3GPP RAN Ad Hoc on Next Generation Access
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RPA-160005

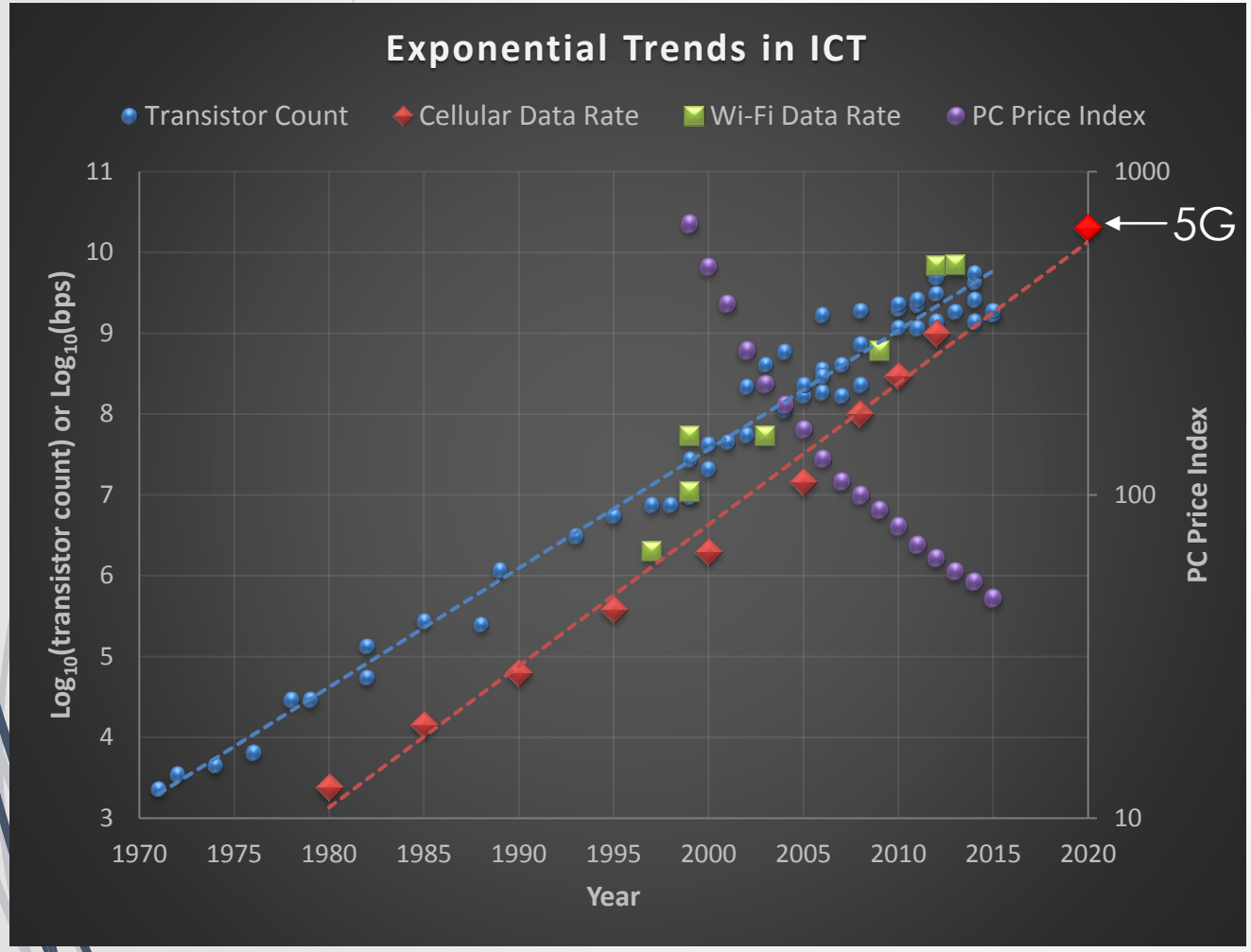
# Requirements for 5G Mobile Broadband

Agenda Item: 5 (Scenarios and Requirements)

Source: Straight Path Communications Inc.

Document for: Approval

# 5G Needs to be Technologically Superior




**Exponential growth of core figure of merit is the driver of ICT**

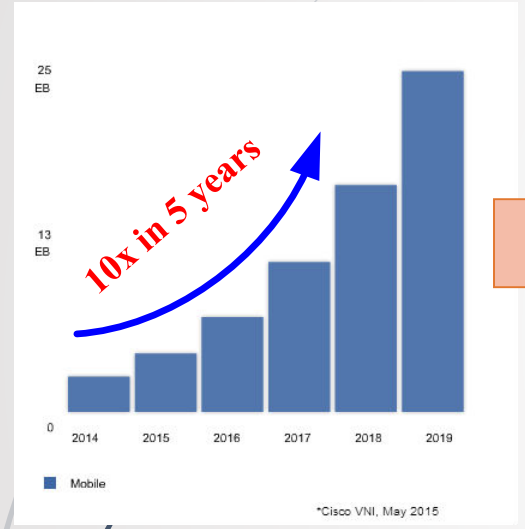
- ICT industry has been thriving on exponential trends for decades
- Successful companies embrace and take advantage of the exponential increase of technology capabilities and decline of price

**Make 5G happen, or let 5G happen to you**

- Huge market demand for a 5G that is significantly better than 4G (Not so much if it's only incrementally better)
- Technologies available to deliver a superior 5G that can be commercially successful
- Great opportunities for technology innovators and business leaders to grow new businesses and leapfrog competition (and great perils for those who retroact and procrastinate)

# 5G Needs to be Economically Viable

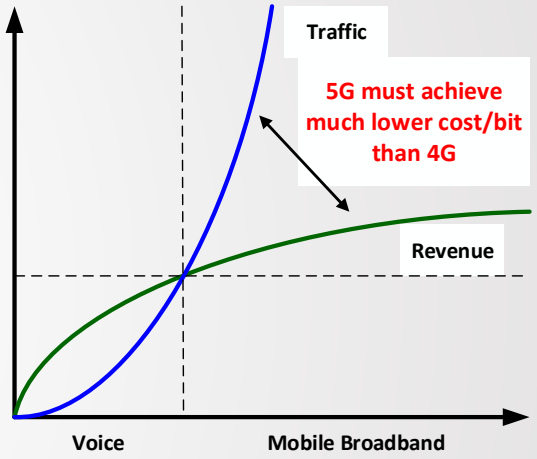
Mobile traffic grows at 60% CAGR




**Between a rock and a hard place**

Sub-6 GHz cellular systems – not enough nor economically viable to meet the growing mobile broadband demand

The widening traffic revenue gap




**5G holds the promise of overcoming the duel challenges of capacity and cost**

- Much higher capacity (100x – 1000x higher than 4G)
- Much lower cost per bit (*e.g.*, ~$10/GB ➔ ~$0.1/GB)

# 5G Needs to Clearly Differentiate from Wi-Fi

**5G must support link budget up to 160 dB**

- 5G should target a wholesale upgrade of mobile broadband experience to Gbps
- Leave the job of hotspots and gap fillers to Wi-Fi and femtocells

Pigeonholing 5G to a hotspot solution tethered to 4G would be a grave mistake for the whole industry

- It does not fully realize what 5G is capable of
- It sets up "5G hot spots" in direct competition with Wi-Fi

If Gbps hotspot with 140 dB link budget is the goal

- 60 GHz technology today can meet that requirement already
- If Gbps hotspots / small cells with 10 – 100 m range is the goal, that should do it (No need for 5G. Pack up and go home now!)

| **5G link budget needs to be 160 dB** | 5G | 60 GHz |
|---|---|---|
| EIRP (dBm) | 65.00 | 43.00 |
| **Path loss (dB)** | **160.00** | **140.00** |
| Received power (dBm) | -95.00 | -97.00 |
| Bandwidth (MHz) | 500 | 1760 |
| Thermal noise (dBm) | -87.01 | -81.54 |
| Noise Figure (dB) | 5.00 | 6.00 |
| SNR (dB) per Rx antenna element | -12.99 | -21.46 |
| Number of Rx antenna element | 16 | 16 |
| Rx antenna element gain (dB) | 6 | 6 |
| Rx antenna feed network loss (dB) | 2 | 3 |
| Total Rx antenna array gain (dB) | 16 | 15 |
| SNR after beamforming (dB) | 3.05 | -6.41 |
| Implementation loss (dB) | 3.00 | 3.00 |
| Number of MIMO streams | 1 | 1 |
| Spectral efficiency (bit/channel use) | 1.01 | 0.16 |
| System overhead | 40% | 40% |
| Duty cycle | 62.50% | 62.50% |
| **Throughput (Mbps)** | **189.11** | **103.18** |

# 5G Mobile Broadband Requirement – Range

**5G cells must achieve similar footprint as 4G in order to be commercially competitive**

- Wide-area coverage is the core differentiator that makes cellular networks that much more valuable than Wi-Fi networks
- 5G must achieve wide-area coverage with a significant upgrade of mobile broadband experience to be a commercially successfully evolution for the industry
- Site availability, acquisition, backhaul, and cost issues make it unrealistic to expect a significant increase of cell sites for 5G
- Same footprint of 5G as 4G allows reuse of existing cell sites and infrastructure to achieve wide-area coverage – a strong value proposition key to the initial success of 5G

| Environment | ISD Target (Typical) |
|---|---|
| Urban Micro | 200 m |
| Urban Macro | 500 m |
| Rural | 1732 m |

O2O and O2I are both important deployment scenarios that need to be evaluated

- Indoor coverage heavily depends on assumptions of building penetration loss, building location
- Business value of indoor and outdoor connectivity can be vastly different
- O2O and O2I can be either evaluated separately or together with a carefully chosen mix

A balanced approach towards coverage, user experience, and system capacity

- Evaluation criteria should include 5-percentile (cell-edge), 50-percentile (typical) user throughput, and overall cell throughput

# 5G Mobile Broadband Requirement – Power

**Same or similar output power level as 4G base stations and mobile stations must be maintained**

- 4G macro/micro base stations (40 – 49 dBm)
- 4G mobile devices (23 – 30 dBm)

The resulted peak EIRP will be higher than 4G due to massive antenna arrays

- 256-element patch antenna array in a 5G base station can achieve directivity ~ 30 dB
- 4-element antenna array in a 5G mobile station can achieve directivity ~ 12 dB (with a mobile station typically having multiple arrays to achieve further spatial diversity)

In the current FCC Notice of Proposed Rulemaking (NPRM) on mmWave frequencies

- Base station EIRP limit – 62 dBm per 100 MHz
- Mobile station EIRP limit – 43 dBm

# 5G Mobile Broadband Requirement – Size

**5G Base stations should, and can, be as small as a notebook PC**

- while achieving same or similar footprint as 4G macro and micro base stations

Notebook-sized 5G base station is technologically feasible

- Much smaller antenna arrays at mmWave frequencies
- Much higher integration of front end transceivers and baseband SoCs

Significant benefits in CAPEX/OPEX and cell density/capacity

- Increases site availability
- Reduces site acquisition cost
- Lowers the cost of high density small cell deployment
  - However, the expectation should still be realistic (*e.g.*, 2 – 3x, NOT 10x)

# 5G Mobile Broadband – The Sweet Spot

**Spectrum**
- 24 – 57 GHz (Phase I supports up to 40 GHz)

**System bandwidth**
- 100 – 1000 MHz

**Cell radii**
- 100 – 1000 m

**Link budget**
- 160 dB

**Data rate**
- 100 Mbps ~ 10 Gbps

**Cell/sector spectral efficiency**
- 5 – 10 bits

**Base station antenna array size**
- 64 – 256

**Base station output power**
- 36 – 46 dBm (63 – 73 dBm EIRP)

**Number of digital MIMO streams (Base Station)**
- 4 - 16

**Mobile station antenna array size**
- 16 – 64 (split into multiple sub-arrays to achieve 360-degree coverage)

**Mobile station output power**
- 23 – 30 dBm (36 – 43 dBm EIRP)

**Number of digital MIMO streams (Mobile Station)**
- 1 - 8

# TR 38.913 Text Proposals

- “Section 6.1.1 Deployment scenarios for eMBB

  Urban Micro, Urban Macro, and Rural deployment scenarios should be supported for eMBB, with the ISD for Urban Micro being 200 meters, the ISD for Urban Macro being 500 meters, and the ISD for Rural being 1732 meters.“
- “Section 7.1.1 Peak data rate

  Peak data rate of 20 Gbps should be supported.”
- “Section 7.1.2 Spectral efficiency at peak data rate

  The spectral efficiency at peak data rate should be no less than 40 bits.”
- “Section 7.1.3 Bandwidth

  System bandwidth from 100 megahertz to 1 gigahertz with 100 megahertz increment should be supported.”
- “Section 7.2.3 User experienced data rate

  User experienced data rate should be at least 100 Mbps .”
- “Section 7.2.5 Median user experienced data rate

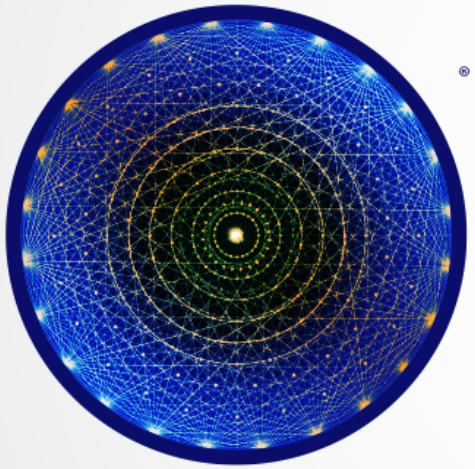
  Median user experienced data rate should be at least 1 Gbps .”
- “Section 10.1 Spectrum

  The following bands should be supported:

  - 27.5 – 28.35 GHz
  - 37.0 – 40 GHz
  - …”

# Summary

- 5G needs to provide *wide-area Gbps mobile* broadband experience at *similar deployment cost* and *cell density* as 4G
- 5G needs to provide up to 160 dB link budget with 100 m – 1 km cell radii in urban areas and >1 km cell radii in suburban and rural areas
- 5G base stations and mobile stations should maintain similar output power as 4G (with increased EIRP due to antenna arrays with large number of elements)
- 5G base stations should and can be as small as a notebook PC to facilitate small cell (100 m – 1 km cell radii) deployment with high density (2 – 3x higher than 4G)



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