Technical Advisory Council
Federal Communications Commission
Summary of Meeting
March 9th, 2016

The Technical Advisory Council (TAC) for the FCC was convened for its twentieth meeting at 12:30 P.M. on March 9th, 2016 in the Commission Meeting Room at the FCC headquarters building in Washington, DC. A full video transcript of the meeting is available at the FCC website at http://www.fcc.gov/encyclopedia/technology-advisory-council together with a copy of all materials presented at this meeting. In addition, all materials presented at this meeting are included in electronic form in an Appendix to this document.

In accordance with Public Law 92-463, the entire meeting was open to the public.

Council present:

Shahid Ahmed, PwC	Brian Markwalter, Consumer Electronics Association
John Barnhill, Genband	Tom McGarry, Neustar
Mark Bayliss, Virginia ISP Association and the West Virginia Broadband CO-OP	Milo Medin, Google, Inc
Nomi Bergman, Bright House Networks	Geoffrey Mendenhall, GatesAir
Lynn Claudy, National Association of Broadcasters	Lynn Merrill , NTCA
Marty Cooper, Dyna LLC	Jack Nasielski, Qualcomm Inc.
John Dobbins, EarthLink, Inc.	Ramani Pandurangan , XO Communications
Adam Drobot, OpenTechWorks	Deven Parekh, Insight Venture Partners
Jeff Foerster, Intel Corporation	Dewayne Sennett, AT&T
Brian Fontes, NENA	Marvin Sirbu, Special Government Employee

Dick Green, Liberty Global, Inc	Kevin Sparks, Alcatel-Lucent
Lisa Guess, Juniper Networks	Paul Steinberg, Motorola
Dale Hatfield, Silicon Flatirons Center for Law, Technology, and Entrepreneurship University of Colorado at Boulder	David Tennenhouse, VMWare
Theresa Hennesy, Comcast Corporation	Michael Tseytlin, Facebook
Steve Lanning, Viasat, Inc.	David Young, Verizon
Gregory Lapin, American Radio Relay League	Russ Gyurek, Cisco Systems

FCC staff attending in addition to Walter Johnston and Julius Knapp included:

Scott Jordan

NTIA Liaison

Rangam Subramanian

Meeting Overview

Dennis Roberson, TAC Chairman, began the meeting asking the TAC members to introduce themselves. He next asked Julie Knapp to review the recommendations made by the TAC in 2015. Mr. Knapp began by noting that over 40 separate recommendations were made and that the FCC was still working through its approach to some of these recommendations. He noted that he viewed the recommendations could be group into three categories: a) Specific recommendations that the TAC could take in the near term b) Recommendations for improving FCC staff skillsets and c) Headlights or technology developments that are expected to be transformational. He noted that some of the TAC recommendations could be implemented quickly while others would need more formal actions such as a rulemaking. He highlighted recommendations from each category as examples within the category.

Mr. Roberson next noted that Mr. Rangam Subramanian has been serving on the TAC as a liaison between the TAC and the Commerce Spectrum Management Advisory Committee, an advisory committee to the Commerce Department/National Telecommunications & Information Administration. Mr. Subramanian reviewed some of the current work of the CSMAC focusing on spectrum sharing between federal and non-federal stakeholders, measurement and sensing in 5 GHz, technology and standardization challenges associated with 5G involving

federal/nonfederal spectrum sharing, Spectrum Access Systems (SAS) and international issues deriving from use of a SAS, and agency to industry collaboration.

Mr. Roberson next proceeded with a readout from each TAC workgroup. The workgroup presentations are attached at the end of this document. Mr. Roberson ended the meeting by thanking the participants and by noting that the work of the TAC was supported not only by TAC members but by individual participants in workgroups and in some instances sub-workgroups. This has greatly expanded the resources accessible to the TAC and has helped in developing their recommendations to the Commission. He noted that the next meeting for the TAC will be held on September 20th and the meeting was adjourned.

A copy of all presentations is attached herein.

Walter Johnston, Chief EMCD-OET
FCC

Technological Advisory Council

March 9th, 2016

Dennis Roberson, Chairman

Agenda

Item	Start Time
Introduction	12:30 PM
Mobile Device Theft Prevention Work Group	12:40 PM
Cybersecurity Work Group	1:10 PM
NG Internet Services Work Group	1:40 PM
Future Game Changing Technologies Work Group	2:20 PM
Implications for Mass Deployment of Aeronautical/Space Transmitters	2:50 PM
Spectrum and Receiver Performance Work Group	3:20 PM
Wrap-up	3:50 PM
Finish	4:00 PM

FCC Implementation of Past Recommendations

- Spectrum access for small cells at 3.5 GHz; multi-stakeholder group
- Spectrum frontiers proceeding
- IP transition - - Technology Transitions proceeding; rural broadband trials
- Progress on Mobile Device Theft Prevention
- Spawned activities in CSRIC on Network Security
- Informed FCC thinking on numerous topics:
  - Receivers/Enforcement/Spectrum Policies
  - Internet of Things & IoT security
  - Unlicensed devices

And many others . . .

Overview of 2015 Recommendations

- **More than 40 recommendations, generally in 3 categories**

- **Specific actions for the Commission to take in the near term:**
  - Some may require rule making or other formal process
  - Example: Identify spectrum for unlicensed between 6 and 57 GHz
  - Considering how best to proceed

- **Develop FCC staff skillsets:**
  - Courses/invited speakers/ hiring etc.
  - Example: Software defined networks; risk-based interference analysis
  - Would take place over time

- **"Headlights"**
  - Technology developments that will be transformational
  - Example: Expanded use of encryption in networks
  - Not clear what, if anything, needs to be done

Many recommendations will take more time to consider

Recommendations

- **Mobile Device Theft Prevention Workgroup**
  - **Recommendation:** FCC to work with CTIA/GSMA/Carriers/LEA to implement MDTF features, improve process and outreach to consumers
  - **Status:** FCC staff currently engaged on a number of fronts implementing these recommendations
- **Future of Unlicensed Workgroup**
  - **Recommendation:** Accelerate search for unlicensed spectrum
  - **Status:** FCC staff engaged on a broad range of unlicensed spectrum issues and will continue to seek opportunities for unlicensed spectrum
  - **Recommendation:** In cooperation with industry, promote sharing of bands between licensed and unlicensed services
  - **Status:** FCC committed to establishing opportunities such as 3.5 GHz where licensed and unlicensed like services coexist; working with standards bodies and industry to resolve conflicts when they arise

Recommendations

- Cybersecurity
  - **Recommendation:** Work with other agencies on IOT security
  - **Status:** FCC working with other agencies towards common cybersecurity goals

  - **Recommendation:** Work with smartphone vendors to improve embedded cybersecurity mechanisms
  - **Status:** Under Consideration

  - **Recommendation:** For SDN, the FCC should work with industry on developing best practices for dominant scenarios
  - **Status:** FCC requested TAC develop further

Recommendations

- Spectrum Receiver and Performance Workgroup
  - **Recommendation:** Develop expertise on risk informed assessments of harmful interference
  - **Status:** Multiple FCC engineers took statistical analysis training
  - **Recommendation:** Future frequency allocations should be based on enumerated risk informed assessment principles
  - **Status:** Excellent paper & recommended principles. Assessing how best to proceed; considering opportunities for applying risk-based interference assessments

Recommendations

- Next Generation Internet Workgroup
  - **Recommendation:** Expand FCC network measurement program to gain better assessment of end to end broadband performance and enhance consumer awareness of QOS/QOE
  - **Status:** FCC working with industry and research community on best measurement practices

- Future Game Changing Technologies
  - **Recommendation:** Assess impact of Programmable Network on current service rules and accelerate growth of SDN/NF
  - **Status:** Working with industry to assess impact of programmable networks
  - **Recommendation:** Consider use of Universal Service Fund to support deployment of edge cloud infrastructure in rural areas
  - **Status:** FCC considering evolution of USF to support broadband deployment

Mobile Device Theft Prevention WG
Report to the FCC TAC

March 9, 2016

Contents

- Mission
- FCC Request for Further Advice
- Results & Conclusions
  - On-device Theft Prevention Features
  - IMEI Hardening
  - Database
- Recommendations
- Next Steps

WG Participants

- Co-Chairs:
  - Brian Daly, AT&T
  - Rob Kubik, Samsung
- FCC Liaisons:
  - Walter Johnston
  - Charles Mathias
  - Chad Breckinridge
  - Elizabeth Mumaw
- Dennis Roberson, FCC TAC Chair
- Document Editor: DeWayne Sennett, AT&T

- Asaf Askenazi, Qualcomm
- Jay Barbour, Blackberry
- Alan Bersin, DHS
- Brad Blanken, CCA
- Matthew Bromeland, Metropolitan DC Police Department
- Craig Boswell, Hobi
- Eric Feldman, ICE/Homeland Security Investigations
- Thomas Fitzgerald, New York City Police Department
- Les Gray, Recipero
- David Dillard, Recipero
- Gunnar Halley, Microsoft
- Joseph Hansen, Motorola
- Jamie Hastings, CTIA
- Joe Heaps, National Institute of Justice
- Gary Jones, T-Mobile
- Steve Sharkey, T-Mobile
- Sang Kim, LG

- Jake Laperruque, Center for Democracy and Technology
- Irene Liu, Lookout
- John Marinho, CTIA
- Samuel Messinger, U.S. Secret Service
- James Moran, GSMA
- Jason Novak, Apple
- Kirthika Parmeswaran, iconectiv
- Greg Post, Recipero
- Deepti Rohatgi, Lookout
- Ogechi Anyatonwu, Asurion
- Mike Rou, eBay
- Kevin Harris, outerwall
- Paul Cashman, outerwall
- Christian Schorle, FBI
- David Strumwasser, Verizon
- Maxwell Szabo, City and County of San Francisco
- Ron Schneirson, Sprint
- Samir Vaidya, Verizon Wireless

2016 MDTP WG

- The MDTP working group will continue to extend its work on device theft prevention

- Work proposed for 2016 includes developing recommendations on:
  - next generation anti-theft features,
  - assessment of the effect of previous recommendations on device theft,
  - development of recommendations for improvements in consumer outreach efforts,
  - development of mechanisms to support easier access for law enforcement to IMEI information,
  - and examination of methods for carriers to provide more useful data related to device theft and for fostering greater global effectiveness of proposed solutions.

2016 Proposed MDTP Topics

- Develop recommendations on next generation anti-theft features to promote widest possible adoption by consumers.

- Continued studies to determine whether implementations post July 2015 have the desired affect on mobile device theft
  - Refers to the planned recurring survey effort for continued monitoring of improvements
  - Set up the common framework for collection of centralized data post July 2015 (e.g., through CTIA with input from OS providers, mobile operators, and law enforcement agencies) and framework for analysis of the data.
    - Consumer adoption rates of background anti-theft features in light of the California requirement and voluntary commitment (effective in July 2015) to prompt users to enable the feature at initial device setup.
    - Better tracking of actual phones stolen – investigate as part of the MDTP working group task 3 deliverable

- Enhanced consumer outreach and education
  - Contribute to a tutorial on anti-theft features of the different mobile operating systems that lives on fcc.gov
  - Investigate use of social media to amplify outreach and education

2016 Proposed MDTP Topics (continued)

- Reporting for Law Enforcement
  - Using the mechanisms being developed in ATIS and GSMA on enabling a mechanism for IMEI to be retrieved on disabled devices and educational outreach to law enforcement on using the mechanism.
- Additional methods to increase consumer adoption of anti-theft features
- Consider a study on how to expand blacklisting to all US carriers, working with the GSM Association/GSMA North American Regional Interest Group and CTIA.
- Examine if anti-theft solution providers may be able to provide consumers a feature to determine enrollment status in their solution in such a way that the consumer does not have to be in physical possession of the device.
- Industry to reinstate a service to monitor for and report device identity security issues, to provide statistical data, and to ensure identified problems are notified to the affected device manufacturers

MDTP WG Survey of 2016 Priorities (Preliminary)

- Set up the common framework for collection of centralized data post July 2015 (e.g., through CTIA with input from OS providers, mobile operators, and law enforcement agencies) and framework for analysis of the data (2.75)
- Consider a study on how to expand blacklisting to all US carriers, working with the GSM Association/GSMA North American Regional Interest Group and CTIA (2.50)
- Using the mechanisms being developed in ATIS and GSMA on enabling a mechanism for IMEI to be retrieved on disabled devices and educational outreach to law enforcement on using the mechanism (2.38)
- Investigate use of social media to amplify outreach and education (2.25)
- Continued studies to determine whether implementations post July 2015 have the desired affect on mobile device theft (2.25)
- Develop recommendations on next generation anti-theft features to promote widest possible adoption by consumers (2.13)
- Additional methods to increase consumer adoption of anti-theft features (2.00)
- Examine if anti-theft solution providers may be able to provide consumers a feature to determine enrollment status in their solution in such a way that the consumer does not have to be in physical possession of the device (2.00)
- Contribute to a tutorial on anti-theft features of the different mobile operating systems that lives on fcc.gov (1.88)
- Industry to reinstate a service to monitor for and report device identity security issues, to provide statistical data, and to ensure identified problems are notified to the affected device manufacturers (1.75)

Preliminary
Tentative

Industry Initiatives Since December Report

- Device Information Portal:
  - CTIA RFP for the portal development, RFP Panel of Evaluators established; evaluation and vendor selection by April 1
  - GSMA soft-launched Device Check USA
- Best Practices/Implementation Guideline for device blacklisting, device blocking, and data sharing
  - GSMA is developing the Best Practices, target completion in the May 2016 NAFFSG meeting
  - Outline reviewed by the MDTP WG
- ATIS to identify key technological areas (including MDTP) where the FCC should seek further information from industry:
  - ATIS Board will be addressing at March 2016 meeting

Industry Initiatives Since December Report

- GSMA-NA liaison to GSMA Device Security Group:
  - Review the 2005 published technical design principles to ensure they remain relevant and take into account current threats and attack scenarios
  - Reinstate a service to monitor for and report device identity security issues to provide statistical data and to ensure identified device identity problems are notified to the affected device manufacturers
- GSMA-NA liaison to CTIA Stolen Phones Working Group:
  - Encourage additional operators to participate in the April 10, 2012 voluntary commitment to take certain actions (e.g., GSMA IMEI Database) to help law enforcement deter smartphone theft and protect personal data
  - Education campaign coordinated with law enforcement associations for dissemination to police officers to educate them on important aspects relative to smartphone theft
  - Develop a voluntary process to report to the FCC statistics on devices reported lost or stolen over a 12 month period
  - Survey of the US carriers to assess and measure the extent to which invalid and duplicate device identities may be in use on their networks
  - Deeper investigation by industry into the causal factors for the increase in consumer use of MDTP functions that could be used for determining how to optimize further efforts to incentivize greater consumer use of anti-theft features
  - Investigation into whether the increased availability of anti-theft functionality on new smartphones as well as the upcoming initial device setup prompts have any effect including increasing consumer use of these features

Next Steps

- **Proposed scope/direction**
  - Leverage the valuable work produced by the 2015 TAC MDTP Working group
  - Complete prioritization of 2016 work items by end of March

- **Key deliverables**
  - **June 2016:** Provide a draft report outline and update on industry initiatives addressing 2014 & 2015 recommendations
  - **September 2016:** Provide draft recommendations and report on impact 2014 & 2015 recommendations are having
  - **December 2016:**Provide final recommendations and industry updates for 2016 work items

Cybersecurity Working Group

Chairs: Shahid Ahmed, Paul Steinberg
FCC Liaisons: Jeffery Goldthorp, Padma Krishnaswamy, Ahmed Lahjouji

9-March-2016

Working Group Members

- WG Chair: Shahid Ahmed, PWC / Paul Steinberg, Motorola Solutions
- FCC Liaisons: Jeffery Goldthorp, Ahmed Lahjouji, Padma Krishnaswamy
- Members:

  - John Barnhill, Genband
  - Mark Bayliss, Visualink
  - Nomi Bergman, Brighthouse
  - Mike Bergman, CTA
  - Ken Countway, Comcast
  - Brian Daly, AT&T
  - John Dobbins, Earthlink
  - Martin Dolly, AT&T
  - Dale Drew, Level 3 Communications
  - Adam Drobot, Open Tech Works
  - Amit Ganjoo, ANRA Technologies
  - Michael Geller, Cisco
  - Dick Green, Liberty Global
  - Craig Greer, Samsung
  - Russ Gyurek, Cisco
  - Kat Hardy, Verizon Wireless
  - Theresa Hennesy, Comcast
  - Farooq Kahn, Samsung
  - Dr. Prakash Kolan, Samsung
  - Tom McGarry, Neustar
  - Jack Nasielski, Qualcomm
  - Ramani Pandurangan, XO Communications
  - Richard Perlotto, Shadowserver
  - George Popovich, Motorola Solutions
  - Christoph Schuba, Ericsson
  - S Rao Vasireddy, Alcatel Lucent
  - Jack Waters, Level 3 Communications
  - Brian Witten, Symantec
  - Lim Youngkwon, Samsung

2015 Accomplishments Summary

- Simplifying Smartphone Security
  - Published Paper: *Requirements and Developer Guidelines for a Security Checker Application*
  - Published Paper: *Smartphone Security Wizard Requirements*
- Applying Security to Consumer IOT Devices
  - Published Paper: *Applying Security to Consumer IoT Devices*

    (No Specific TAC Recommendations to the FCC included.)
- Securing SDN
  - Published Paper: *Considerations for Securing SDN/NFV*

    (No Specific TAC Recommendations to the FCC included.)

* See: TAC Reports and Papers (https://www.fcc.gov/general/tac-reports-and-papers) for all publications

2016 Sub-Working Group Activities

1. 5G Security (Leaders: Amit Ganjoo, Tom McGarry)
2. Securing SDN (Leaders: Ken Countway, Michael Geller)

FCC Direction: Topic 2 – 5G Security

- **FCC's Goal for the WG**
  - "We ask the Working Group (WG) to utilize what the Cyber WG has learned about IoT and programmable networks security, and any other related topics, in order to recommend to the FCC the strategy, procedures and steps necessary to help incorporate the concept of "security by design" into the very fabric of 5G, its design specifications, and consequently 5G's complex multi-product line ecosystem."
- **FCC's Questions**
  1. What other key technical areas, if any, should be researched while exploring ways to integrate the "security by design" concept into 5G design specifications?
  2. What are the important tools and security controls that should be built into 5G design specifications in order to make 5G networks and devices sufficiently secure from the onset?
  3. What are the SDOs most active in the 5G standards development process? To what extent do TAC members participate in those SDOs? What opportunities exist for those members, either through direct voting or other advocacy mechanisms, to support the TAC's recommendations and ensure future standards to incorporate security from the outset?
  4. How do we make sure the security controls identified become integrated into 5G design specifications? Describe strategy, procedures involved and specific step to take in this regard.
  5. How should the FCC and industry coordinate efforts in order to maximize their effectiveness in this endeavor?

5G Applications: Topic 2 – 5G Security

- **Mobile Broadband** – providing high bandwidth media and entertainment, e.g. video streaming, remote work in the cloud, gaming, virtual reality, augmented reality

IoT Applications

- **Automotive** – communications for vehicles, e.g. V2V, self-driving vehicles, AR dashboards
- **Smart Society** –smart cities and smart homes consisting of intelligent sensors that identify conditions for cost and energy efficiency, and convenience , e.g., energy management, alarming, surveillance
- **Smart Grids** – managing consumption and distribution of energy
- **Healthcare** – monitoring individual's health conditions and improving access to medical services
- **Industrial** – replacing cables with wireless links
- **Logistics/Freight Tracking** – using location based information to track inventory and packages

Work plan: Topic 2 – 5G Security

- **Proposed scope/direction**
  - Start by leveraging the valuable work produced by the 2015 TAC IoT Working group
  - Address IoT architectures that use 5G technology then expand into other 5G use cases
  - Create a list of key security principles that should be built into the 5G ecosystem
  - Identify the SDOs most active in developing 5G specifications
  - Develop an action plan to use the TAC's 5G key security principles into the standards development process
- **Key deliverables**
  - **June 2016:** Provide a draft recommendation for integrating key security principles into the standards development process for the highest priority 5G IoT applications
  - **September 2016:** Provide a draft recommendation for integrating key security principles into the standards development process for the next highest priority 5G applications
  - **December 2016:** Provide a final recommendation for integrating key security principles into the standards development process for the highest priority 5G applications

2016 Sub-Working Group Activities

1. 5G Security (Leaders: Amit Ganjoo, Tom McGarry)
2. Securing SDN (Leaders: Ken Countway, Michael Geller)

FCC Direction: Securing SDN

- **FCC's Goal for the WG**

  "SDN is sometimes considered to carry significantly more cyber risk than traditional network architectures. Therefore, the need to manage cyber risk in the SDN centralized network's control plane and distributed dataplane seems essential. It would be worthwhile to build security in up-front as opposed to retrofitting it, and seeking to apply lessons learned from the long running efforts to secure existing control plane protocols such as BGP and DNS. To that end, we suggest the following approach: Leverage what has been learned during the first phase of this work to develop Best Common Practices (BCP) to mitigate cyber risk associated with SDN/NFV."

- **FCC's Questions**

  1. Identify existing BCPs that focus on securing programmable networks, particularly those that are based on SDN/NFC network architectures
  2. Develop BCPs that close the gaps identified.
  3. What effective mechanisms should be employed to keep these BCPs current, and relevant to the industry?
  4. How should the FCC and the industry, together, promote adoption of these BCPs?
  5. How should the FCC and the industry, together, assess the effectiveness of these BCPs?

Securing SDN – Dominant Use Cases*

- **Intelligent VPN**
- **Service Chaining - Combining with Cloud Services (VNF's)**
- **Network Management and Traffic Control**
- **Virtual CPE**
- **Virtualization of CDNs (vCDN)**

* *Considerations for Securing SDN/NVF*, "Discovering these dominant use cases in itself proved to be challenging as many POC's (Proof Of Concept) are still in stealth mode and public announcements lack the necessary detail. Based on general knowledge we picked up through our extensive interviews with industry vendors and service providers, our collective knowledge as a team, and the help of some industry publications like Heavy Reading… "

Securing SDN

- **Proposed Scope / Direction**
  - For the TAC, last cycle, the Securing SDN group captured the industry landscape with respect to security challenges and opportunities, now we will build on that research to develop recommended best common practices based on our further analysis of the threat surface of SDN and NFV
  - We found it relevant and necessary to couple SDN and NVF together
  - Conduct research using industry resources (vendors, SPs, SDOs, Communities)
  - Consult - SDN / NFV Security SMEs from vendors, operators and communities (e.g. OPNFV, OpenDayLight)
- **Key Deliverables**
  - **June 2016:** a) Ecosystem Engagement and Strategy to Develop / Maintain BCPs with Industry, b) Confirm Prioritized Use Cases
  - **September 2016:** BCP Drafts developed for Prioritized Use Cases
  - **December 2016:** a) BCPs Finalized for Prioritized Use Cases, b) Promotion Activity

Securing SDN

- **Possible Additional Work Items**
  - Application of Threshold Cryptography across controller replicas and dynamic device association for SDN NFV
  - Use of Open Source with a view to encourage the acceleration of development in this area for SDN / NFV.
  - Many others under review

Next Generation (NG) Internet Service Characteristics & Features Working Group

Chairs: Russ Gyurek, Cisco
John Barnhill, Genband

FCC Liaisons: Walter Johnston, Scott Jordan, Alec MacDonell

Date: March 9, 2016

2016 Working Group Team Members

- Mark Bayliss, Visualink
- Brian Daly, AT&T
- John Dobbins, Earthlink
- Adam Drobot, OpenTechWorks
- Andrew Dugan, Level3
- Lisa Guess, Juniper
- Stephen Hayes, Ericsson
- Theresa Hennesy, Comcast
- Brian Markwalter, CE
- Milo Medin, Google
- Lynn Merrill, NTCA
- Jack Nasielski, Qualcomm
- Ramani Pandurangan, XO
- Mark Richer, ATSC
- Hans-Juergen Schmidtke, FB
- Steve Sharkey, T-moblie
- Marvin Sirbu, Carnegie Mellon
- Kevin Sparks, Nokia
- David Tennenhouse, VMware
- David Young, Verizon

+ Other Industry SME's

NG Internet Service Characteristics & Features Charter

2 Areas of Focus: General Improvements and Meaningful Metrics

1. Working across ISPs, the work group will seek to **identify achievable Internet improvements** that could **increase network efficiencies**, **security** or **otherwise improve the Internet ecosystem**;
2. Building on 2015, the work group will consider proposals to **extend data collection efforts**, both in terms of **efficiency** and **scale**, as well as **identifying network points** from which data should be available.
   - The possibility of end-to-end **measurements** will be examined together with the potential impact of **differentiated E2E QOS,** leveraging **alternative sources** of data (e.g. crowd sourcing), and **examining broadband bottlenecks** and **breakpoints**.

Team Agenda 2016

- Measuring QoS- BIAS
  - *What, where, how to execute the 2015 recommendations*
- Internet improvements and efficiencies
  - *New topic for WG in 2016*
- E2E QoS
  - *Continued work from 2015: "Fork in the Road"*

Seeking input from fellow TAC members on these topics

QoS

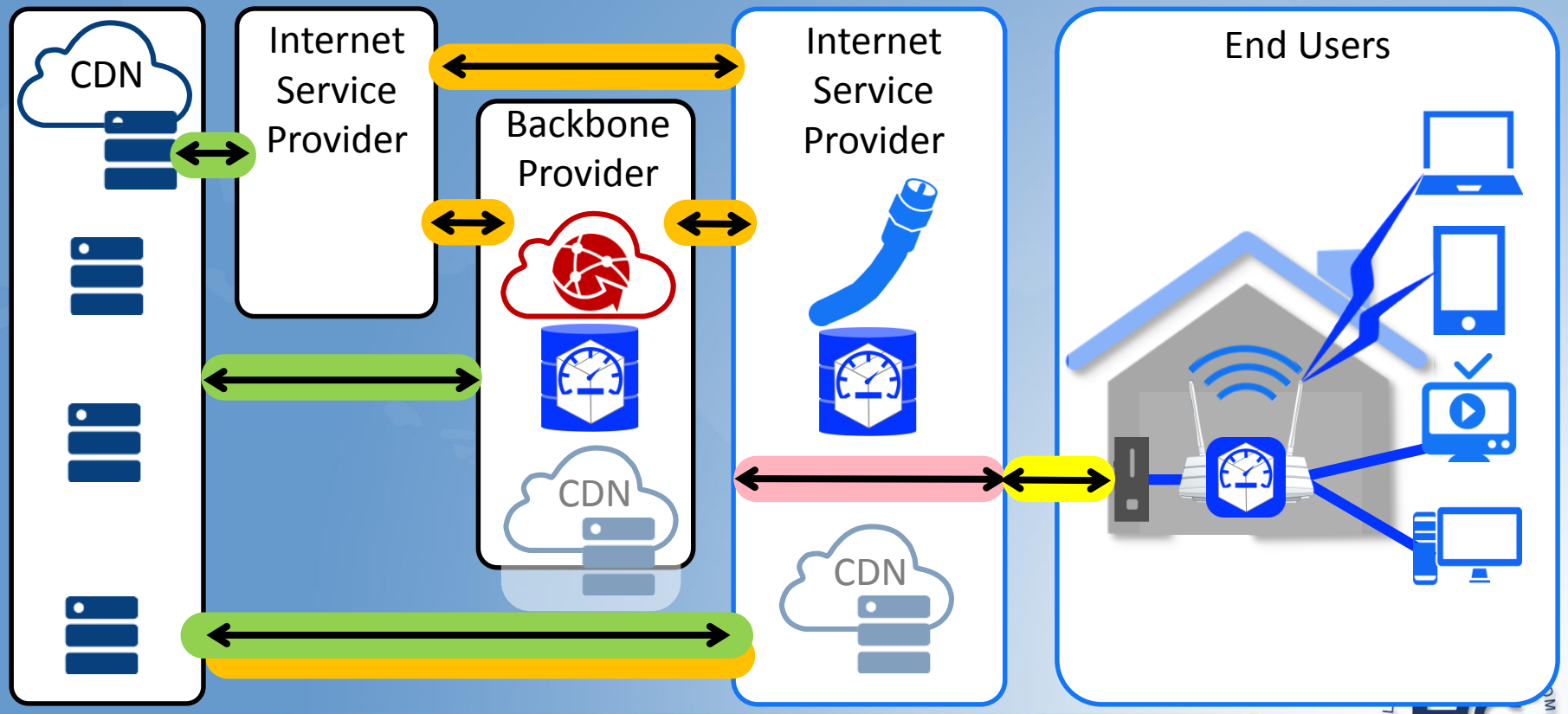
2016 Suggested Work Plan

- Follow-up on 2015 Recommendations and adapt as necessary.
- General Trends and Improvements:
  - Encryption growth: Impact on security and privacy
  - NG internet may have differentiated E2E QoS, more work needed
- Measurements
  - Summary of QoS/ QoE Work in other standards bodies
    - ETSI, ITU, 3GPP, BiTAG, AT&T/ DirectTV, ATiS, etc.
  - Identify Quality of Service/ Experience factors by traffic type
  - Identify Industry efforts to improve in-home performance

2016 Suggested Work Plan: Continued

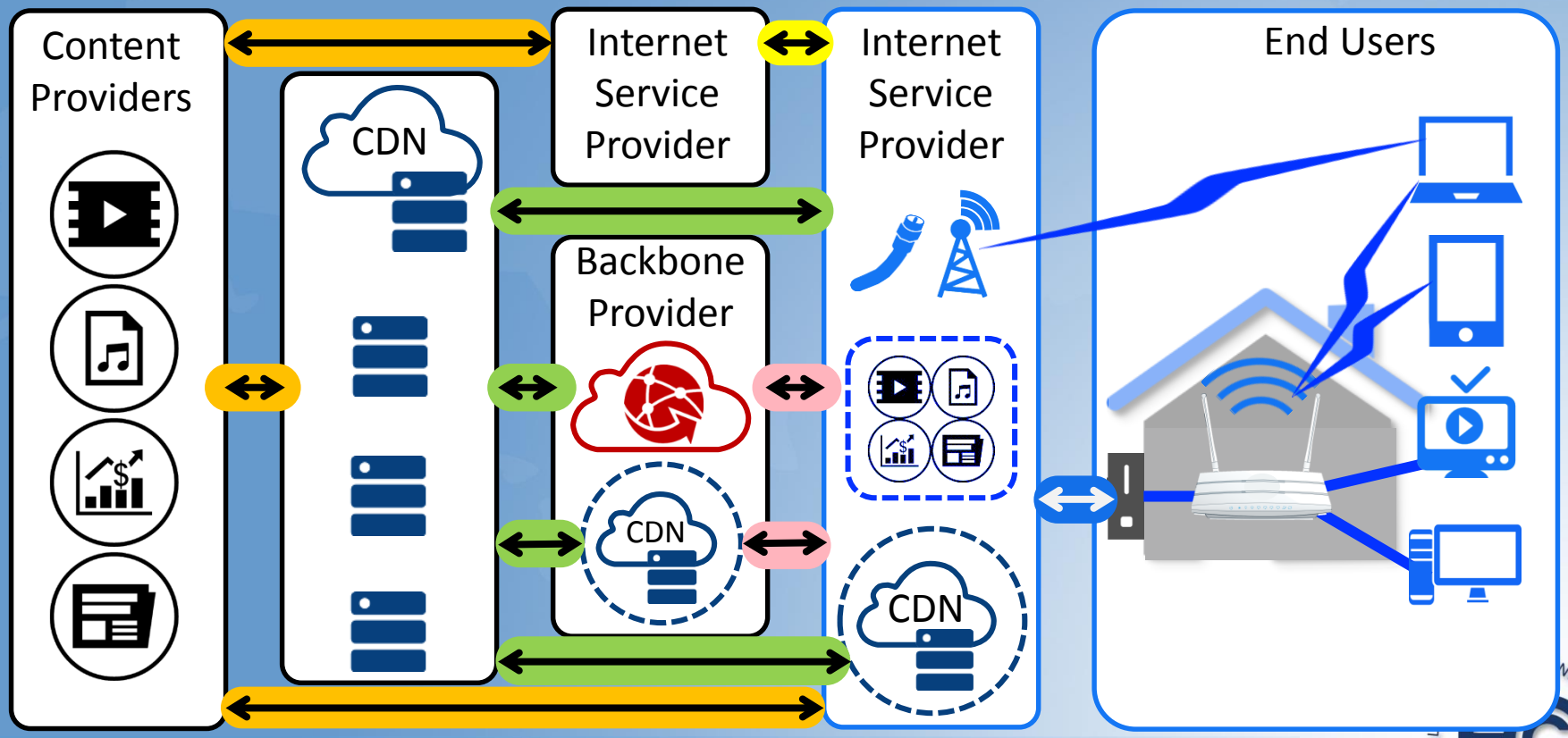
- Identify Metrics and Measurement Points to support Commission mission
  - Identify key network points affecting QOS and potential measurement approaches
  - Minimum, Meaningful, Material: Identifying bottlenecks, breakpoints and limitations
  - Explore OS community for SW based measurements
  - How to leverage alternate sources of data. i.e. Crowd-sourced data
  - MBA program in 2 years, 5 years, 10 years. Should get locked in. Integrated testing metrics
  - Data repository/observatory
    - What will the Commission do with the collected data?
    - Will it be made available for public or third party analysis?

QoS: From Content to Consumption



CDN Performance
Interconnection Health
BIAS Cloud
BIAS Last Mile
Existing MBA

Connecting Users to Content: All Paths Aren't Equal



2016 Proposed Work Teams: 4 Teams with Special Focus on 5G

Content

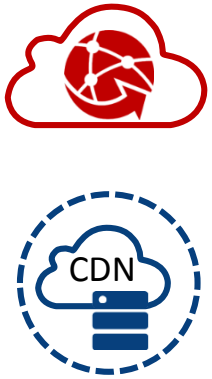
Facebook
Google
Hulu
Netflix
Apple

CDN/ Compute

M. Sirbu
A. Dugan
K. McElearney

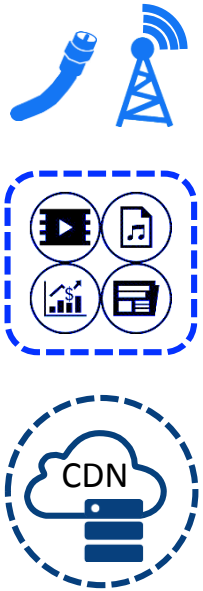
Backbone/ ISP

M. Browne
M. Dolly
K. McElearney
R. Pandurangan
M. Richer



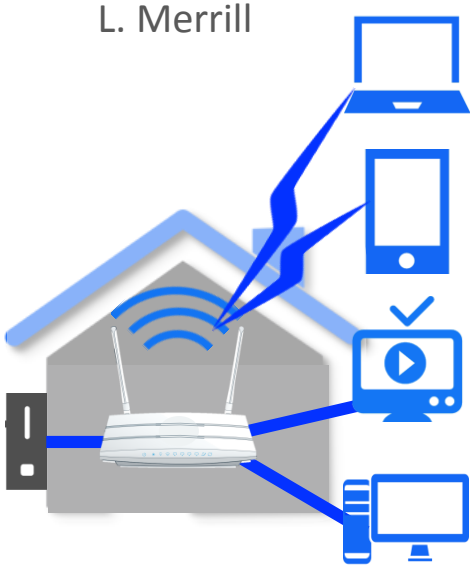
5G - Mobile/ ISP

J. Nasielski
B. Daly
M. Browne



In-Home/ End User Networks

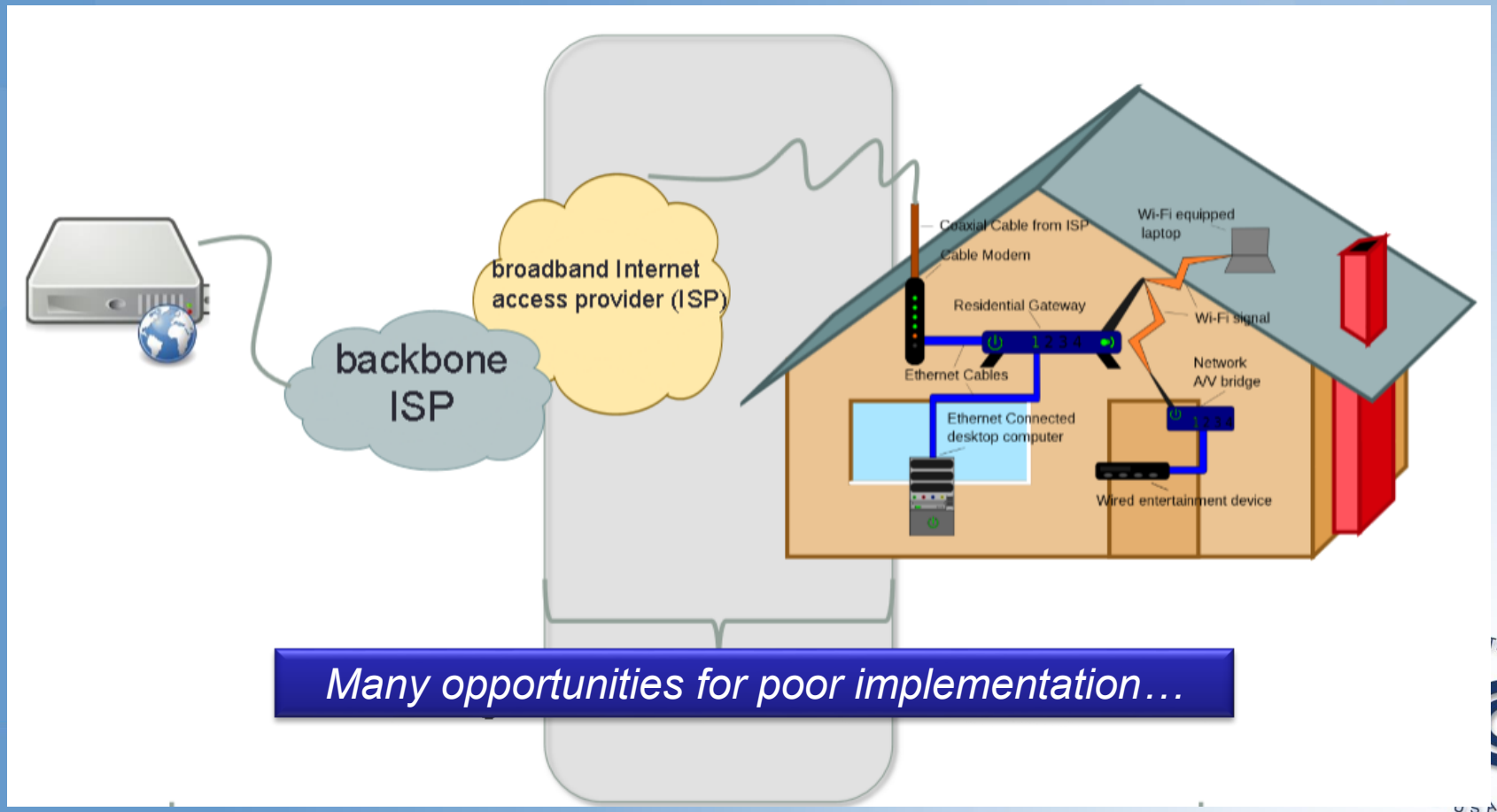
W. Johnston
A. MacDonnell
B. Markwalter
M. Medin
L. Merrill



QoS: In-Home/End User Components Key Points for Review

- Identify research efforts focusing on in-home broadband performance
- Determine current and future software products which can be included in applications to allow for self-monitoring by homeowners
- Discuss future features which might easily show the homeowner performance issues and suggest improvements
- Determine the extent mechanisms exist or are needed to provide detailed performance indicators to the network service provider outside the home while ensuring the privacy of the subscriber.
- What are the current trends in the Industry (first, what capabilities exist today?), Visualware. On-hub: diagnose where problem is in network
- No data collected today by FCC. Actions: Create matrix of groups looking at in-house perf. Seek input from ISP's on in-home wi-fi.

In-Home: Where Broadband may not Equate to Quality



QoS: In-Home/End User Components Action

- Contact Broadband Forum
  - TR-69 and WT345 Architecture and Migration work area to discuss placement of triggers in products to enable transparent measurements
  - Discuss with forum software gateway manufactures to collect an understanding on required work to add measurements and other reporting statistics for customer and broadband provider use
- Broadband ONT Manufacture
  - Interview ONT providers for capabilities within ONT's for in-home network performance and monitoring
- CTA
  - Interview key industry experts from CTA on in-home electronics for future considerations for performance monitoring on network routers and Gateways
- FCC Take-a-way
  - What are the processes or capabilities needed by the FCC (How to integrate information and process data into the MBA program or other FCC designated process)
  - What limited information is needed to complete measurement capabilities

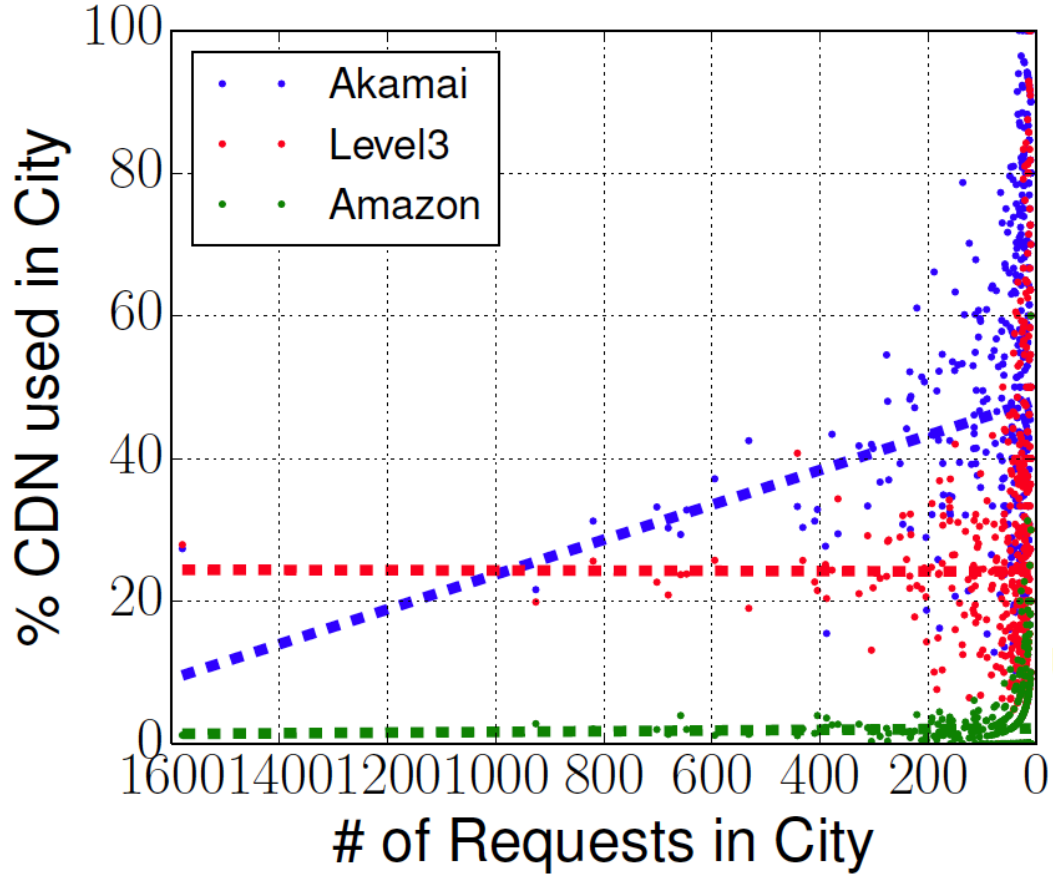
QoS in home (continued)

- IHS consultants predicts that by 2019 90% of broadband households will have vendor provided wifi
  - http://press.ihs.com/press-release/technology/nine-10-global-broadband-households-have-service-provider-wi-fi-2019-ihs-sa
  - Implies vendors in position to monitor in-home network performance

CDNs and QoS/QoE

- MBA measures performance to monitoring points in backbone
- Majority of content (esp video) is delivered from CDNs, often directly connected to BIAS network
- Need to monitor CDN performance to consumer
  - Metrics
    - Startup latency
    - Maximum throughput
    - Rebuffering events
  - https://www.sandvine.com/downloads/general/whitepapers/measuring-internet-video-quality-of-experience.pdf

Publishers shift usage among multiple CDNs depending upon customer city and local request rate



Conviva Data

Grouped by City

Definitely varied usage based on CDN

Source: Matt Mukerjee, Carnegie Mellon University

CDNs and QoS/QoE

- Market Measurement Solutions Exist:
  - ISP's actively monitor
  - Content providers/CDNs actively monitor
    - *e.g.* https://www.google.com/get/videoqualityreport/
  - 3rd party/vendor solutions
    - Conviva Whitepaper: Https://www.usenix.org/conference/nsdi15/technical-sessions/presentation/ganjam
  - Requires instrumenting browser or video player

E2E QoS

Today: E2E QoS Only Available via Managed Services

Managed Connectivity	**Enterprise VPNs** **ISP Video Services** **ISP Voice Services**	▪ Managed End-end QoS/SLAs ▪ Coordinated between network operators ▪ Essential for ensuring the integrity of ISPs' own services & many "mission critical" enterprise uses ▪ Applicable to fairly high end users/uses, given cost
Internet	**Skype** **OTT Video** **OTT Voice** **Internet VPN's** **Web Browsing**	▪ User flows undifferentiated (best effort) ▪ Shared resource = universally accessible ▪ Low cost = universally applicable ▪ Enabler of unrestrained innovation & rapid/viral adoption of new services

Should the range of type & quality of services expand in the NG Internet?

NG Internet – *The E2E QoS Fork in the Road*

Undifferentiated Internet

Current Internet, massively scaled

- Ever higher BW applications enabled
- QoE still not predictable
- Capacity upgrades gated by ISP access ROI

Differentiated Internet

New- Unpaid QoS Internet

- What users and apps get differentiation?
- If QoS traffic unlimited there's no differentiation
- No clear model exists!

Non-Transactional

New- Paid QoS Internet

- For subset of traffic only
- △cost constraints
- $: Direct user or indirect app/content provider
- Predictable QoE for wider range of uses

Best Effort ← → **Transactional**

2016 WG EXPECTATIONS

June 2016 Deliverables

- Summary of QoS/ QoE Work in other standards bodies
  - ETSI, ITU, 3GPP, BiTAG, ATiS, etc.
- Identify Quality of Service/ Experience factors by traffic type
- Identify Industry efforts to improve in-home performance

2016 Suggested Work Plan

- Follow-up on 2015 Recommendations
  - Adapt as improvements are discovered
- General Trends and Improvements:
  - Encryption growth: Impact on security and privacy
  - NG internet may have differentiated E2E QoS, more work needed
  - Broadband bottlenecks and breakpoints; where are the limitations
- Measurements
  - End-to-end QoS: measurement possibilities
  - How to create “automated capability” on MBQ testing and measurements
  - Explore OS community for SW based measurements
  - How to leverage alternate sources of data.
    i.e. Crowd-sourced data

THANK YOU!

Back-up Material

Actionable Recommendations: NG-I WG 2015

- Encryption: Assume majority of data as encrypted in all future policy decisions
- Expand MBA program to add QoS and QoE measurements → MBQ
  - Measurements should be as automated as possible
  - Open Data/ Data transparency, while protecting privacy (ISP & consumer)
  - Add/include CDN performance to metrics measured
- QoE: Contract a professional consulting company to create a questionnaire to poll consumer experience data, and to potentially administer the poll
  - Consumer data correlated with relevant MBA performance measurements and QoS data to develop valuable insights on the relationship between objective QoS data and subjective QoE consumer data
  - Purpose: Assist the FCC with future BB policy considerations, current performance programs as well as consumer awareness
- Fund a consumer education program: Variables that impact BB performance
- FCC to allocate resources to data science needs of the measurement program
- Funded research support for QoS measurements

Future Game Changing Technologies Working Group

Chairs: Kevin Sparks and Adam Drobot
FCC Liaison: Walter Johnston

9-March-2016 Washington, DC

Working Group Members

- WG Chairs: Kevin Sparks, Nokia
  Adam Drobot, OpenTechWorks

- FCC Liaison: Walter Johnston

- Members:
  - Kumar Balachandran, Ericsson
  - John Barnhill, Genband
  - Mark Bayliss, Visualink
  - Lynn Claudy, NAB
  - Brian Daly, AT&T
  - Hans-Juergen Schmidke, Facebook
  - Jeffrey Foerster, Intel
  - Dick Green, Liberty Global
  - Ramani Panduragan, XO Communications
  - Jack Nasielski, Qualcomm

Working Group Members Cont'd

- Russ Gyurek, Cisco
- Brian Markwalter, CEA
- Paul Misener, Amazon
- Lynn Merrill, NTCA
- Mark Richer, ATSC
- Marvin Sirbu, SGE
- Paul Steinberg, Motorola Solutions
- Lisa Guess, Juniper Networks
- Nomi Bergman, Brighthouse Networks
- Michael Browne, Verizon
- Steve Lanning, Viasat
- J Pierre de Vries, Silicon Flatirons
- Marty Cooper, Dyna LLC

FGCT Working Group Charter for 2016

The work group will continue its focus on seminal technical areas for 2016:

i) Concentrate on identifying the technical challenges in developing 5G and what can to be done to ensure rapid deployment in the U.S;
ii) Examine potential new business models and service regimes that could be enabled by future programmable networks. The work group will also address the adoption of dynamic, virtualized networks and the implications for current FCC rules and policies;
iii) Address how the FCC can better anticipate rapid changes in technology and an approach to rules and policies that have the best outcome for rural and urban settings.
iv) Finally, the work group will continue its efforts to identify key new and emerging technologies

FGCT WG Tracks and Products for 2016

Proposed Sub-Working Groups (SWGs):

- 5G Adoption – White Paper
  Chairs: TBD

- Programmable Networks: Business Models, Rules, and Policies – White Paper
  Chairs: TBD

- Education – Briefing, Presentation
  Chair: Nomi Bergman

- New and Emerging Technologies – Briefing, Presentation
  Chairs: Kevin Sparks and Adam Drobot

FGCT WG Scope and Direction for 2016

- Proposed scope/direction - **5G**
  - 5G areas of advancement and challenge, to analyze
    - Densification (small cells and siting)
    - Spectral efficiency and coverage (smart antennas, cognitive radio)
    - Automation and optimization
    - mmWaves at frequencies > 24GHz (technology and best uses)
    - Cloud infrastructure and network functions virtualization
  - Drivers for - and benefits of - rapid deployment
    - User benefits: area coverage, throughput, capacity, cost, hyper-connectivity
    - Leverage of licensed, unlicensed, and shared spectrum
    - Enabling new applications such as IoT with widely ranging requirements (low cost/low power, very low latency, high throughput, etc.)
    - Timing of capabilities – latency, security, …

FGCT WG Scope and Direction for 2016

- Proposed scope/direction - **Programmable Networks**
  - Enablement of new business models and service regimes
    - Range of potential new use cases, and ways of innovating and delivering them
    - Requirements from IoT and other broad Application use cases
    - User benefits of applications in Health, Education, and Collaboration; ubiquity, affordability
    - Timing of capabilities – APIs, low latency, security, …
    - Potential for economic growth
  - Architecture considerations
    - As an enabling technology can this area be isolated?
    - Do considerations for computing dominate?
    - Construct for decoupling of technologies – i.e. computing from communications from storage
    - Use of Open Source
  - Regulatory implications of a programmable networks ecosystem
    - What FCC rules and policies could hinder (or encourage) adoption?
    - Who has regulatory responsibility, and oversight of interoperability?

FGCT WG Scope and Direction for 2016

- Proposed scope/direction - **Education**
  - Aimed at FCC
    - Sources of Information
      - » Four levels – Commercial Input, Advisory Bodies, Technology Scouting and Intelligence Capabilities at FCC, Organized Open Participation Activities
    - Technology Neutral Policies and Regulations with pathways for resolving practical issues
      - » Maintaining Competition
      - » Serving Public Needs
      - » Promoting Innovation
      - » Global Harmonization
  - Aimed at the Industry
    - Mechanisms for pre-competitive trials and experimentation
    - Transparency of practices and performance
    - Certainty in policies and regulations for making investments
  - Aimed at Public Awareness
- We are looking for further input from the TAC

FGCT WG Scope and Direction for 2016

- Proposed scope/direction - **New and Emerging Technologies**
  - Advanced Antennas and Signal Processing
  - Wireless Charging
  - Dynamic Spectrum Sharing
  - Timing of capabilities – latency, throughput, ubiquity, area coverage, security, privacy, ….

  – Seeking Input from TAC for additional ideas

FGCT WG Scope and Direction for 2016

- SME talks throughout the year
- Schedule for Key deliverables
  - June 2016
    - Well defined scope and direction for SWGs
    - Preliminary definition of work areas
    - Status of Initial results
  - September 2015
    - In progress versions of White Papers, Briefings, and Presentations
    - Early Recommendations
  - December 2015
    - Final White Papers, Briefings, and Presentations
    - Actionable Recommendations

Thank you!

FCC Technological Advisory Council Working Group:

Implications for Mass Deployment of Aeronautical/Space Transmitters

January 9 2016

Working Group

Steve Lanning (ViaSat) co-chair
Michael Tseytlin (facebook) co-chair
Jeffrey Foerster (Intel)
Dale Hatfield (U Colorado)
Adam Drobot (OpenTechWorks)
Russ Gyurek (Cisco)
Lynn Merrill (Monte R. Lee & Company)
Brian Daly (AT&T)
Pierre deVries (U Colorado)
Brian Fontes (NENA)

Brian Swenson (Microsoft)
Lisa Guess (Juniper)
Geoffrey Mendenhall (GatesAir)
Hans Juergen Schmidtke (facebook)
McNamara, Mike (TW Telecom)
Hennesy, Theresa (Comcast)
Amit Ganjoo (ANRA Technologies)

Michael Ha (FCC liason)
Robert.Pavlak (FCC liason)

Charter

Technological advances are enabling a potential explosion in the development and deployment of new types of aeronautical and space transmitters, including unmanned aircraft systems (UAS), aerostats, balloons, high altitude/long endurance platforms, Low Earth Orbit (LEO) satellites and other aeronautical and space systems. This work group will examine the implications these systems relative to FCC rules and policies, including identifying any spectrum issues and recommending how the Commission might address them.

Restatement

Technological advances are enabling a potential explosion in the development and deployment of new types of aeronautical and space transmitters. The aeronautical platform include manned and unmanned aircraft systems (UAS), aerostats, balloons, high altitude/long endurance platforms (HALE) and other aeronautical communications and controls emitters. The space transmitters consists of space communications, active and passive observations systems at GEO/MEO/LEO orbits.

This work group will examine the implications these systems relative to FCC rules and policies, including identifying any spectrum issues and recommending how the Commission might address them.

Working Targets

- Study and Document the Changes Occurring in the Aeronautical and Space Transmitters
- Identify, Analyze and Document Communications Capabilities and Spectrum Requirements of the current and future Aeronautical and Space Transmitters
- Spectrum/Interference Analysis
  - Access, Traffic and Feeder links (forward and return)
  - Inter-Satellite/inter-Aeronautical and Satellite to Aeronautical communications
  - Control channels if needs to be separate from access/traffic/feeder links
  - Interference mitigations techniques
  - What spectrum can be shared and how to manage co-existence?
- Develop the framework and recommendations for spectrum allocation and spectrum co-existence for Aeronautical and Space Transmitters
- Areas of improvement/vulnerability
- Recommendations for needs of FCC action
  - Tracking
  - Rulemaking

New Aerial Platforms Enabled By Technological Advances

- Reductions in launch costs ($/payload kilo)
- New platforms (drones)
- New and improving technologies
  - 5G
  - Geo capacity increases in design and ground stations
  - SDN/NFV make hybrid networks more elastic
  - Other

Initial List Of Outside Groups To Gather Information

- Government Agencies
  - NSF, DAPPA, FAA and NASA
- Aeronautical manufacturers Boeing, LMT and others
- GEO manufacturers – Boeing,SSL/Loral, ViaSat etc.
- LEO manufacturers – SpaceX, OneWeb, etc
- Small UAV manufacturers (Amazon, Parrot, DJI, etc)
- HALE manufacturers (Facebook, Google)
- Antenna manufacturers for steerable and fixed antennas
- 5G service providers - AT&T, Verizon, etc

- Others

Thank You

Technological Advisory Council

Spectrum and Receiver Performance

Working Group

March 9, 2016

Spectrum and Receiver Performance Working Group

- **Chair:**
  - Lynn Claudy, NAB
  - Greg Lapin, ARRL
- **FCC Liaisons:**
  - Julius Knapp
  - Robert Pavlak
  - Matthew Hussey
- **Participants / Contributors:**
  - Dale Hatfield, University of Colorado
  - Pierre de Vries, Silicon Flatirons
  - Brian Markwalter, CTA
  - Geoff Mendenhall, GatesAir
  - Michael Tseytlin, Facebook
  - David Gurney, Motorola Solutions
  - Robert Dalgleish, Ericsson

Recent Work Group Recommendations

- Basic Principles for Assessing Compatibility of New Spectrum Allocations – A White Paper (12-11-2015)
- A Case Study of Risk-Informed Interference Assessment: MetSat / LTE Coexistence in 1695-1710 MHz (12-9-2015)
- A Quick Introduction to Risk-Informed Interference Assessment (4-1-2015)
- Multi-stakeholder Organization to Develop Interference Limits Policies – Recommended Charter (6-17-2014)
- Introduction to Interference Resolution, Enforcement and Radio Noise – A White Paper (6-10-2014)
- The Impact of Emerging Receiver Technologies on Changing Standards and Spectrum Allocations – A Brief Study (6-10-2014)
- Interference Limits Policy and Harm Claim Thresholds: An Introduction (3-5-2014)

Underlined text – Hyperlink to document

2016 Proposed Mission

- **Make recommendations in areas focused on improving access to and making efficient use of the radio spectrum from a system and receiver perspective**
  - Provide support as the Commission considers TAC recommendations related to a next generation systems architecture for radio spectrum interference resolution
  - Conduct analysis and make recommendations related to ex ante / ex post risk assessments and the statistics of interference in a rapidly changing RF environment

Working Group Areas of Focus

- ***"A Study to Develop the Next Generation Systems Architecture for Radio Spectrum Interference Resolution"***
  - Encourage FCC and other government agencies, academic and private sectors to study and develop next-gen interference resolution system architecture
- **Risk and statistics of interference**
  - RF noise assessment and baselining interference
    - Research and analyze noise floor, emission limits, trends & emerging requirements
    - Consider case study of radio service(s), classes of incidents, incident and technology trends, useful information (e.g., receiver reference sensitivities; I + N)
  - Investigate and make recommendations on propagation modeling
    - Factors affecting interference prediction, tools, analysis, and service rules

A Study to Develop the Next Generation Systems Architecture for Radio Spectrum Interference Resolution

- **Motivation**
  - Exponential growth in demand for radio spectrum driven by:
    - More users using more devices consuming more bandwidth per device (e.g., video in advanced multimedia applications)
    - New and emerging uses for spectrum important to both government and civilian users (e.g., UAVs and IoT)
    - Increasing number of other electrical and electronic devices that unintentionally or incidentally emit radio waves
  - Growth in demand and use of spectrum leads to the need for:
    - Increased densification in frequency, time and space dimensions
    - Dynamic spectrum access using sophisticated SAS systems that use geo-location data-bases and/or spectrum sensing to increase sharing

- **Motivation (Continued)**
  - Vulnerabilities of systems and devices to both malicious intentional and unintentional interference changed by densification and dynamic sharing
  - Dramatically improved capabilities for detecting, classifying/identifying, locating, reporting, mitigating and remediating interference
  - The above, coupled with budgetary realities and the need to automate systems to speed responses and reduce costs, suggests the need for a study whose objective is to:
    - Use modern system engineering tools, analyses, and techniques
    - Produce a **Next Generation Systems Architecture for Interference Resolution**
  - Report being offered for approval today contains a Statement of Work (SOW) for such a study

- **SOW Specific Tasks and Key Activities (7)**
  - Identify, analyze and document:
    1. Traditional radio system interference resolution environment
    2. Changes occurring in the radio environment and the interference challenges associated with them
    3. Improved capabilities for detecting, classifying/identifying, locating, reporting, mitigating and remediating interference
    4. Current and evolving requirements for a next generation systems architecture for interference resolution
    5. Privacy issues associated with the development of the next generation systems architecture
    6. Potential cybersecurity issues associated with the development of the next generation systems architecture
    7. **Develop the Next Generation System Architecture for Radio Spectrum Interference Resolution**

- **System architecting involves the identification and specification of –**
  - the major hardware and software components that will comprise the system
  - the functions to be performed by each of those components
  - the interfaces among these components,
  - the associated protocols that allow the components to communicate with one another using the interfaces
- Note a system architecture is not a detailed system design; rather a framework within which detailed design can take place that takes into account the specific context e.g., in interference resolution, the specifics of the bands and adjacent bands and resources available

- **Working Group requests that, after discussion:**
  - Report containing the SOW titled ***"A Study to Develop the Next Generation Systems Architecture for Radio Spectrum Interference Resolution"*** be approved by TAC membership and posted on the TAC website
  - TAC membership recommend that the FCC work with other government agencies and the academic and private sectors to facilitate the undertaking of the study by:
    - Cooperating in the refining and completing the SOW
    - Identifying potential funding sources
    - Establishing a governing structure for overseeing the accomplishment of the work
    - Identifying potential performers of the tasks and activities identified

RF Noise Assessment

- Topic of addressing rising RF noise floor presented at September 2015 TAC meeting; deferred to 2016
- Proposed work for 2016…
  - Research literature and measurements on RF noise floor changes
  - Research FCC rules on RF emission limits
  - Compare available test data from devices relative to current emission limits
  - Research required noise floor for various radio service bands and assess RF environment contributions to noise floor(s)

Propagation Modeling

- Last Year: We presented *Basic Principles for Assessing Compatibility of New Spectrum Allocations*
- This Year: We drill down on one of the factors that affect those principles

<u>Principle 1</u>: *Harmful interference is affected by the characteristics of both a transmitting service and a nearby receiving service in frequency, space or time.*

- Interference between two services is affected by:
  - How much spectrum is placed between them,
  - **How much physical space is placed between them**,
  - If services can coordinate their operations to occur at different times.

Propagation Modeling

- Tools
  - SEAMCAT modeling software
    - Spectrum Engineering Advanced Monte Carlo Analysis Tool
    - Statistical Modeling of Radio Interference Scenarios
    - Written for Java Runtime Environment
    - Developed by the European Communications Office of CEPT
  - Models – open, proprietary, outdoor, indoor
    - ITU-R P.452, ITM, Extended Hata, Others
  - Key factors affecting ex ante interference protection
    - Scattering, urban clutter, indoor/outdoor, ducting

Propagation Modeling

- Collaborators
  - NTIA
    - Institute for Telecommunication Sciences
  - Researchers
  - Spectrum users / spectrum managers

THANK YOU