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Spectrum Sharing Unleashed

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Current Members



The Jetsons Future and Beyond!

In some ways, the Jetsons future is already here:



Video Phone









Flat panel TV



Tablet



But more is coming ... beyond even our futuristic family ... to boldly go ...



Advanced Robotics



Smart watch

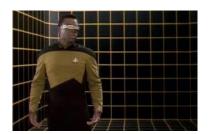
Self driving (or flying) cars



Maybe even Elon Musk's Hyperloop!



Internet of Things



Virtual Reality



The Future Will Require a Next Generation Internet

- Tomorrow's innovations will require connectivity anytime, any place, and with virtually any throughput
- Connecting the Next 4 Billion must be an integral part of the solution
 - Affordability
 - Sustainability
 - Digital Literacy
- All technologies will need to be part of the solution

4G, 5G, WiFi, TVWS, Satellites, Drones, Fiber, Fixed Wireless, High Altitude Platform Stations

IOT Alone Will Drive Tremendous Demands on the Internet

McKinsey & Company 3

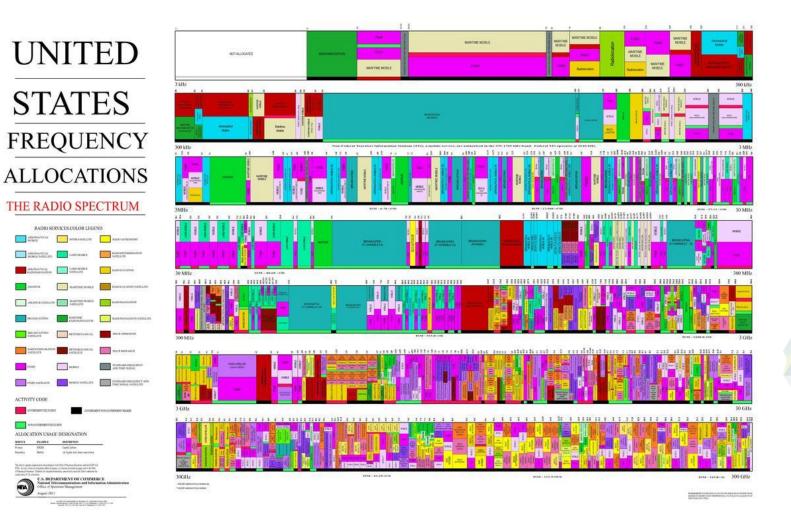
THE IOT PLATFORM OPPORTUNITY

SOURCE: McKinsey Global Institute analysis

impact of 2.7-6.2 trillion USD until 2025 Range of sized potential Impact from other economic impacts potential applications \$ trillion, annual (not sized) Low X-Y 3.7-10.8 Mobile Internet Automation of 5.2-6.7 knowledge work **Internet of Things** 2.7-6.2 1.7-6.2 Cloud technology 1.7-4.5 Advanced robotics Autonomous and near-0.2-1.9 autonomous vehicles Next-generation 0.7-1.6 genomics Energy storage 0.1-0.6 5)+ AAA 3D printing 0.2-0.6 Who will Advanced materials 0.2-0.5 capture this Advanced oil and gas 0.1-0.5 exploration and recovery opportunity 0.2-0.3 Renewable energy

The Internet of Things (IoT) has a potential economic

But Where Will The Spectrum Come From?





Key Challenge: Eliminating spectrum scarcity

Spectrum scarcity is not a law of nature!

- Most spectrum, in most places, is unused most of the time
- Today's allocation system based on a 100 year old model focused on avoiding interference with old tools
- Dynamic access can yield a substantial increase in available spectrum

Solution: Moving to Spectrum Abundance

Dynamic Spectrum Access: Protect incumbents and drive more efficient use through opportunistic access



Dynamic Spectrum Access optimizes and enables access to under-utilized spectrum



Dynamic Access: The Basics

- It starts with the **protection of incumbent** licensees.
- Rules or regulations define the requirements of protection
- Databases, location identification, sensing, etc. are the tools that enable compliance



The Technology is here:

- Over 25+ TVWS Trials have been successfully deployed globally
- ✤ U.S. FCC issued rules for dynamic sharing in the 3.5 GHz CBRS Band
- ✤ Additional Shared Spectrum for WiFi is being studied
- Unlicensed spectrum in 60 GHz will also enable more dynamic uses



TVWS: The Time is Now

- TVWS spectrum (unused UHF & VHF channels) is available today on an unlicensed basis in growing list of countries
- Radios in TVWS spectrum provide point-to-multipoint connectivity of 10+ km
- Spectral efficiency similar to other leading wireless access technologies
 - Throughput of 16 Mbps in 8 MHz UHF channel
 - ASICs and 2 and 4 channel bonding/aggregation coming
- Reduces cost of network deployment (CAPEX and OPEX)
 - Equipment is cheap and easy to deploy.
 - TVWS network infrastructure cost can be just a fraction of LTE



3.5 GHz Three Tier Dynamic Sharing

U.S. FCC created the Citizens Broadband Radio Service to drive innovation through dynamic access

- Supported by incumbent U.S. DoD
- Three tier regime includes:
 - Incumbent tier government users and FSS satellites
 - Priority Access License tier 70 MHz of spectrum, dynamically allocated
 - General Authorized Access tier Licensed by rule, but receives no protection from the other tiers
- Spectrum Assignment System (SAS) for coordination and frequency assignment
- Investment by large players already driving innovation
 - CBRS band expected to be in operation in 2018



WiFi: On-Ramp for 5G and IOT

WiFi carries the dominant share of Internet access traffic

• Not WiFi Offload, WiFi Primary!



WiFi helps drive mobile carrier growth

- WiFi and Cellular demand have grown together each benefiting from the other
- WiFi is cost effective for consumers through cheaper access
- WiFi is cost effective for network operators Efficient network CAPEX investment

WiFi will be even more important for 5G networks with billions of additional IOT devices, most of which will be WiFi enabled

WiFi Spectrum Demand

Estimated Gap for Unlicensed Spectrum

- By 2020: 200 600 MHz
- By 2025: 600 1600 MHz
- Although mmW will be important, mid-band spectrum critical for home and business coverage

Targets for Mid-Band Unlicensed Spectrum

- 5 GHz: is important but continues to be challenged due to govt users
- 6 GHz: best opportunity Europe has begun studies

WiGig at 60 GHz

WiGig poised to be the "the next big thing" in WiFi

- 802.11ad provides speeds at up to 4.6 Gbps
- High capacity wireless networking faster than standard gigibit ethernet!
 - 4K video streaming and next generation gaming will be a breeze
 - High-end wireless virtual reality will be ... a reality

Unlicensed spectrum continues to flex its muscles

Propogation characteristics in mmW will demand unlicensed



Dynamic Spectrum Access: The Future is Now

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Thank you!