5G Technology Elements for Future Internet of Things

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The future of Internet of Things

Future IOT requires new network capabilities to support massive number of devices, and efficient SW/HW platforms for both devices and networks.

Future IOT requires close partnership among many industries and ecosystems to offer integrated compute and communication capabilities.
IOT expectation gaps

Source Bain: Reflects n=37 interviews with tier 1 leaders in Smart Factory, Smart Building, Smart Fleet, Smart Grid Substation and Smart City Environmental Sensing domain
Enabling future IOT

Technologies

IOT requires end-to-end design considerations, from sensors to the cloud

Standards and regulations

Standards collaboration and regulatory compliance are essential
## 5G design goals

5G has to be designed as a system
Compute + communication becomes a necessity

<table>
<thead>
<tr>
<th></th>
<th>IoT</th>
<th>4G</th>
<th>mmWave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data rate</td>
<td>Can be very low</td>
<td>100s Mbps</td>
<td>1-10 Gbps</td>
</tr>
<tr>
<td>Latency</td>
<td>From 2 ms to hours</td>
<td>Moderate</td>
<td>2 ms</td>
</tr>
<tr>
<td>Battery life</td>
<td>Up to 10 years</td>
<td>Smart phone</td>
<td>Depends on app</td>
</tr>
<tr>
<td>Link budget</td>
<td>Penetration</td>
<td>Coverage</td>
<td>High data rate</td>
</tr>
<tr>
<td>Multiple access</td>
<td>Massive # of devices</td>
<td>Smart phones</td>
<td>Bursty/opportunistic</td>
</tr>
<tr>
<td>Network</td>
<td>Overlay</td>
<td>Hetnet</td>
<td>Hetnet/underlay</td>
</tr>
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5G is designed as a system where compute and communication become necessities.
Air interface for IOT

5G

Machine-Machine interaction
Latency 1s ms
Direct link or tactile Internet

4G

Human-Human Interaction
Latency 10s ms

Wearable underlay networks
Varying latency req.
Ad-hoc networks

Sensor Network
Latency often less an issue
Massive # of devices

Ultra-high data rate
High peak to average
Short range, opportunistic
Het-net carrier aggregation

Platform innovations enable applications/services innovations
Underlay networks for things and wearables

One big intelligent and information network
Compute, storage, networking

Many devices, types of devices, connections
Many moving underlay network clusters
Virtualization of device and access

- Future applications require intensified compute and communication but often smaller device form factor
- 5G high data rate + low latency radio links enable mobile device + access virtualization across the air interfaces
- 5G services are immersive. Sensing, intelligence and contents require edge cloud and device + access virtualization
- Breaking computing barrier through communication may transform consumers' relationship with network

5G device + access virtualization for scalability, versatility, energy efficiency
Future research areas

System design
- Compute and communications tradeoffs
- Device and access network architecture tradeoffs
- Underlay networks and connectivity design tradeoffs

User experience
- Privacy and security
- System manageability
- Subscriber ownership
The evolution towards a world of IOT