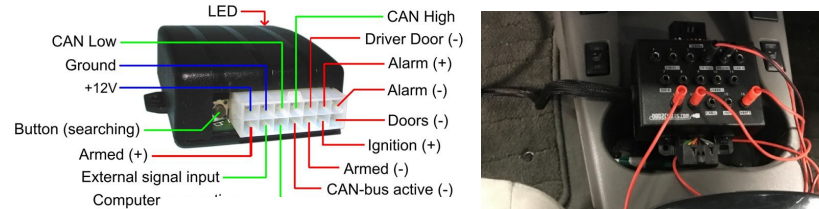


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Vehicle Vulnerabilities

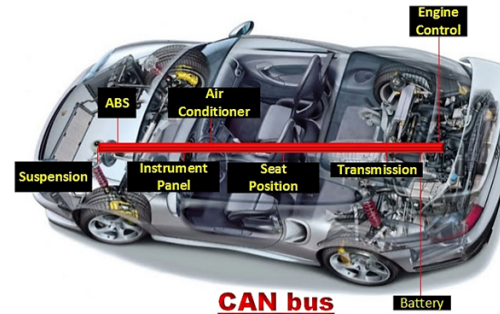
- CANBUS

- Connects all major controls, sensors & actuators



- Attacks

- Need Physical access without connectivity
 - All connected components are vulnerable



- Key Fob

- Bluetooth

- Wi-Fi

- Cloud security

- “People”



Source:
<http://thehackernews.com/2016/11/hacking-tesla-car.html>



Charlie Miller • Chris Valasek •
 Work diligently since 2010 on
 DARPA funding • VIDEO DEMO
 Hacking Chrysler Jeep
 Remotely

Protecting “Smart Campus” Infrastructure

- It ain't smart unless it is secure
- SCADA systems are not designed for IoT
- Lack of tools to detect potential entry points, and attack paths to SCADA systems
- 2015 NIST Industrial Control Systems (ICS) Security Guide



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

Internet-enabled portable devices are now a way of life

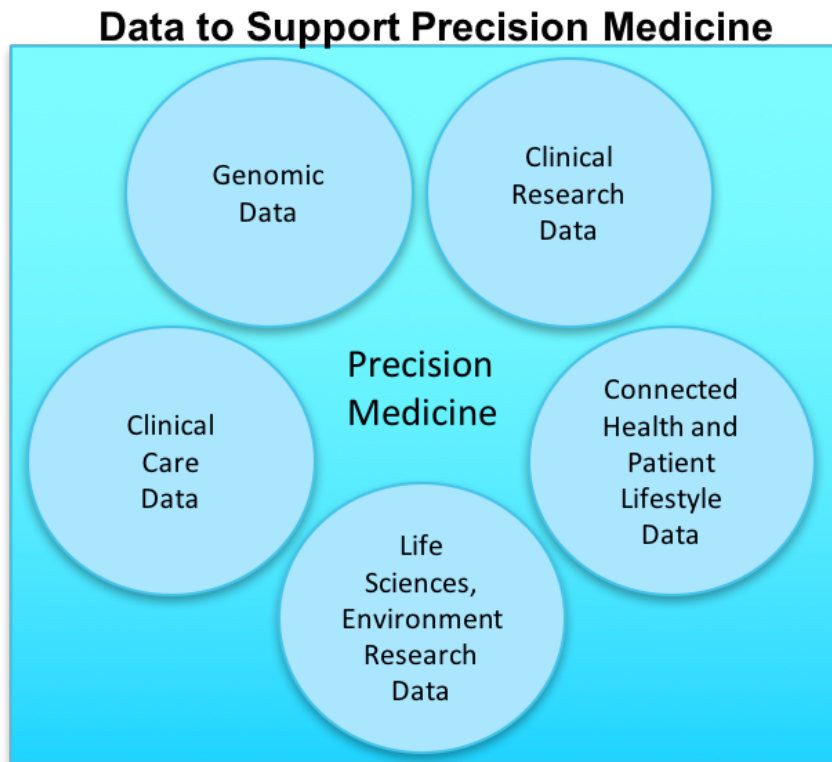
- By 2020, 4 Internet-Connected devices for every human
- Mobile computing devices, high-speed wireless connectivity, and applications
- Healthcare could benefit the most from Mobile Internet
- Consider a Connected Healthcare scenario:
 - <http://bit.ly/asperationalhealthcare>



Healthcare Leads Mobile Internet Potential in 2025



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



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

Smart Campus/Cities and IoT Data Sharing Challenges

Data sharing evolving needs

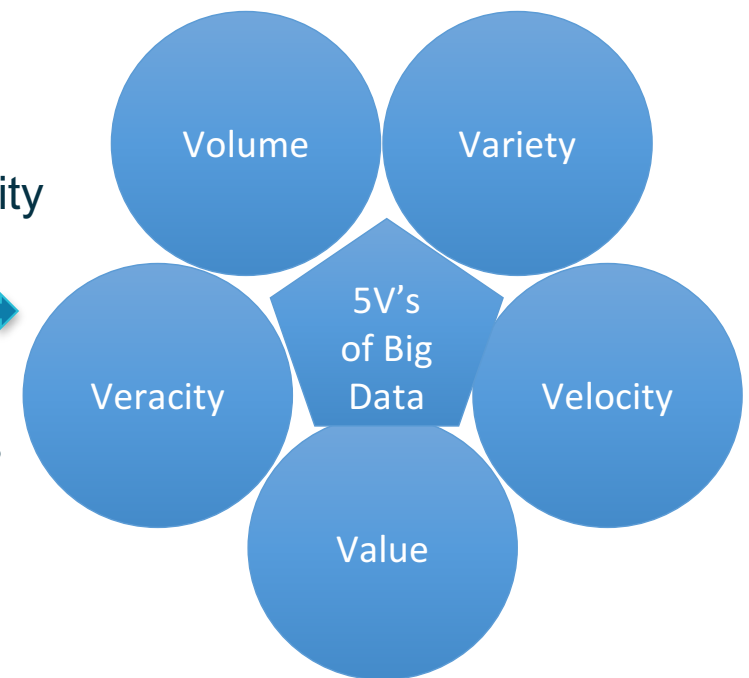
- Distributed big data and analytics
- Data integration across many data types
- Increasing need for end-to-end TIPSS –
Trust, Identity, Privacy, Protection, Safety, and Security

Data sharing challenges

- Dealing with the 5 V's of Big Data →
- End to end performance of data sharing
- Trust and identity of devices, people, services, systems
- Contracts, Intellectual Property, Regulations
- Use of student data for student success

Data sharing tools and techniques

- Advanced Networking
- Trust and Identity Solutions
- Data-Sharing Licensing Framework / Generator & Platform



Internet2 Smart Campus Initiative Next Steps.

- **Increase** IoT systems risk awareness leveraging Shodan and Censys.io, demos at GS17
- **Share** IoT Systems Vendor Requirements Document at GS17
- **Planning Workshop** with Princeton University Center for Information Technology Policy (CITP) on TIPPSS and Ethics in Campus IoT Networks, 2017
- **Create** thought leadership on TIPPSS for IoT for smart & connected campus/communities
 - **White paper collaborations:** Enterprise IoT ITANA Collaboration and Internet2 CINO PAG-led White Paper
- **Participate** in new initiatives and collaborations toward a Smart Campus
- **Identify** additional smart campus best practices across the community and enable sharing
 - Whitepapers, wiki's, systems risk management documents, campus presentations



Questions & Answers...

Thank You

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@FIoInternet2

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



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



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Source: Frost & Sullivan 2016

Opportunities for the Research & Education Community.



- **Develop curricula & labs to build the technical & business leaders of the future economy**
 - TIPPSS, IoT, Precision Medicine, Smart Campus/Cities/Grids, new business models, technologies
- **Create technology innovation through research and testbed programs**
 - Testbeds leveraging Internet2, international & regional networks: Smart Campus/Smart City/Smart Grid
 - Collaborative research and Innovations for device, chip, app, network, architecture, security ...
- **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
- **Higher education and K-12 opportunities to leverage innovations for R&E**
 - Advanced networking, Trust & identity, Innovation communities, cloud services
 - Leverage current innovations, enable collaborative research for future innovations

