Qualcomm’s 5G vision
Mobile is the largest technology platform in history

~7 billion connections, almost as many as people on earth\(^1\)

Evolving into Internet of Everything: cars, meters, sensors, health devices, etc.

More prevalent than electricity or running water in some regions

At the center of breakthrough experiences like 4K UHD video

\(^1\) ~7B connections (~3.5B subs) — GSMA Intelligence, Apr. '14.
Mobile has made a leap every ~10 years

1G
Analog voice
AMPS, NMT, TACS
1980s

2G
Digital voice
D-AMPS, GSM, IS-95 (CDMA)
1990s

3G
Mobile broadband
WCDMA/HSPA+, CDMA2000/EV-DO
2000s

4G
Faster and better MBB
LTE, LTE Advanced
2010s
Mobile surpassed fixed-line, then PC

Human communication

Era of mobile phones
Primary communication device

Era of Smartphones
Center of new experiences and services

2002
Surpassed fixed voice

2010
Surpassed fixed BB

2013
Surpassed PC

5G to meet needs beyond today’s trends
Mainly addressed by 3G/4G/Wi-Fi and its evolution

More video
Richer content like 4K Video
~2/3 of mobile traffic will be video by 2017³

More devices
Smartphones
~8B Cumulative smartphone shipments forecast between 2014-2018¹

More things
Connected
~25B Interconnected device forecast in 2020²

More data
Small cells
1,000x from ~2010 to the 2020’ies

Can we predict the world in 2025?

To maximize the opportunity, we need a user-centric approach—around human, thing, machine

- Communication
  - Also to control and discover
- Best effort data
  - Also ultra reliable and aware services
- Device as end-points
  - Also new ways of connecting everything
Scalability and adaptability

To connect everything, across an extreme variation of types of services and use cases

User-centric design

To scale for billions of connected things, provide new ways of connecting, and to improve cost and energy efficiency

Unified platform

Unifying platform for all spectrum, new deployment/business models, and a wide range of new services for the next decade
In parallel: driving 4G and 5G to their fullest potential

- Fully leverage 4G investments
- Improve cost and energy efficiency
- Enable a wide range of new services
- A unified, much more capable platform

LTE
- SON
- CoMP
- Carrier aggregation
- Device-to-device
- TDD/FDD
- Broadcast

LTE Advanced
- Unlicensed spectrum
- Massive MIMO
- MTC
- 256QAM
- Enhanced CA
- Lower latency

4G
- Dual connectivity
- SON+
- SIPTO

5G
- Further backwards-compatible enhancements

2010

~2020

2030

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Scalability and adaptability to connect everything
Support current and emerging services

- Extreme mobile broadband indoor/outdoor
- Smart homes/buildings/cities
- Sensing what’s around, autonomous vehicles
- Health care and emergency response services
- Critical infrastructure, protection, and control
- Remote control, process automation
- New form factors, wearables, and sensors
- Extreme mobile broadband indoor/outdoor
Support current and emerging services

Massive number of things
Connect everything

Proximal and aware services
New ways of interacting

Mobile broadband
Enhancing the foundation

Extreme mobile broadband indoor/outdoor

New form factors, wearables and sensors

Smart homes/buildings/cities

Sensing what’s around, autonomous vehicles

Health services and emergency response

Critical infrastructure, protection and control

Remote control, process automation

Mission-critical services
Failure is not an option
Support extreme variation in requirements

- Ultra-low cost
- Ultra-low energy
- Ultra-high reliability
- High security
- Flawless mobility
- Ultra-low latency
- Deep coverage
- Enhanced Mobile Broadband
- Deep awareness
- Mission Critical Services
- Massive Number of Things

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A user-centric design
User-centric

Bring connectivity, computing and content close user

Computing

Connectivity

Content/data
User-centric connectivity

Device is not just an end-point—integral part of the network
User-centric connectivity
Achieving truly edgeless connectivity with 5G

- Multi-hop to extend coverage
- Device-to-device discovery and communications
- Integrated access and backhaul, relays
User-centric computing—on devices, things
Continuing today’s trend, and more cognitive technologies

Expanded human abilities
Contextual personalization
Human-like interactions

Reasoning
such as learn and adapt

Actions
such as act intuitively

Perception
such as see and hear
And multiple enablers for uniform user experiences and more capacity

- Context and service awareness
- Full Self-Configuration
- Truly unplanned deployments
- Hyper dense deployments
- Coordinated Spatial Techniques
- Advanced Receivers
- Backhaul Coordination
- Interference Coordination
- Beam forming
- Massive Spatial Processing

And multiple enablers for uniform user experiences and more capacity
A **unified** connectivity platform for the next decade and beyond
Unified 5G design across spectrum types and bands

<table>
<thead>
<tr>
<th>Licensed Spectrum</th>
<th>Shared Licensed Spectrum</th>
<th>Unlicensed Spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleared spectrum</td>
<td>Complementary licensing</td>
<td>Multiple technologies</td>
</tr>
<tr>
<td>EXCLUSIVE USE</td>
<td>SHARED EXCLUSIVE USE</td>
<td>SHARED USE</td>
</tr>
</tbody>
</table>

- **Below 1 GHz**: longer range, massive number of things
- **Below 6 GHz**: mobile broadband, mission critical
- **Above 6 GHz including mmWave**: for both access and backhaul, shorter range
User-centric, flexible and scalable network

- **Virtualized network functions**
  Dynamically distributed based on mobility

- **Modular core network**
  Scale from wide area deployments to hotspot nodes

- **Flexible business models**
  Deployment, subscription, charging

- **Lower latency**
  Such as control and user plane closer to edge

- **Edge security**
  Design for less-trusted nodes

**Distributed Architecture**

- **Multi access to a single core network**
  And simultaneous connectivity

- **Reduced overall cost, reduced backhaul and lower energy**

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Simultaneous connectivity to leverage 4G investments

Small cell
- 5G above 6Ghz
- 5G below 6GHz
- 4G and Wi-Fi

5G/4G/3G/Wi-Fi multimode device

5G Carrier Aggregation

Simultaneous connectivity across 5G, 4G and Wi-Fi

Macro
- 5G below 6GHz
- 4G

5G coverage

4G coverage

1Thanks to integrated MAC across sub 6 GHz and above 6 GHz
Scalable from wide area to local area deployments

Wide area network

Local area network

Hotspot/residential

Operators

MVNOs  Enterprises  Consumers

Network sharing & hosting
A unified platform for expanded connectivity needs for the next decade and beyond

- Unknown new service
- Mission-critical services
- Proximal/aware services
- Massive # of things
- Mobile broadband

New services, unify all spectrum

Scalability across broader dimensions

Wide to local area deployments

New services & devices

Cost and power efficiency

Thanks to a user-centric, distributed design
Meeting new connectivity needs for the next decade

- Uniform fiber-like mobile broadband with deep awareness
- New services like mission critical remote surgery
- Connecting everything from simple sensors to complex robots
5G: not just a new generation, but a new kind of network

- **Enabling**
  - new services

- **Connecting**
  - new industries and devices

- **Empowering**
  - new user experiences
Questions? - Connect with Us

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http://www.slideshare.net/qualcommwireless evolution

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