

INTERNET²
2016
GLOBAL
SUMMIT
MAY 15-18
CHICAGO



INTERNET OF THINGS INNOVATION WORKING GROUP MEETING

Internet of Things (IoT) Innovation Working Group Meeting

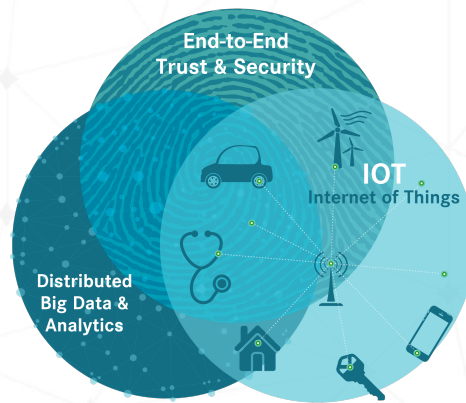
AGENDA

- **Evolution of the IoT Innovation Working Group:** Florence Hudson, Internet2
- **Update on Recent IoT Working Group Activities:** Brian Stengel, University of Pittsburgh and Steve Wallace, Internet2
- **IoT Related Policy, Ethics and Education:** Ed Aractingi, Marshall University
- **Introducing the Smart Campus Initiative:** Emily Nichols, Internet2
- **IoT Systems Risk Management Task Force:** Chuck Benson, University of Washington
- **Connected Vehicles as Things on the Internet:** Clark Gaylord, Virginia Tech Transportation Institute
- **Next Steps:** Florence Hudson, Internet2



Collaborative Innovation Program

**Established three new Collaborative Innovation Working Groups
During Global Summit 2015 based on March 2015 Member Survey**



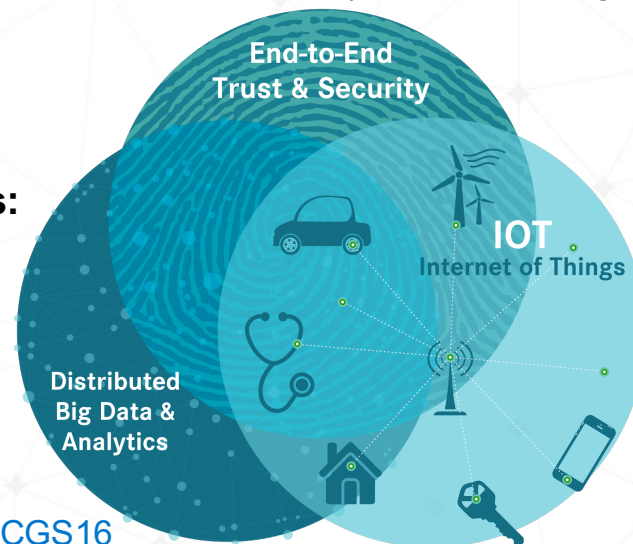
Collaborative Innovation Program Current Focus Areas

E2E Trust & Security:

- End to End Trust and Security for IoT
- TIPSS – Trust, Identity, Privacy, Protection, Safety, Security
- SDP (Software Defined Perimeter), Network Segmentation

Distributed Big Data & Analytics:

- Genomics
- Smart Campus/Smart Cities
- Digital Humanities

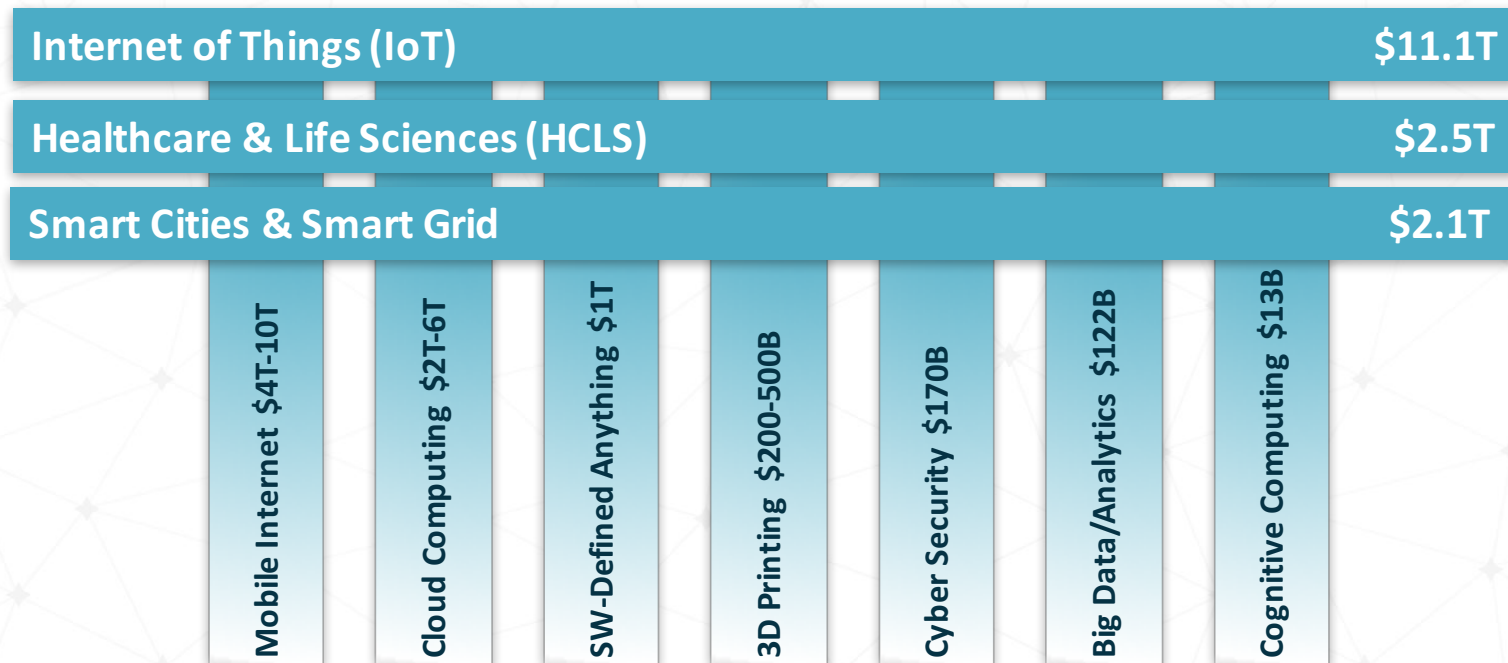


Internet of Things:

- IoT Sandbox
- Smart Campus/Smart Cities
- Smart Grid Testbed

Join a working group: <http://bit.ly/CINCGS16>

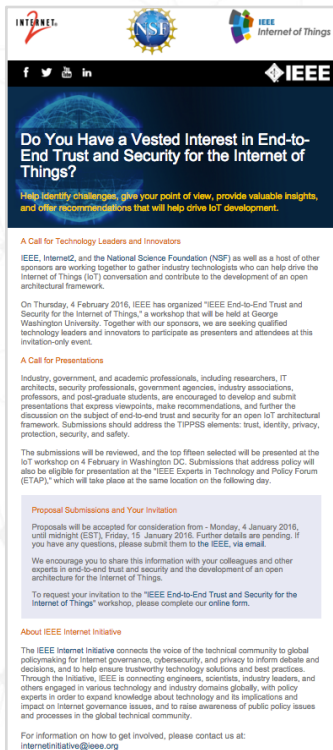
The Internet of Things, Healthcare & Life Sciences, and Smart Cities could represent \$15T in global economic value in 2025



Economic value includes revenues, cost reductions & service improvements achieved

Sources: Internet2 CINO analysis; BizTech; Deloitte; Consultantcy.uk; Forbes; Markets and Markets; McKinsey; US Department of Agriculture, Economic Research Services.

Recent IoT Activities: E2ET&S for IoT Workshop, February 4, 2016



- **Event at the George Washington University Marvin Center in Washington, DC in conjunction with IEEE, NSF, and George Washington University**
 - Followed by IEEE Experts in Technology & Policy (ETAP) event. Final ETAP report available on our Wiki (<http://bit.ly/1rpQN6u>)
- **150+ participants, 35+ papers presented**
- **Agenda:**
 - Opening panel with participants from the US DoE, IEEE, IIC, NSF, and M2MI
 - Afternoon break outs on Access Control & Identity Management; Architectural Framework; Policy & Standards; and Scenarios & Use Cases
 - Focus on TIPPSS: Trust, Identity, Privacy, Protection, Safety & Security
- **Next Steps:**
 - Opportunity for IoT-related education a key theme (E2ET&S, educating future leaders)
 - IEEE conference on Connected Health: Applications, Systems & Engineering Technology (CHASE) event, June 27-29 in Washington, DC (<http://bit.ly/1W6x1Wt>)

Recent IoT Activities: Webinars

- Network Segmentation for IoT: February 2, 2016
 - Cisco's Paul Forbes Bigbee outlines the use of network segmentation to ensure additional IoT connected devices don't undermine overall network security
 - Based on a blog post by Scott Harrell, Cisco Vice President Product Management, Security Business Group in *The Security Ledger* <http://bit.ly/1A1acwl>
 - Recording and slides available: <http://bit.ly/1Q2eDcl>
- Cisco Digital Ceiling Project: March 14, 2016
 - Cisco's Todd Federes shares the vision for the new Digital Ceiling product, enabling the integration of smart lighting, building automation, and IoT technologies over a single converged IP network
 - Recording and slides available: <http://bit.ly/26ZHjij>

Recent IoT Activities: IoT Sand-BOX



DRAFT

Internet2 IoT Sand-BOX Program

- **Goal:** Provide cloud-based IoT software development teaching platform to member universities, so that instructors can incorporate a hands-on, cloud-centric approach to IoT in their class curriculum
- Address needs of Internet2 University Members with potential to expand:
 - Other Internet2-connected university and 4 year colleges
 - Community colleges
 - K-12

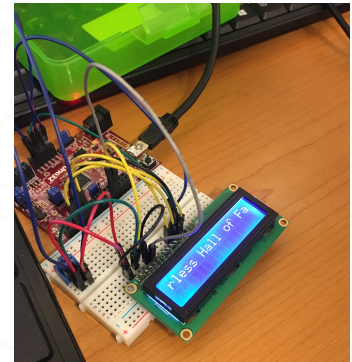
IoT Related Policy & Ethics

- Starting a dialogue with colleagues from Berkeley, Princeton, Virginia Tech, UMBC, University of Pennsylvania around IoT related policy and ethics

IoT and Education

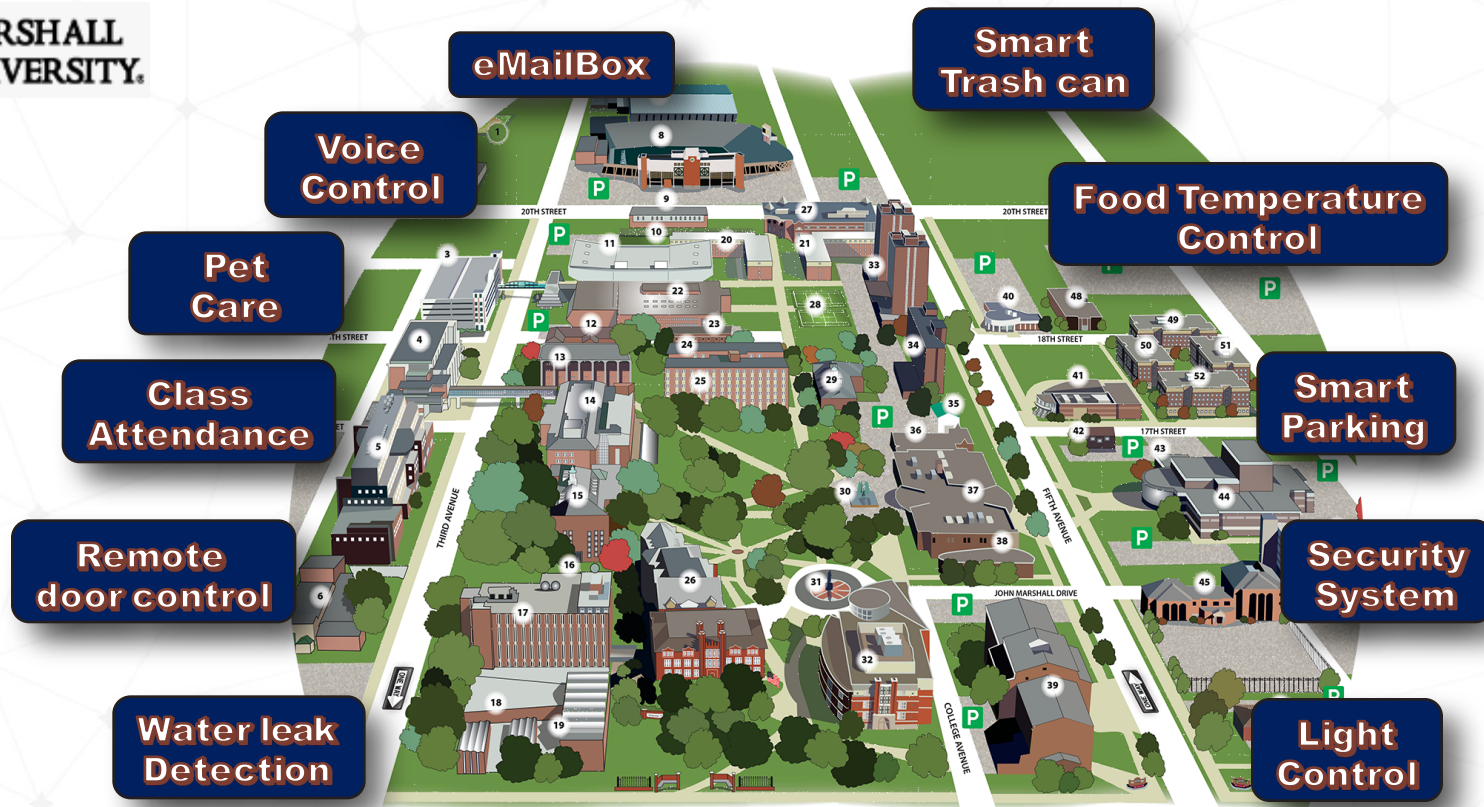
- IoT is becoming part of the curriculum
 - Marshall University class
 - University of Pittsburgh class
 - East Carolina class
 - IEEE online class initiative

IoT Education at Marshall University



IoT Education at Marshall University

- Used connected devices (Raspberry Pi, Arduino...etc)
- Sensors (motion, distance, humidity, temperature.....etc.
- Cloud services for IoT (Bluemix IoT Foundation, AWS IoT, Azure IOT Hub)



**Smart Campus
Internet of Things
CS652 Class Projects**

Welcome to the Smart Campus Initiative

- Forum to share learnings and develop new insights and practical recommendations
- Create focused task forces to support collaborative development of practical recommendations
- Guided by a Smart Campus CIO Advisory Council



CIO Smart Campus Advisory Council Interview Results

Expectations

- “Knowledgeable knowledge transfer”
- Technology diffusion
- Stakeholder discussions for longer-term campus planning
- Enable the facilitation of smart campus to extend to a smart community

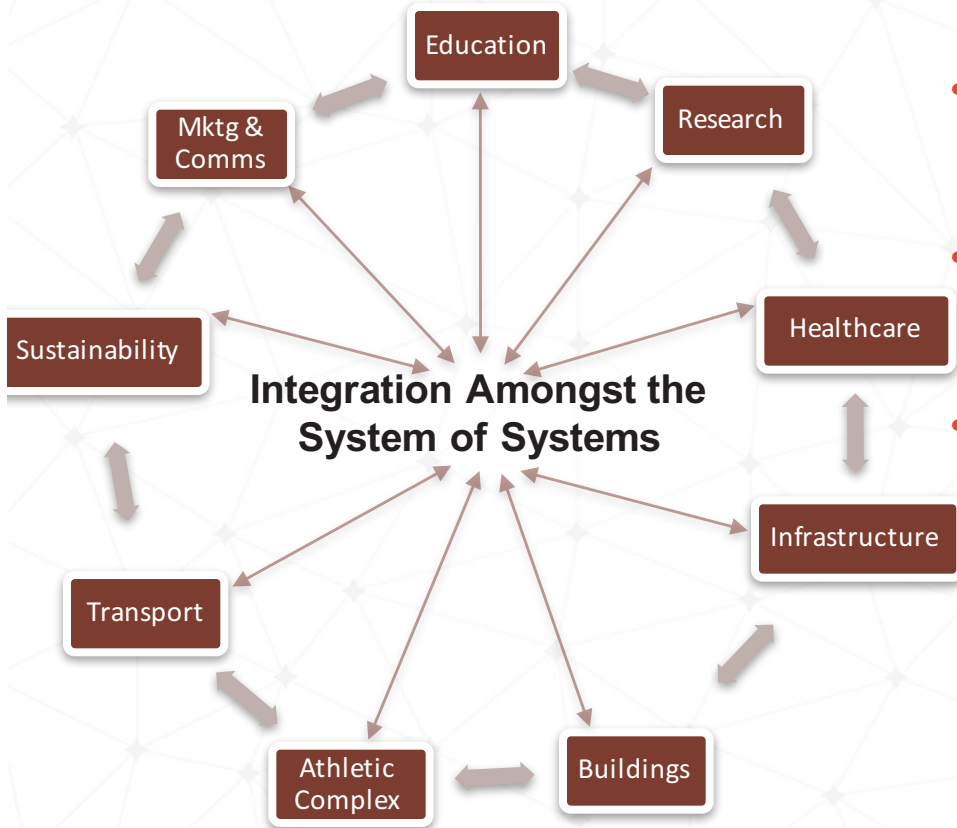
• Smart Campus Potential Focal Areas

- Student experience & success
- Facilities/Buildings: lighting, HVAC, etc.
- Smart stadiums: fan experience & revenues
- Identify & define common infrastructure standards
- Security: physical, data, holistic approach
- Connected vehicles
- Identify adoption roadblocks
- Smart Campus 2025: Anticipating future needs

• Smart Campus Challenges

- Managing the data
- Standards
- Ethics
- Infrastructure management
- Power supply: batteries, PoE
- Privacy & security
- Enterprise risk management

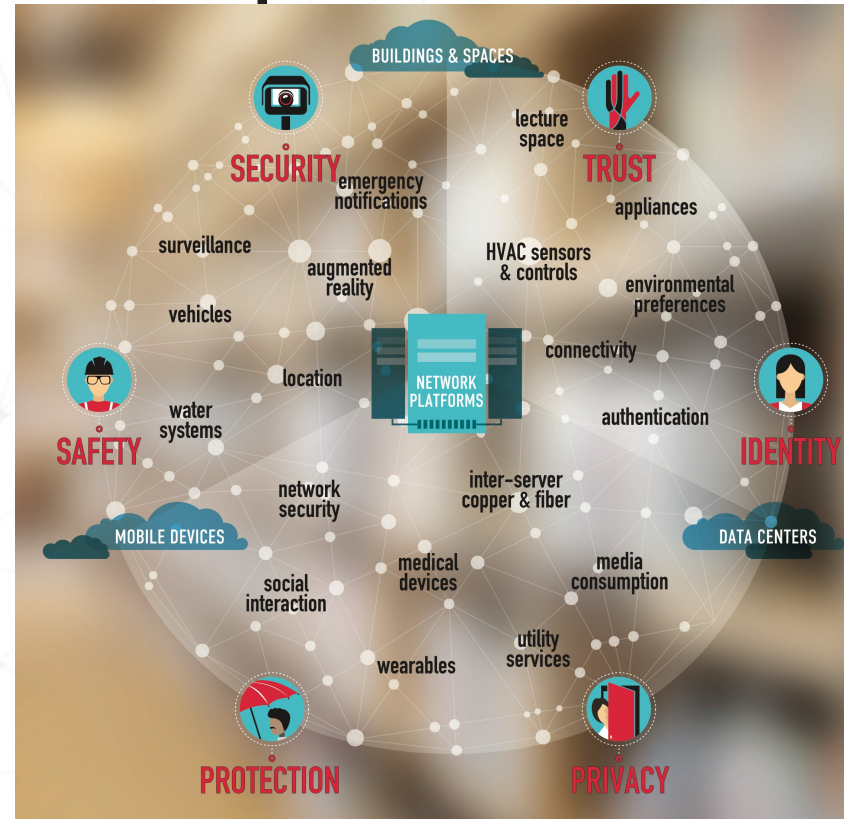
Defining a Smart Campus



- A Smart Campus leverages data to **improve student success, experience and campus operations**
- Requires integration of Information Technology and Operational Technology to **better inform decision making** in each domain and across the campus
- Achieving a Smart Campus will involve cross-campus collaboration with multiple stakeholder partnerships. These partnerships will include, but not be limited to:
 - Facilities
 - Administration
 - Central IT
 - Research Community
 - Campus Security
 - Faculty & Students

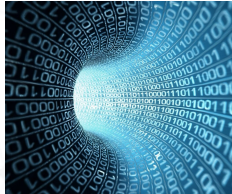
Addressing TIPPSS is essential to achieving safe, secure, scalable future smart city and campus architectures

Trust
Intity
Privacy
Protection
Safety
Security



Identifying a framework for segmenting IoT devices & the potential risks is a first step towards creating a TIPSSS environment

Hacking an IoT device can have implications across multiple fronts:



Data



Physical



Financial



Reputation

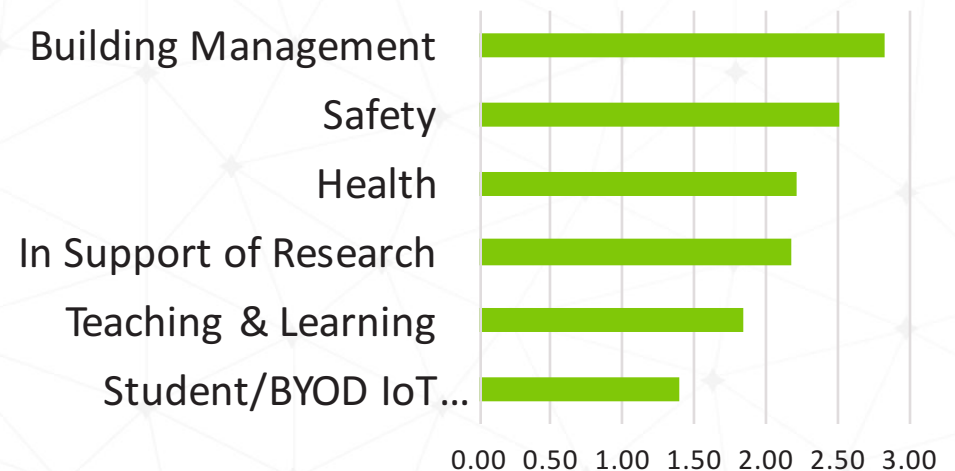
CSG Session on E2ET&S for IoT: IoT is becoming a campus reality in Smart Buildings, Research, & Healthcare

Participation in IoT use cases on or off campus

	On Campus	Off Campus
Smart buildings	6	0
Research projects	5	3
Connected healthcare	3	3
Smart stadiums	3	1
Connected vehicles	2	2
Smart museums	1	0

N = 6

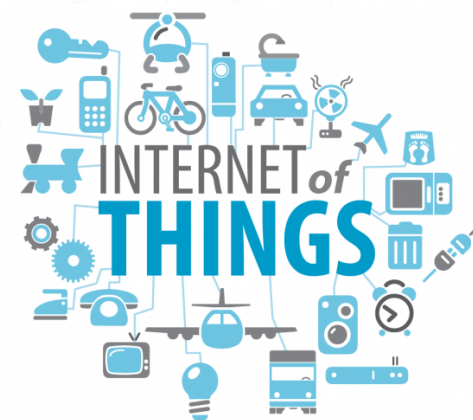
Rank importance of IoT use cases on your campus



Smart Campus Initiative: DRAFT Charter Statement

- Equip Internet2 members with the skills and guidance to effectively deploy Smart Campus capabilities by:
 - Sharing best practices from current Smart Campus projects
 - Engaging campus strategic stakeholders through the CIO to share interest and vision for a Smart Campus
 - Identifying needs and challenges that can be addressed with potential Smart Campus and IoT approaches
 - Providing recommended courses of action that resolve challenges, leveraging best practices

Smart Campus Initiative: IoT Systems Risk Management Task Force



Great potential in IoT Systems in Higher Ed institutions --
Energy management, sustainability, building access control,
research automation & environmental control, building
automation, safety systems, academic learning systems ...

But potential not realized if IoT System is not implemented & managed well. Topics include:

- Vendor management – articulating & raising expectations
- Vendor management – multiple proprietary systems
- System ownership
- IoT System selection, procurement, installation
- Costing models & approaches
- System risk identification & management
- Network segmentation & portfolio management
- Organizational/Culture change
- Others

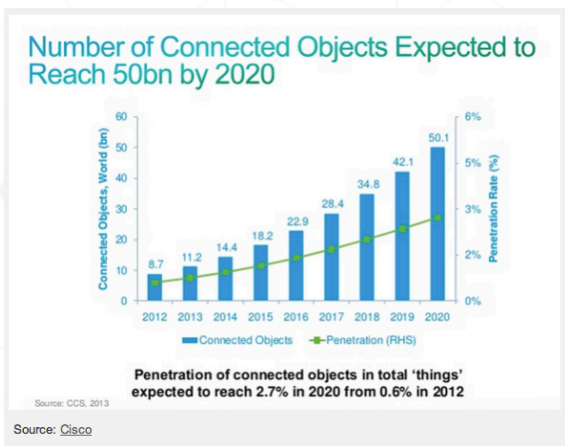
IoT Systems

Implementation & Management

The Real World – e.g. Campus, City, ...

Smart Campus Initiative: IoT Systems Risk Management Task Force

- IoT Systems are different from traditional enterprise systems
 - Large numbers of networked, computing devices
 - High variability within device types
 - Little language/conceptual framework for system planning & managing risk
 - Out of sight, out of mind – Systems embedded in the environment around us
 - IoT Systems tend to span multiple organizations within an institution



Smart Campus Initiative: IoT Systems Risk Management Task Force

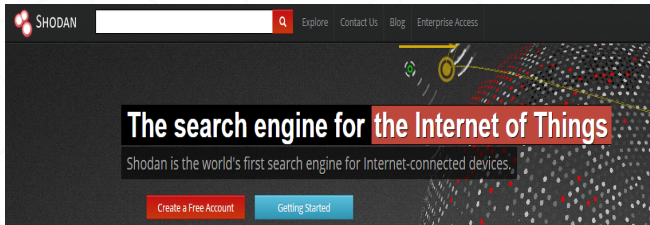
Some participating schools/networks:

- Clemson
- Cornell
- Indiana University
- MIT
- Princeton
- Rice
- Virginia Tech
- University of Pittsburgh
- University of Washington
- University of Wisconsin-Madison
- Yale
- HEA-Net (Ireland)

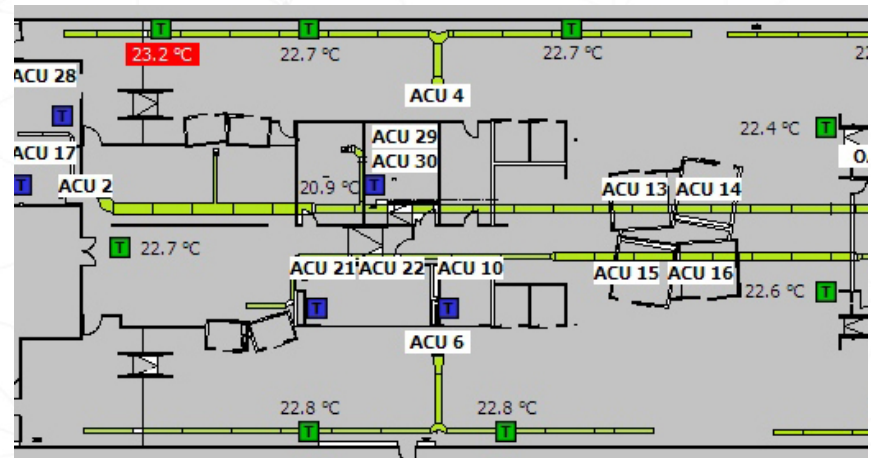
Some roles/titles of participants:

- AVC Operations & Maintenance
- AVP & Chief Facilities Officer
- Associate CIO
- Chief Technology Officer
- Deputy CIO/Chief of Staff
- Enterprise Architect
- Infrastructure Director
- IT Service Owner for Research
- Network Development Manager
- Research Cyber Infrastructure Liaison
- Security Manager
- Senior Applications Systems Engineer

Smart Campus Initiative: IoT Systems Risk Management Task Force



- The search engine for **Power Plants**
- The search engine for **Buildings**
- The search engine for **Refrigerators**
- The search engine for **Webcams**



Smart Campus Initiative: IoT Systems Risk Management Task Force

Proposed topics for Quarterly Report Outs to Smart Campus CIO Advisory Council:

Quarter 1 – Sept 2016: Ability to profile IoT Systems exposure w/public tool (e.g., Shodan.io or Censys.io)

Quarter 2 – Dec 2016: Vendor management – Requirements doc for IoT Systems vendors (process, checklist, etc.)

Quarter 3 – March 2017: Cost model for IoT Systems selection, procurement, & management

Quarter 4 – May 2017: Recommendations for further work in 3 – 5 areas

- network segmentation management ?
- organizational/culture change ?
- development of IoT Systems risk language/taxonomies ?
- dependence on non-interoperable proprietary IoT Systems ?
- other ?

Connected Vehicles as things on the Internet

big data, the cloud, and advanced automotive research

Clark Gaylord
Chief Information Officer
Virginia Tech Transportation Institute



Virginia Connected
Corridors

 VirginiaTech.
Transportation Institute

Virginia Connected Corridor

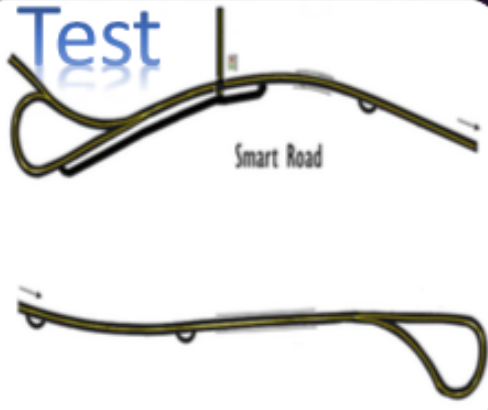
- In 2014, VDOT and VTTI introduced the Virginia Connected Corridors (VCC) initiative
- Includes the Smart Road in Blacksburg, VA, and the Northern Virginia Connected-vehicle Test Bed in Fairfax Co., VA
- One of the most congested corridors in the U.S. (I-66, I-495, U.S. 29, and U.S. 50)
- 44 Roadside equipment units (RSEs) installed that enable DSRC CV communication
- Multiple challenges
 - High levels of recurring and non-recurring congestion
 - HOV configurations
 - Changeable dynamic message signs



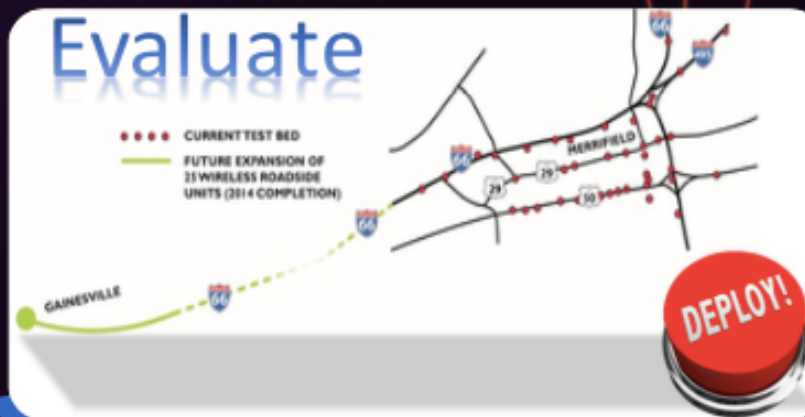
VCC Supports Deployment Process

Design &

Test



Deploy & Evaluate



Virginia Connected
Corridors

VirginiaTech.
Transportation Institute

VCC Development

- Develop computing, network, and communication infrastructure to support Connected Vehicle applications
- Identify communication and infrastructure gaps
- Develop and evaluate CV applications that address VDOT operational priorities

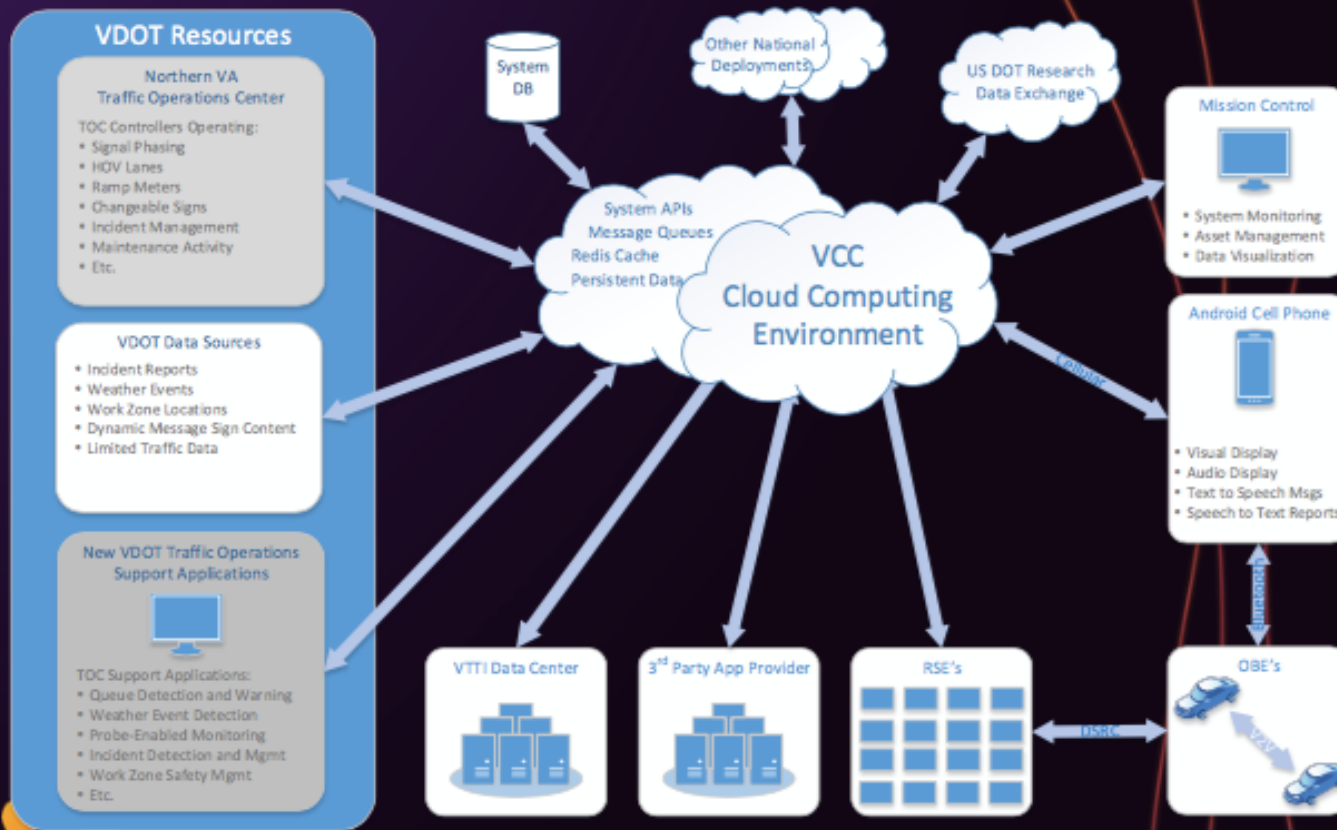
Initial Core Application Priorities

- Work Zone Alerts for Drivers and Workers
- Signal-Related Applications (SPaT enabled)
 - Red Light Violation Warning
 - Emergency Vehicle Preemption (expanded)
 - Integrated Traffic Signal Systems and EcoDrive
 - Transit Signal Priority
- Real Time In-Vehicle Dynamic Messaging
- Incident Scene Alerts for Drivers
- Road-weather applications/information
- Queue Warning (V2I and V2V)
- Probe Enabled Traffic Monitoring (to support anomaly detection)

DevOps Deployment Model

- Applications built on modular micro-services architecture
- Cloud deployment architecture
 - Currently using Docker containers
 - Potential hyper-scalability
- Importance of IPv6
 - Essential for transportation system scale
 - Still a challenge for legacy transportation environments
 - Also a challenge for some public cloud providers

VCC Open Cloud Environment



Connected Vehicle Technology

- SAE J2735 standardized messages
 - As opposed to intra-vehicle Component Area Network messages!
- Radio interfaces
 - Direct Short Range Communications for Vehicle to Vehicle and Vehicle to Infrastructure (5.9GHz)
 - Cellular, Wi-Fi for Internet scale
 - Bluetooth
- Vehicles also have OnBoard Diagnostics, which uses Component Area Network protocol
 - Virtually *no* data standards for these data

SAE J2735 DSRC Message Dictionary Overview

- SAE J2735 (Rev002)
 - Message set & data elements/frames dictionary
 - Focus on 5.9GHz DSRC communication use however does not exclude other communication channel/technology use
 - Follow ASN1 and DER-BER encoding scheme

- * Message usage and performance requirements are addressed in SAE J2945 draft. Currently working on J2945.1 Basic Safety Message for V2V safety application use.

J2735 Defined Messages

ID	Messages	Typical Use	Status
0	Reserved	N/A	
1	MSG_A_la_Carte	V2X	
2	MSG_BasicSafetyMessage (BSM)	V2V	Used by USDOT program & other ITS industry research
3	MSG_CommonSafetyRequest	V2?	
4	MSG_EmergencyVehicleAlert		
5	MSG_IntersectionCollisionAvoidance	V2X	
6	MSG_MapData	I2V	Based on USDOT/CAMP CICAS-V project. Used by various demo/research program
7	MSG_NMEA_Corrections	I2V	
8	MSG_ProbeDataManagement	I2V	Used by VII Proof of Concept (PoC) project
9	MSG_ProbeVehicleData	V2I	Used by VII PoC project
10	MSG_RoadSideAlert		
11	MSG_RTCM_Corrections	I2V	Based on USDOT/CAMP CICAS-V project. Used by various demo/research program
12	MSG_SignalPhaseAndTiming	I2V	Based on USDOT/CAMP CICAS-V project. Used by various demo/research program
13	MSG_SignalRequestMessage	V2I	
14	MSG_SignalStatusMessage	I2V	
15	MSG_TravelerInformation Message	I2V	Used by VII PoC & will be used in Model Deployment (Curve Speed Warning)

March 8, 2012

-- CAMP - VSC3 Consortium Proprietary --

3

VCC Monitor Application

- Provides situation awareness for monitoring corridor activity and events
- Map centric with detail overlays
 - RSE location and communication status
 - Active TIM message postings
 - Connected vehicle / RSE DSRC interaction
 - Vehicle speeds and brake state
 - General traffic speeds (from Google)
 - Dynamic Message Sign locations

VCC Monitor

https://vcc-mon.vtti.vt.edu/index.html#/map/

VCC Monitor Main Map Assets 4

RSE Group
Northern Virginia

Connected Vehicles in Corridor
Opt-in Study Vehicles 2
Anonymous Vehicles 0

Roadside Equipment Inventory
Active and Communicating 41
Active and Not Communicating 6
Planned 17
Proposed 48

Message Traffic
71
0
05:18:50 PM 05:19:12 PM 05:19:33 PM 05:19:55 PM

Show
 Roadside Equipment
 Dynamic Message Signs
 Connected Vehicles
 Vehicle Speeds
 Vehicle Identifiers
 Virginia 511 Data
 Satellite Imagery
 Traffic Conditions
 Messages (TIMs)

26895
uniqueID: SU1TAAAAAEma
start: Wed Jan 20 2016 15:31:01 GMT-0700 (Mountain Standard Time)
stop: none
modified: Wed Jan 20 2016 15:31:42 GMT-0700 (Mountain Standard Time)
area: Circle
radius: 20 meters
direction: 3000
message Congestion on I-66. Traffic backups are approximately 4.5 miles.
full map: Congestion on I-66. Traffic backups are approximately 4.5 miles.

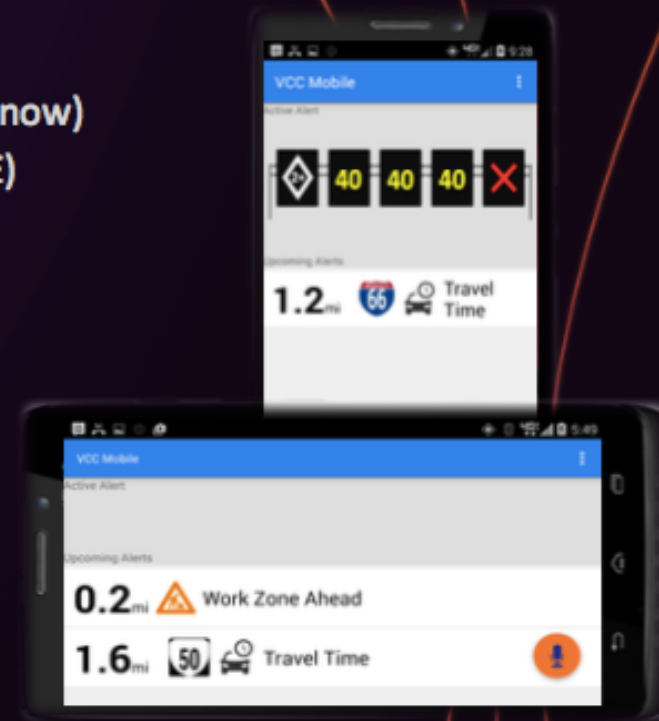
The screenshot displays the VCC Monitor web application interface. The main map shows a geographic area in Northern Virginia, including cities like Washington, Alexandria, and Fairfax. The map is overlaid with various data points and lines, including a prominent purple line along a major road (I-66) and several green circles. A pop-up window is visible over the map, displaying details for a specific asset (ID: 26895), including its unique ID, start and modified times, stop status, area type (circle), radius (20 meters), direction (3000), and a message about congestion on I-66. The sidebar on the left contains a dropdown menu for the RSE Group (set to Northern Virginia), a table of connected vehicles in the corridor (2 opt-in study vehicles, 0 anonymous vehicles), a table of roadside equipment inventory (41 active and communicating, 6 active and not communicating, 17 planned, 48 proposed), a message traffic bar chart showing a peak of 71 messages, and a list of map layers to show or hide, including Roadside Equipment, Dynamic Message Signs, Connected Vehicles, Vehicle Speeds, Vehicle Identifiers, Virginia 511 Data, Satellite Imagery, Traffic Conditions, and Messages (TIMs).

TIM Generator Application

- Provides ability to manually create and post Traveler Information Message (TIMs)
- Select area on map with point and radius
- Enter short text, long text, category, directionality, start/end time, and RSE deployment set
- Can manually create TIMs of any type, duration and purpose
- Includes table of historical postings

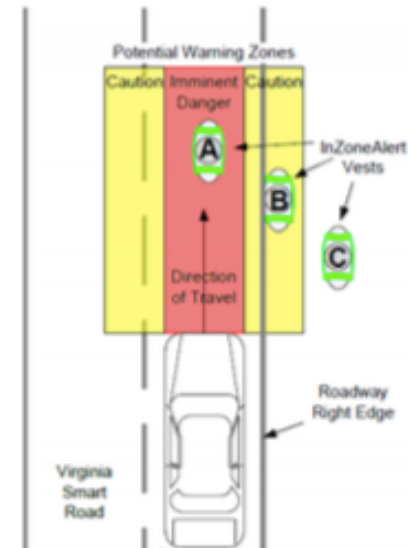
VCC Mobile App

- Smart Phone App (Android-only for now)
- Cellular + DSRC (requires link to OBE)
 - All advisory level information
 - Warning alerts
 - High-rate BSM
- Cellular-Only
 - Advisory level information
 - Low-rate BMM
- Messaging to Support:
 - Work Zone Details
 - Weather Advisories
 - Traffic Incidents
 - Dynamic Message Sign Content
 - Driver Reported Issues
- No geographical limitations
 - Basic capability works state-wide, nationally
 - Practical limitation is source data for messages



Connected Worker Solutions

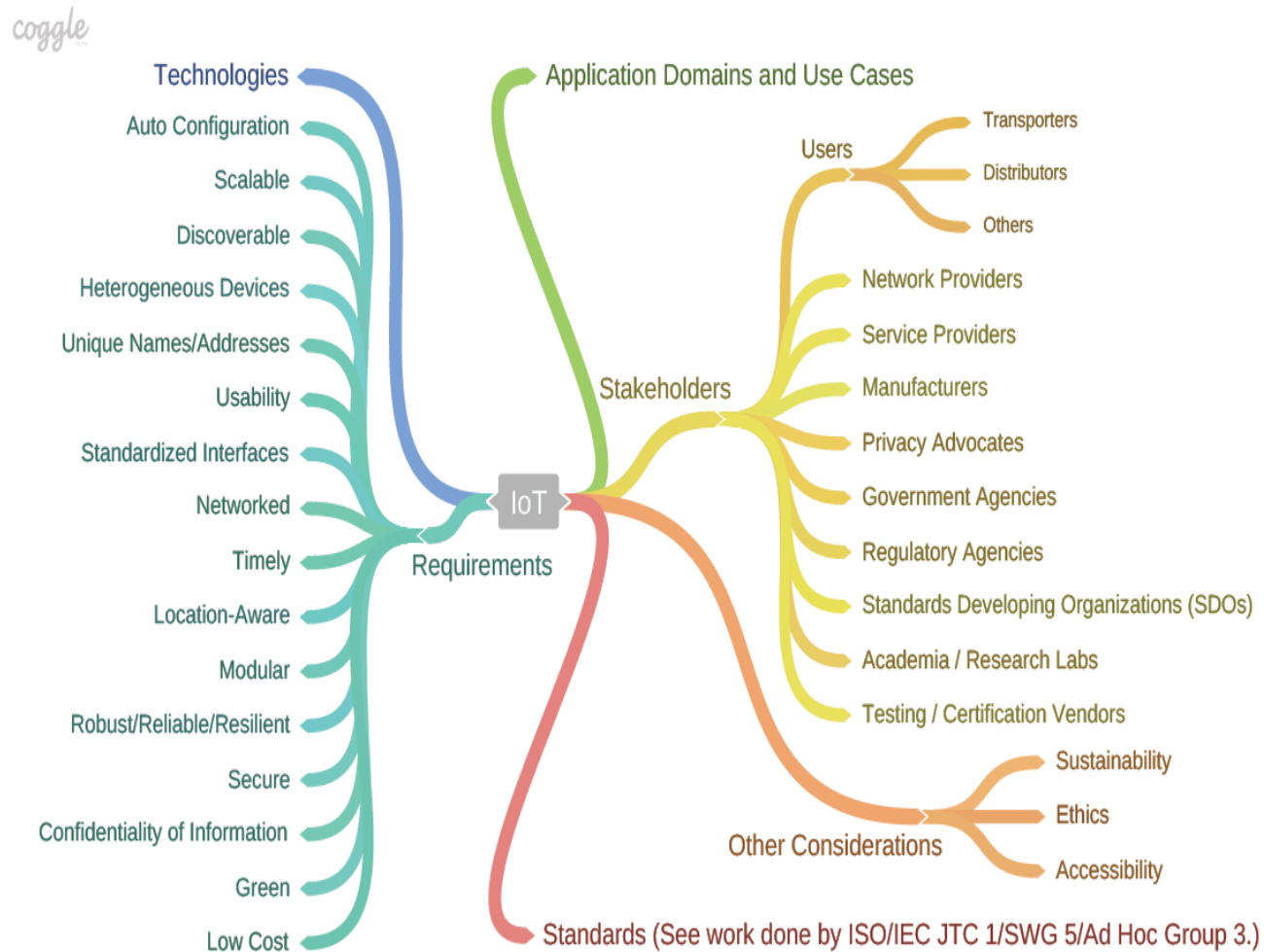
- Integrate GPS and DSRC or Cellular into personal protective equipment
- Worker and passing vehicles independently determine and exchange position information
- Warn the worker through audio, flashing led lights, haptic depending on urgency



Takeaways for IoT Applications

- Application-specific message/communications standards
 - Data standards, data standards, data standards!
- Connectivity and scale
 - Local vs Global
 - Does the application require an *Internet* of things or simply a *Network* of things?
- Scalability
 - Network Protocol – IPv6
 - Elastic deployment model for application stack

Potential Additional Focal Areas for IoT Working Group



Next Steps

- Let us know if you'd like your institution to participate in the IoT SandBox with IBM BlueMix: Email CINO@internet2.edu
- North Carolina Smart Grid Testbed on Internet2 + Regional Network expansion opportunity
- IoT related policy, ethics and education discussion underway with colleagues at Berkeley, Princeton, Virginia Tech, UMBC, University of Pennsylvania
- Let Chuck Benson know if you're interested in participating in the IoT Systems Risk Management Task Force: Email iotsys-tf-request@internet2.edu
- Save the date! CINC Up Call for entire Collaborative Innovation Community on Monday, June 6 at 2PM ET. Topic: OpenFog Consortium presented by Mung Chiang, Princeton University and OpenFog Consortium Board Member
- Let us know if you'd like to participate in the IoT Working Group, or any of the other Collaborative Innovation Community Working Groups: Email CINO@internet2.edu

Join us for other Collaborative Innovation Community Meetings during Global Summit

- **Sunday, May 15**
 - Healthcare and Life Sciences Working Meeting: 10:30AM-12PM, Cook Room, 3rd Floor
 - Smart Campus Initiative & Innovations: 4-5:30PM, Kane Room, 3rd Floor
- **Monday, May 16**
 - Internet of Things (IoT) Innovation Working Group Meeting: 8-9:30AM, Kane Room, 3rd Floor
 - End-to-End Trust & Security Innovation Working Group Meeting: 10-11:30AM, Kane Room, 3rd Floor
- **Tuesday, May 17**
 - Distributed Big Data and Analytics Innovation Working Group Meeting: 7:30-8:45AM, Kane Room, 3rd Floor
- **Wednesday, May 18**
 - Gender Diversity in the Internet2 Community: 7:15-8:45AM, Addison Room, 4th Floor
 - Innovation Development and Management – Think Local, Act Global: 12-1:15PM, Kane Room, 3rd Floor

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