How will sidelink bring a new level of 5G versatility?

For diverse devices and services beyond automotive – smartphones, IoT, and more
Sidelink is a core topology of the 5G system design

Further extending the connected intelligent edge
Sidelink is a core topology of the 5G system design
Also known as direct communication or D2D (Device-to-Device)

Original 5G vision
Envisioned to be part of the 5G NR flexible framework with forward compatibility

Service coexistence
Multiplexing seamlessly with other 5G NR communication in time and frequency domain

New system values
Offering a wide range of benefits to complement network-to-device (i.e., Uu) communication

Technology foundation
Building on the learnings of LTE Direct (Rel-12+) technology, its evolution, and deployments
To efficiently scale, AI processing is expanding toward the edge.

Connected intelligent edge

Central cloud | Edge cloud | On-device

Privacy | Reliability | Low latency | Efficient use of network bandwidth

Qualcomm is leading the realization of the Connected Intelligent Edge

Convergence of:
- Wireless connectivity
- Efficient computing
- Distributed AI

Unleashing massive amount of data to fuel our digital future
Sidelink can further extend the connected intelligent edge

Extending beyond network-to-device communications to connect more devices closer to the end-users
Sidelink is being designed to meet diverse 5G system requirements.

Complementing network-to-device communications, starting in 3GPP Release 16.

**Wide range of devices**
- Smartphones, wearables, XR, cars, robots, sensors, IoT, etc.

**Diverse services**
- Data offload, peer discovery, public safety, automotive, etc.

**All spectrum**
- Sub-7 GHz, mmWave, licensed, unlicensed, shared, etc.

**Broad deployments**
- Public network, private networks, mesh, ad-hoc, etc.

**Multiple communication modes**
- Broadcast, multicast, unicast messaging
Sidelink can operate in different spectrum configurations

**Dedicated**
Applications-specific spectrum allocated for specialized use cases

E.g., 700 MHz (B14) has been allocated for public safety

**In-band licensed**
Network dynamically allocating spectrum for Uu and PC5

E.g., wide-area bands such as 3.5 GHz can be used for device access and device relay

**Unlicensed**
Contention-based access suitable for best-effort services

E.g., 5 GHz, 60 GHz unlicensed band can be used for data offload in private networks

Flexibility to support a wide range of devices, bandwidth requirement, quality of service, and deployment scenarios
Two possible approaches to sidelink network management

1. **Centralized control sidelink (NCIS)**
   - Resources managed by mobile operators
   - Requires wide-area network coverage and a SIM
   - Timing derived from network

2. **Dynamic and self-organizing sidelink**
   - Resources managed dynamically by connected devices
   - Does not require network coverage or a SIM
   - Timing derived from GNSS or synchronized to one node
5G sidelink creates new business opportunities for the entire ecosystem

Mobile operators
Differentiated services that can bring new revenue streams (e.g., ubiquitous asset tracking)

Private network operators
More flexible capacity and performance in e.g., industrial and enterprise settings

Governments
More secure, robust, self-reliant public safety and low-visibility tactical communication

End users
New and enhanced user experiences such as lower latency and more efficient data usage

Infrastructure vendors
New deployments targeting expanded applications such as roadside units (RSUs)

App developers
New classes of service that can bring new monetization models and opportunities

Device manufacturers
More efficient design implementations and new device types (e.g., device relays)

New stakeholders...
Future applications building on sidelink can broaden ecosystem, open door to new entrants...
Sidelink delivers a broad set of system benefits

Supporting diverse 5G devices, use cases, and deployments
**Sidelink** delivers a broad set of benefits for the overall 5G system.

<table>
<thead>
<tr>
<th>Network benefits</th>
<th>Device/service benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expanded coverage</strong></td>
<td><strong>Extended battery life</strong></td>
</tr>
<tr>
<td>Extending coverage with device relays for many 5G use cases (e.g., IoT)</td>
<td>Supporting low power consumption capabilities by reducing output power in devices</td>
</tr>
<tr>
<td><strong>Increased capacity</strong></td>
<td><strong>Lowered Latency</strong></td>
</tr>
<tr>
<td>Providing efficient data offload from wide-area network to meet growing capacity needs</td>
<td>Providing supplementary connectivity in the edge to further enable low-latency communications</td>
</tr>
<tr>
<td><strong>Deployment flexibility</strong></td>
<td><strong>Improved Reliability</strong></td>
</tr>
<tr>
<td>Enabling sidelink in infrastructure (i.e., relays) can greatly improve deployment efficiency</td>
<td>Establishing an additional link to meet real-time communication and mission-critical demands</td>
</tr>
</tbody>
</table>
Sidelink can enable new benefits for a wide range of new use cases

**Automotive safety and beyond**
Allowing vehicles, devices, and infrastructures to connect amongst themselves, enhancing overall performance and efficiency

**Public safety and tactical communication**
Enhancing existing LTE-based system to provide services over 5G NR, including one-to-many device broadcast

**Data offload**
Providing high-capacity/throughput to devices in proximity, for use cases such as gaming, and data backup

**Wearable connectivity**
Creating a personal area network to connect the smartphone directly to wearables such as smart watches, XR, and more

**Range extension**
Extending coverage via direct communication (e.g., massive IoT devices such as meters) with multi-hop mesh relays

**Industrial IoT capacity**
Expanding system capacity with direct communications between automation controllers (i.e., PLCs) and sensors/actuators

**Expanded positioning**
Improving positioning accuracy for all situations including challenging scenarios such as dense urban areas and tunnels
Connecting emergency services in challenging areas for enhanced public safety

- More reliable, secure, and interoperable networks
- Readily available capacity and coverage
- Enhanced awareness, safety, and coordination for first responders in emergencies
- Innovations leveraging large established device and apps ecosystem
- For firefighters, police, EMT, and others
Sidelink can provide efficient data offload for additional capacity and improved experience.
Efficiently connect new generation of wearable devices with sidelink
Extending service coverage for wide-area 5G use cases such as multi-hop IoT mesh

Utilizing sidelink communication to extend network coverage for 5G NR-Light IoT services, enables cost-efficient connectivity for multiple devices through a single wide-area connection.
Sidelink can greatly expand system capacity to enable large-scale industrial IoT deployments.
Sidelink can complement existing location technologies to provide more robust and precise positioning.
Sidelink continues to evolve in 5G Advanced and beyond

Standardized and commercialized today
The sidelink technology foundation began more than a decade ago

**Advanced Research**
Our foundational system research for sidelink communications began around 2010

**Release 12 / 13**
LTE device-to-device (D2D) support first adopted in 3GPP standards, aimed to provide proximity services and public safety applications

**Release 14 / 15**
D2D enhancements and expansion to automotive that brings improved road safety

**Release 16**
Establishing the 5G technical foundation for broader applications and evolution to support advanced automotive use cases

**Release 17**
Expansion of 5G sidelink beyond automotive, including device relays that can efficiently extend network coverage

**Release 18+**
5G Advanced evolution of sidelink that brings improved performance, efficiency and further use case expansion

Continued sidelink technology evolution into 5G Advanced and beyond
A rich technology history for sidelink communication

Began with LTE Advanced and continues into 5G evolution and beyond

**Technical foundation for sidelink or D2D**
- D2D discovery and communications (1000s of devices/services in ~500m)
- One-to-many communications (in- and out-of-coverage)

**Enhancements focusing on public safety**
- Flexible discovery such as private and inter-frequency
- Device-to-network relays

**Expanding into automotive and broader use cases**
- Sidelink for automotive
- Additional D2D communication capabilities
5G NR Sidelink
Release 16

Technical foundation applicable for broader sidelink use cases

5G support for sidelink started in 3GPP Release 16

5G sidelink brings many improvements over previous direct communications design

Lower latency
Sidelink supports a flexible sub-carrier spacing (i.e., 15, 30, 60, 120 kHz) enabling shorter slots delivery and lower transmission latency

Wider bandwidth
Sidelink supports a 2x2 MIMO scheme enabling a higher data rate for direct communications

Expanded applications
Sidelink supports various cast types such as broadcast, multicast/groupcast, and unicast

Improved reliability
HARQ\(^1\) procedure is introduced on the sidelink interface providing retransmissions based on the receiver’s feedback

Flow-based QoS framework
Full-fledged mechanism for sidelink provides the means to meet QoS requirements of direct communications for public safety services

1 Hybrid Automatic Receive Request
Release 17 expands sidelink to new use cases

Sidelink Enhancements

Release 17

For public safety, IoT, commercial use cases and beyond

Updated sidelink evaluation methodology
Reusing existing evaluation assumption and performance metric\(^1\), based on feedback from car manufacturers

Improved resource allocation
Reducing device latency, power consumption, and improving reliability (e.g., half duplex, collision detection indication, control forwarding, inter-device coordination)

Power saving enhancements
Defining sidelink DRX for broadcast, groupcast, unicast, and power-efficient resource selection for devices

New sidelink frequency bands
Ensuring sidelink and network communication coexistence in the same and adjacent channels in licensed spectrum

Geographic confinement
Limiting sidelink operations to be within a predetermined area for a given frequency range in non-ITS\(^2\) bands

Sidelink relay
L2/L3 device-to-network relay for coverage extension. Follow-up work item for device-to-device relay in scope for Release 18

Source: RP-202846 (NR Sidelink enhancement); RP-212601 (NR Sidelink Relay); 1TR 36.843 and/or TR 38.840; 2 Intelligent Transport System
Expanding foundational 5G Sidelink capabilities in Release 18

For use cases that require increased data rate over sidelink

Unlicensed spectrum
Supporting optimized sidelink operations over unlicensed bands such as 5 GHz

Multi-beam operation
Supporting sidelink beam management by reusing and enhancing existing framework and concepts

Sidelink carrier aggregation
Supporting enhanced use cases that can benefit from wider bandwidths

Source: RP-213678 (Sidelink enhancements)
Further extending 5G Sidelink relay capabilities in Release 18

**Device-to-device relay**

Support for device-to-device relay is essential for the overall sidelink coverage extension use case.

- Support for L2/L3 device-to-device relay
- Allowing single-hop operation with forward compatibility for more hops

**Device-to-device relay**

Service continuity enhancements in device-to-network relay are necessary to cover the mobility scenarios not supported in Release 17.

- Supporting inter-gNB path switching and service continuity
- Enhancing reliability and throughput with multi-path connectivity
- Completing features such as DRX^2 for sidelink relay operations
Layer 3 (L3) Relay

- Cloud Apps
- 5G Core
- 5G RAN
- Relay device
- Tethered devices

No 5G connection to the tethered device
Application-level quality-of-service (QoS) supported on the tethered device

L3 Relay with N3IWF

- Cloud Apps
- 5G Core
- 5G RAN
- Relay device
- Tethered devices

5G core network connection is extended to the tethered device
Some 5G performance benefits can be realized on the tethered device

Layer 2 Relay

- Cloud Apps
- 5G Core
- 5G RAN
- Relay device
- Tethered devices

5G core and radio access network connection is extended to the tethered device
Full 5G performance optimization can be realized on the tethered device

Device disaggregation technology evolution
Proposed to 3GPP Release 18 – extending direct connection user experience over tethered device connection

1 Non-3GPP Interworking Function
Advancing 5G positioning with sidelink and RF sensing

3GPP Release 18 and beyond
Strengthening security for critical 5G sidelink use cases

5G Sidelink Security Requirements

- Provisioning of security credentials to support various use cases
- Support of flexible deployment options across multiple operators
- Secure relaying operations, including device-to-network and device-to-device relay scenarios

Areas of 5G Sidelink Security Enhancements

Rel-16/17
- Security provisioning at scale and on-demand
- Secure group member and service discovery
- Flexible configuration of security and privacy per application
- Unicast, multicast, and broadcast security
- Support of device-to-network relay

5G Advanced
- Support of device-to-device relay, i.e., multi-hop discovery and unicast communication
- Support of emergency services
- Secure ranging and sidelink positioning at scale

Others
- Device authentication and/or attestation based on hardware root-of-trust as proof of integrity
- Physical-layer resource randomization for LPI/LPD\(^1\) and jamming resilience
- Physical-layer encryption of control information and reference signals for ultra-secure communication, e.g., military use cases

\(^1\) Low Probability of Intercept/Detect
Pushing the technology boundary for sidelink in 5G Advanced

Foundational technology that will expand to many applications
Qualcomm is leading the way

Driving future 5G sidelink technologies and new use cases
Qualcomm drove direct communications into global cellular standards

LTE Direct is part of 3GPP Release 12

Initial D2D efforts led to many new use cases

- Public safety
- Coverage extension
- Automotive safety

3GPP RAN1 #72
Malta Feb 2013

MWC 2013
Qualcomm pioneered device-to-device communication and showcased LTE-Direct proximity services over-the-air demos
C-V2X has been commercialized based on sidelink

C-V2X
Introduced in 3GPP Release14

Qualcomm® 9150 C-V2X chipset commercialized starting 2018

Integration of C-V2X into the Snapdragon® Auto Platforms

C-V2X already deployed commercially in China; U.S. deployment in progress

Broad industry support with 3GPP, 5GAA, GSMA, SAE, ITE, NEMA, IEEE, and 5G Americas
Our innovations expand the foundation of 5G

Foundational Qualcomm innovations lead 3GPP Releases 15, 16 and 17
Our Release 16 inventions expand the 5G NR foundation

**Unlicensed spectrum**
Shared spectrum, LAA, standalone operation
For improved capacity and new use cases

**Advanced power saving & mobility**
WUS, faster CA, full-power UL, dual connectivity
For better device performance and coverage

**High-precision positioning**
OTDOA, PRS, UE-based positioning, multi-cell RTT
For more accurate indoor and outdoor positioning

**Sidelink**
Direct communication between devices
For broader use cases, e.g., smartphones, IoT

**Mission-critical design**
Multi-TRP, CoMP, service multiplexing & preemption
For meeting ultra-high reliability of up to 99.9999%

**New deployment models**
Non-public network, TSN, IAB, in-band eMTC/NB-IoT
For new deployments such as IIoT & enterprise

**Early R&D investments**
Cutting-edge prototypes
Fundamental contributions to 3GPP
## Qualcomm innovation leadership in 3GPP Release 17

### mmWave expansion
- **For more capacity, new use cases and deployments**
- Licensed and unlicensed spectrum operations in 52.6-71 GHz

### Reduced capability devices (NR-Light)
- **For expanded IoT:** wearables, sensors, surveillance cameras
- Lower complexity devices with 20 / 100 MHz max bandwidth in sub-7 / mmWave with 1 or 2 Rx antennas

### Device enhancements
- **For enhanced device user experience and performance**
- More antennas, higher throughput, battery life, mobility, coverage, positioning accuracy, multi-SIM

### Non-terrestrial networks (NTN)
- **For ubiquitous coverage and expanded use cases**
- Satellite communications for mobile devices and IoT, leveraging 5G NR framework

### Topology expansion
- **For more efficient deployments, public safety, and others**
- Enhanced IAB, relay, broader use cases for smartphones and beyond

---

### Early R&D investments

### Cutting-edge prototypes

### Fundamental contributions to 3GPP
Demonstrating 5G sidelink technologies delivering new capabilities and benefits for diverse use cases

Industrial IoT capacity expansion
Release 18+ | Over-the-air testing
Leveraging direct communication, with dynamic path switching, between devices and PLC (Programmable Logic Controller) over 5G sidelink to expand system capacity

Multi-hop mesh coverage extension
Release 18+ | System Simulation | Over-the-air testing
Utilizing sidelink communication to extend coverage for 5G NR-Light IoT, enabling cost-efficient connectivity for multiple devices through a single wide-area connection
5G sidelink facilitates direct communication, with dynamic path switching, between devices and PLC, delivering expanded system capacity.
5G sidelink can extend NR-Light coverage, enabling cost-efficient IoT connectivity for multiple devices through a single wide-area connection.
Sidelink is a core topology of the 5G system design that can further extend the Connected Intelligent Edge.

Sidelink delivers a broad set of system benefits to diverse 5G devices, use cases, and deployments.

Sidelink is commercialized today and continues to evolve in the 5G era and beyond.

Bringing next-level 5G versatility with sidelink

To enable new system efficiencies and vertical use cases.

Qualcomm is leading the way driving future 5G sidelink technology evolution and into new use cases.
Thank you