The essential role of technology standards

Driving interoperability, ecosystem development, and future innovation
The virtuous circle of technology innovation

Early R&D and technology inventions essential to leading ecosystem forward

**Commercialization**
Engage with global ecosystems to deploy new features with standards-compliant infrastructure and devices

**Trials**
Collaborate on field trials that track standards development and drive ecosystem towards rapid commercialization

**Standardization**
Lead ecosystem towards new projects and drive system design through technology standardization process

**Vision**
Identify a problem or need; establish requirements

**Invention**
Invent new technologies and end-to-end system architecture

**Proof-of-concept**
Deliver end-to-end prototypes and impactful demonstrations
The value of standards

Why leadership in standards is important
Standards create significant value for the wireless ecosystem

Communications industry is based on technology standards

- **Ensuring system interoperability**: while enabling product differentiation and spurring transparent industry competition
- **Meeting regulatory requirements**: test and certification procedures are developed to aid in meeting obligations
- **Reducing market risk**: especially in areas of large investments (e.g., 5G infra)
- **Creating new markets**: and expanding addressable markets of existing products and technology
- **Lowering cost**: through economies of scale and multi-vendor sourcing
- **Improving technology**: multiple companies participate, collaborate, compete – best prevails

Standards create significant value for the wireless ecosystem
Industry leaders contribute to technology standards

Better, quicker-to-market products
Communications standards are very complex in nature; thus, leadership in designing technology standards goes hand in hand with leadership in product development

Valuable intellectual property (IP)
When inventions are contributed to standards, they become available to everyone in the ecosystem; therefore, it is important to have a solid IP framework that adequately incentivizes inventors to contribute their innovation to standards bodies

Driving technology forward with new functionalities and efficiencies, fostering healthy market growth that benefits the broader ecosystem
What are the ingredients of a successful standard?

- Addresses the global market need of solving vital technology problems
- Defines great technologies with superior performance and efficiency
- Allows a wide ecosystem to address attractive business opportunities
- Garners broad ecosystem adoption and implementation
- Drives marketing and regulation guiding activities
- Provides the proper tools (e.g., testing, certification) for mass market productization
- We have the deep technical expertise, broad ecosystem reach, and decades of global experience to drive successful standards
We participate in ~200 global standards and industry organizations.
Recent events leading to new standardization challenges

COVID-19 preventing in-person meetings in the foreseeable future

Virtual meetings can be harder to manage and less efficient for consensus driven work

Global trade tension\(^1\) preventing participation of key standards members

Interim Final Rule in June 2020 partially solved some issues but needs to be further enhanced

\(^1\) For example, companies put on the U.S. Bureau of Industry and Security (BIS) Entity List

We’re doing what’s right to move standards forward
Standards in mobile devices

Complex systems that require global interoperability

Also broadly applicable across device categories and industries
Many standardized components and interfaces in a smartphone

**Cellular connectivity**
- 3GPP, ATIS, TIA, ETSI, TTA, TTC, ETRI, ARIB, CCSA, TSDSI, GCF, PTCRB, FCC, GSMA, GSA, CCF, RED, Future Forum, 5G Forum, CTIA

**WLAN & WPAN connectivity**
- IEEE, WFA, WBA, WAPI Alliance, Bluetooth SIG, NFC forum

**Emergency & location services**
- Galileo, 3GPP, ATIS, CCSA, CEN CENELEC, CSRIC, ETSI, GUTMA, OMA

**Security and local content protection**
- ETSI-SCP, GlobalPlatform, Eurosmart, JHAS-SOGIS, TCA, GSMA, JEDEC, EMVCo, TCG

**Multimedia services**
- MPEG, 3GPP, Khronos Group, INCITS, DASH-IF, DVB, CTA WAVE, ATSC, SMPTE, AIS, IVAS

**Semiconductor manufacturing**
- Si2, Accellera, UEFI, GSA, FlexTech, LTAB, CSIA

**Wired connectivity**
- MIPI Alliance, JEDEC, NVMe, PCI-SIG, USB-IF, DMTF, VESA, UHD Alliance, HDMI, RISC-V, xHCI

**AI processor**
- MLPerf/ML-Commons, FIDO, SAE, Khronos, MPEG, NIST, ORAN-AI, ISO/IEC SC42

And many others…
Standardized technology across components and interfaces in automotive
Cellular standards

The heart of the mobile ecosystem – leading standards development and the ecosystem expansion
Cellular has revolutionized the way we communicate

From voice only to a plethora of new services that our lives depend on today (e.g., smartphone)

Source: Ericsson Mobility Report, November, 2019
3GPP drives global cellular standards
2G, 3G, 4G and 5G

- 22 Years driving cellular tech evolution
- 14 Major releases
- >1.4K Tech specifications*
- 100,000’s Technical contributions
- 3rd Generation Partnership Project
- 700+ Member companies
- ~20 Technical groups
- 6-8 Working group meetings per year
- 2,000+ Man years in cumulative meeting time*

* Source: 3GPP Mobile Competence Centre (3GPP Support Team) Summary Report from RAN#86 (RP-192371); Including 3G/4G/5G Release 9/4/5/6/7/8/9/10/11/12/13/14/15/16

Member-driven organization
Relies on R&D and tech inventions from members, e.g., ‘contributions’

Collaborative engineering effort
Consensus-based, tech-driven effort across 100s of entities

Distributed work-flow
Scale/complexity requires division of work into smaller, specialized pieces
This large scope requires division of work into smaller, specialized working groups in 3GPP

3GPP defines complete end-to-end system specifications

Radio Access Network (RAN)
Implements radio access technology, e.g., 5G NR, LTE, managing radio link to connect UEs to networks

Core Network (CN)
Manages macro-mobility, sessions, quality of service, policies, security, and routes traffic to outside world, e.g., Internet, or local intranet

User Equipment (UEs)
Devices, e.g., smartphones and all types of IoT devices that connect to services via radio access technology

Services
Framework for service delivery architecture, multimedia, billing, charging, etc.

Test Requirements
Defines performance and conformance test procedures to ensure interoperability used for certification (e.g., GCF)
3GPP is a collaborative, system-engineering effort
Analogous to other large-scale engineering efforts

1. Early R&D and project proposal to management
2. Break project into specialized areas, e.g., jet engine
3. Feasibility study and explore different technical solutions
4. Develop solution(s) based on agreed work plan

3GPP projects are similar to other complex system-engineering effort, e.g., designing an airplane. 3GPP develops technical specifications for different parts of the system (vs. jet engines, wings, …), is constrained by meeting time (vs. OPEX) and is a collaborative, consensus-based effort across 100s of different entities with diverse interests/incentives (vs. collaboration of teams and suppliers in a single company).
A typical workflow in 3GPP

1. Vision and concept
2. Project proposal
3. Feasibility ‘Study Item’
4. Development ‘Work Item(s)’
5. Commercial deployments

Outside 3GPP
Individual 3GPP members

Concept contribution(s)

Early R&D

Inside 3GPP
Ongoing, iterative member R&D that tracks 3GPP development

Technical contributions

Tech report tracking decisions and agreements

Approval

Product development

Tech specs

Change requests (corrections)
Some assert 3GPP leadership based on # of contributions

<table>
<thead>
<tr>
<th>Analogy</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analogous to asserting leadership in sports on the basis of time-of-possession</td>
<td>Analogous to assessing the impact of an author by counting the # pages written</td>
</tr>
</tbody>
</table>
Qualcomm has led the evolution and expansion of LTE
Delivering fundamental systems-level inventions that are essential to 5G

- Carrier aggregation (FDD, TDD, FDD+TDD)
- CoMP
- Fast link adaptation
- OFDMA, SC-FDMA
- VoLTE
- Handover procedure
- Advanced MIMO technologies, e.g. UL MIMO
- Hybrid ARQ
- LTE IoT (eMTC, NB-IoT)
- LTE in Unlicensed (LAA/eLAA)
- HetNets with Small Cells and Interference Management
- Positioning
- Broadcast (eMBMS, enTV)
- MulteFire
- Security
- LTE Direct and C-V2X

Leading in 5G requires 4G LTE Leadership
Our wireless inventions are leading the 5G evolution.
Virtual Central Unit
Control and user plane separation

Distributed Unit

Radio Unit

Designed for unprecedented flexibility and cost-effective network deployments

CU: Central unit; DU: Distributed unit; MAC: Medium access control; PDCP: Packet data convergence protocol; PHY: Physical layer; RF: Radio frequency; RLC: Radio link control; RRC: Radio resource control; SDAP: Service data adaptation protocol

Access point with scheduler; allows for interworking with third party CU

Remote radio head w/ centralized baseband

Remote radio head + PHY with centralized baseband

Option 1, Option 2, Option 6, Option 7, Option 8
Wi-Fi Standards
Driving the technology evolution of wireless local area networking
Wi-Fi has revolutionized the way we access the internet
Cutting-the-wire for a wide range of devices—PCs, tablets, TVs, smartphones, etc...
Wi-Fi complements cellular connectivity for local broadband access

- Utilizes unlicensed spectrum (e.g., 2.4/5/6/60 GHz)
- Focuses on indoor use cases
- For human and machine communications (i.e., IoT)
- Supports fixed and mobile devices
Evolving networks from speed to capacity
Core technology evolution and Qualcomm Technologies leadership

The first 10 Billion
Enabling mobility
- Speed #s prioritized
- Increased bandwidth
- Introduced modulation schemes
- Introduced MIMO

The next 20 Billion
Connecting everything
- Network efficiency
- Usable performance at device
- Value when AP/Clients reach critical mass
- Scheduled access
- MU-MIMO / OFDMA

Wi-Fi

<table>
<thead>
<tr>
<th>Year</th>
<th>Standard</th>
<th>Frequency</th>
<th>Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>802.11</td>
<td>2.4 GHz</td>
<td>20 MHz</td>
</tr>
<tr>
<td>1999</td>
<td>11a/b</td>
<td>2.4 GHz</td>
<td>20 MHz</td>
</tr>
<tr>
<td>2003</td>
<td>11g</td>
<td>2.4 GHz / 5 GHz</td>
<td>Up to 4x4 MIMO</td>
</tr>
<tr>
<td>2007</td>
<td>11n</td>
<td>2.4 GHz / 5 GHz</td>
<td>Up to 8x8 MIMO</td>
</tr>
<tr>
<td>2013</td>
<td>11ac (w1)</td>
<td>2.4 GHz / 5 GHz</td>
<td>256 QAM</td>
</tr>
<tr>
<td>2015</td>
<td>11ac</td>
<td>Wi-Fi 5</td>
<td>8x8 MIMO</td>
</tr>
<tr>
<td>2018/19</td>
<td>11ax</td>
<td>Wi-Fi 6</td>
<td>8x8 MIMO</td>
</tr>
</tbody>
</table>

Modulation Schemes:
- OFDM
- 20 MHz
- Up to 4x4 MIMO
- 40 MHz
- 2.4 / 5 GHz
- Up to 8x8 MIMO
- 80 MHz
- 5 GHz only
- 256 QAM
- DL MU-MIMO
- 5GHz only
- 8x8 MIMO
- OFDMA
- Scheduled Access
- 2.4 / 5 GHz
- 1024 QAM
IEEE 802.11 Working Groups

- Develops and maintains backward compatible global MAC and PHY standards
- Defines spectrum use for Wi-Fi: 2.4 GHz, 5 GHz, 6 GHz, 60 GHz, and sub-1 GHz unlicensed bands
- Releases key MAC and PHY performance upgrades with 4-6 year cadence

Wi-Fi Alliance (WFA)

- Develops test plans, manages interoperability test programs, and organizes industry plug fests
- Develops industry specifications complementary to IEEE standards
- Conducts regulatory advocacy for Wi-Fi technologies
- Drives Wi-Fi technology marketing activities

Symbiotic relationship since 1999

Industry standards

Feedback on standards and market requirements
IEEE 802.11 Working Groups

- Actively drives Wi-Fi technology standardization process
- Holds key leadership positions in working/task groups, e.g., 802.11 Vice Chair, 802.11be Chair, etc.
- Leads in quality contributions to Wi-Fi standards (e.g., 802.11ax)

Wi-Fi Alliance (WFA)

- Consistently selected to be part of industry interoperability testbeds
- Holds key leadership positions on the Board of Directors (since 2008) and WFA task groups
- Received “Wi-Fi Alliance 2020 Industry Impact Award” and “Outstanding Leadership and Contribution” awards for sponsor members in multiple years

We are committed in pushing standardized Wi-Fi technology forward
A rich history of leading key Wi-Fi innovations

Advanced R&D | Standardization | Successful commercialization

### 802.11g
Drove OFDM into the 802.11g standard
Implemented OFDM in 1st commercial CMOS 5GHz product, then rapidly ported to 2.4 GHz
Enabled successful proliferation of 802.11g that greatly expanded the Wi-Fi ecosystem

### Wi-Fi Mesh
Pioneered multi access point (AP) technology
Led contributions to the Wi-Fi EasyMesh industry specification

### Wi-Fi 5: 802.11ac
Drove MU-MIMO – the foundational technology – into the 802.11ac standard
Proved to the ecosystem on the viability and value of MU-MIMO for Wi-Fi systems

### Wi-Fi 6: 802.11ax
Drove key UL OFDMA and UL MU-MIMO designs into the 802.11ax standards
Developed synchronized AP scheduling, trigger-based OFDMA and MU-MIMO

### Wi-Fi 4: 802.11n
MIMO-OFDM (spatial multiplexing) and transmit beamforming
Implemented MIMO-OFDM system architecture for mass market products (e.g., PCs, routers)
Drove the success of "pre-standard" MIMO products

### 802.11ad / ay
Pioneered mmWave beam forming & antenna designs
Delivered the highest performing mmWave implementation, proving the viability of mmWave
Drove mmWave into the 802.11ad and brought wider bandwidths via channel bonding in 802.11ay

### 802.11ah
Drove key technologies enabling extended range, small battery operation and low-power for Wi-Fi operating in sub-1 GHz
Facilitated opening of spectrum for 802.11ah sensors in Europe

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1 Based on 802.11a; 2 Including Airgo, Atheros, and Wilocity

Nominal work on Wi-Fi 7 / 802.11be is just starting

Continued leadership in IEEE and WFA
Our historical Wi-Fi pedigree

- First MIMO chip
- 1st Mobile Wi-Fi solution
- 500M Wi-Fi chipsets shipped
- 1st Wi-Fi attach to Qualcomm Snapdragon™
- 1st 11ad chipset
- 1st 2x2 MU-MIMO mobile platform
- 1st 11ay products
- Wi-Fi SON
- Mesh Voice
- 1st Wi-Fi Mesh Networks
- 1st Wi-Fi 5 products
- Wi-Fi 6 network
- 1st Mobile solution
- 1st Wi-Fi 6E products

Standardization timeline:

- 11n
- Wi-Fi 4
- Wi-Fi 5
- Wi-Fi 6

Acquisitions
Product milestones

Qualcomm Snapdragon is a product of Qualcomm Technologies, Inc. and/or its subsidiaries.
Bluetooth Standards

Connecting wireless personal area networks
Bluetooth supports broad use cases across a wide range of industries.

- Audio streaming
- Data transfer
- Location services
- Device network

Source: Bluetooth SIG Market Update 2020
Driving the technology evolution and commercial success

Technology standardization

~15 promoter/associate members actively contributing to Core WG meetings to evolve Bluetooth specifications

Product qualification

World-class programs that drive product interoperability, and give access to technology and trademark licensing

Brand promotion

Campaigns to increase the awareness, understanding, and adoption of Bluetooth technology

Source: Bluetooth SIG Market Update 2020;
1 Audio/Telephony/Auto, Automation, Core Specification, Direction Finding, Discovery of Things, Easy Pairing, Generic Audio, Hearing Aid, HID, Internet, Medical Devices, Mesh, PUID, Sports and Fitness
2 Based on 6 months attendance records, analysis done in June 2020
Leading the way in Bluetooth SIG

Working Group/committee leadership and participation

Current working groups

- Core Specification (CSWG) – Chair
- Generic Audio (GAWG) – Chair
- Bluetooth Test and Interoperability (BTI) – Chair
- Automotive, Telephony, Audio (ATA)
- Mesh

Current committees

- Bluetooth Architecture Review Board (BARB)
- Bluetooth Qualification Review Board (BQRB)
- Bluetooth (Qualification) Technical Advisory Board (BTAB)

Past leadership positions

- **Board member:** 2012-2014 (CSR), 2014-2016 (Qualcomm)
- **Chairs or vice chairs:** BARB, BQRB, Regulatory, ATA, Automation, Mesh, Internet, HID, HCI, Radio Improvements
- **Contributing member:** Regulatory, Automation, Direction Finding, HID, Internet, Medical Devices, PUlID, Sports and Fitness, HCI, Radio Improvements

Key recognitions for our leadership role

- **Awarded “Working Group and Committee Chair of the Year” in 2010, 2018, 2019**
- **Awarded “Bluetooth Core Specification Team Award” in 2014, 2016**
- **Inducted to “Bluetooth Hall of Fame” in 2017 (x2), 2010, 2011**
A rich history of leading key Bluetooth innovations

Advanced R&D | Standardization | Successful commercialization

- Bluetooth 1.2: Adaptive frequency hopping
- Bluetooth 2.0: Enhanced data rate design (EDR)
- Bluetooth 2.1: Secure pairing/connection
- Bluetooth 2.0: Enhanced data rate design (EDR)
- Bluetooth 4.1: Dual mode devices
- Bluetooth 4.0: Low energy (LE) design
  - Attribute protocol (ATT)
  - Generic attribute profile (GATT)
- Mesh networking: Mesh design
- Bluetooth 5.2: Enhanced Attribute Protocol
- Bluetooth 4.1: Dual mode devices
- Bluetooth 5.0: Long range PHY
  - Advertising extensions
- Bluetooth 5.1: Location services (AoA/AoD)

Also actively involved in creation/revisions of various Bluetooth SIG processes (e.g., Bluetooth Specification Development Process, Qualification Process)

1 As part of Mesh Networking specifications v1.0 first adopted on July 13, 2017; 2 Angle of Arrival/Departure
Our legacy of Bluetooth leadership

Key product milestones

- First single-chip Bluetooth controller
- First Bluetooth controllers qualified for new releases
- First Bluetooth mesh product

MSM is a product of Qualcomm Technologies, Inc. and/or its subsidiaries.

Standard timeline

<table>
<thead>
<tr>
<th>BT 1</th>
<th>BT 2</th>
<th>BT 3</th>
<th>BT 4</th>
<th>BT 5</th>
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<tr>
<td>2000</td>
<td>2001</td>
<td>2002</td>
<td>2003</td>
<td>2004</td>
</tr>
<tr>
<td>1st Bluetooth 1.1 controller</td>
<td>1st MSM modem with integrated Bluetooth 1.1 support</td>
<td>Bluetooth 2.0 + EDR controller qualified</td>
<td>1st Bluetooth 4.1 dual mode device</td>
<td>1st Bluetooth 5.0 controller</td>
</tr>
<tr>
<td>2005</td>
<td>2006</td>
<td>2007</td>
<td>2008</td>
<td>2009</td>
</tr>
<tr>
<td>Bluetooth 1.2 controller qualified</td>
<td>Bluetooth 2.1 + EDR controller qualified</td>
<td>Bluetooth 3.0 controller and host subsystem stacks</td>
<td>1st Bluetooth 4.2 dual mode device</td>
<td>Bluetooth 5.1 + mesh device qualified</td>
</tr>
<tr>
<td>2010</td>
<td>2011</td>
<td>2012</td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>1st MSM modem with integrated Bluetooth 4.2 support</td>
<td>Bluetooth 4.0 low-energy controller chip</td>
<td>1st Bluetooth mesh product</td>
<td>1st Bluetooth 5.2 with isochronous Channel feature</td>
<td></td>
</tr>
</tbody>
</table>

2. Acquisitions
3. Product milestones
Video Coding Standards

Powering the creation and consumption of rich digital media experiences
Video technology revolutionized how we create and consume media. Enhanced video quality with less bits lead to broad adoption across a wide range of devices and services. According to the Cisco Annual Internet Report, 2018-2023, 82% of internet traffic will be video by 2022.
SC 29 (MPEG)
Motion Picture Experts Group

Founded in 1988 as part of ISO/IEC JTC 1

Developing international standards for compression, decompression, processing, and coded representation of moving pictures, audio, and their combination, in order to satisfy a wide variety of applications

VCEG
Video Coding Experts Group

Developed first spec in 1984 as part of ITU-T

A long and rich history in visual compression coding work focusing on video and still image, with three ITU standards before working jointly with MPEG

-driving the technology evolution and commercial success-

Expert working groups | Technology standardization | Product interoperability

*not the official name yet
Technical innovation drives video evolution

A regular cadence of technical advancement in video codecs has led to massive reduction in file size

The first evolution
Introduced flexibility
- Focused initially on optical disc media
- Increased efficiency
- Introduced internet video

Evolution transformed
Enriched experiences and proliferation
- Emerging video applications and technology
- Robust network efficiency
- Enabling user experiences as demand surges
- Continued technical advancement

1995
MPEG-2
DVD, digital TV

2003
AVC
Blu-ray, HDTV, internet ~50% compression ↑

2013
HEVC
Streaming, 4k, HDR, 360° ~50% compression ↑

2020
EVC and VVC
8k, immersive video ~30% compression ↑

~1000x
Reduction in file size with VVC versus no compression¹

¹ On a 1080p video at 30 frames per second; EVC = Essential Video Coding, VVC = Versatile Video Coding.
Key contributions across video technologies

A rich heritage of leading video innovation

**Standard video codecs**

H.265/HEVC

In addition to being a key contributor to HEVC initiation, our innovations provide broad impact across coding features

**Next generation video codecs**

VVC and EVC

Continued industry leadership in contributing fundamental innovations in next generation high performance video codec standards

**Coding performance and efficiency**

Implementation

Contributions facilitate coding efficiency and low computational complexity at reduced power consumption for video codec implementors

**Video delivery**

DASH and file format

Innovations, such as adaptive streaming and extensible file formats
HEVC coding gain leadership
Our innovations contributed to coding tools that provide significant gain

HEVC complexity reduction leadership
Our innovations contributed to tools that provide more efficient processing

- Parallel processing
  Real-time encoding and decoding of UHD signals through coarse and fine granularity parallel processing provisions.

- Entropy coding (CABAC)
  Reduced number of context coded bins, context sharing, grouping bypass bins, and grouping bins with the same context.

- Deblocking filter
  Selection of filtered block boundaries, and hierarchical filtering decisions efficiently avoiding filtering in unwarranted situations.

- Inter-coding
  Higher level of parallelism for merge mode processing of neighboring blocks through the use of configurable merge mode motion estimation region.

- Coefficient coding
  Coefficient grouping into 4x4 sized subblocks harmonizing transform block processing design and enabling use of a common scan pattern.
VVC coding gain leadership

Initial or a main contributor to tools that provide 80% of VVC’s rate reduction

- **Parallel processing**
  - Parallel processing within a picture through the use of tile partitioning and/or wavefront parallel processing (WPP), as well as virtual pipeline data units (VPDU) at an even finer granularity.

- **Intra-coding**
  - Simplified calculation of position-dependent intra prediction sample combining (PDPC) weights through the use of position dependent integer shift operations.

- **Transforms**
  - Low Frequency Non-Separable Transform (LFNST) use through zeroing out the transform coefficients outside LFNST support region.

- **Entropy coding (CABAC)**
  - Efficient multi-hypothesis weighted probability estimation through the use of estimator functions incorporating integer shift operations rather than division operations.

- **Viewport-dependent 360° video coding**
  - Efficient tiled streaming of 360° video content through the use of subpictures (independent coded regions) and scalability features, enabling simple extraction and merging.
A prominent contributor to 3GPP DASH and MPEG DASH
Enabled streaming at scale

Our key contributions

Reach
Flexibility to create a variety of encoded media and use a common protocol to serve any device, under virtually any network condition

Quality
Decreased start-up time, faster seeking, and quicker buffer fills to reduce video freeze while maintaining the highest video quality

Scalability
Adaptive bit-rate to serve many clients in a scalable and cost-efficient manner without network architecture changes - smart and power clients
Our legacy of video product leadership

First 4K AVC encode and decode
First 4K HEVC encode and decode
First HEVC 10-bit and HDR10

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Our contributions to standards drive the future for industries

Leading technology standardization in a complex global ecosystem – key for future innovations

Technology leadership
Driving cutting-edge R&D and taking bold bets to address fundamental challenges and deliver industry-changing breakthroughs

Standards leadership
Taking leadership positions in standards and industry organizations to set guiding directions and do what’s right to move the industry forward

Ecosystem support
Supporting ecosystem development through higher membership levels and close collaboration with 80+ leading universities on future research
Thank you

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