In his opening remarks, Dr. Lee welcomed everyone to the workshop and thanked speakers and attendees. He presented an overview of voice quality for PSTN, ISDN, 2G, 3G and VoIP. Over the last twenty years, there have been large improvements in the use of voice, but none in the quality of voice. ITU first defined 7 kHz audio (Hi-Fi audio) for B-Ch (64 kbps) in 1988. Now, we live in the broadband era, but problems still persist with voice quality. VoLTE is available within an operator’s network, but there is no interoperability between operators or countries. With the agreement of the CTO Round Table, this meeting is convened to consider how best to support VoLTE and ViLTE. Interoperability should be taken into account from the start.

Session 1: Domestic and international use cases of VoLTE/ViLTE services

- China Mobile VoLTE status: Yachen Wang, China Mobile  [Biography | Abstract | Presentation]

Mr. Wang presented China Mobile’s launch of VoLTE services in July 2015. VoLTE should be rolled out in 145 cities by end 2015. VoLTE major functionalities include: network attach, IMS registration, HD voice & video; Mobility management; IPv6 supported; policy charging control. VoLTE services can include: Intelligent Network Services (INS), value-added services (VAS), HD voice & video; supplementary services; and eSRVCC (emergency calls & international roaming still to be decided). VoLTE can reduce cost of all-IP provision by 70%; double HD voice and video throughput; improve capacity by 2.5 times and halve call set-up times. Operators must develop their own strategy for service migration, and choose between functionality and extending coverage. For international roaming, GSMA has identified two roaming architectures (RAVEL and s8HR), but these cannot interwork (mainly due to whether there is access IMS in the visited network or in the home network). China Mobile has released “VoLTE International Roaming Trial Guidance”. It is important to define a detailed VoLTE UNI profile to eliminate the IOT issue. Collaborations on VoLTE international roaming could help. ITU standardization on “VoLTE+” would be beneficial for operators and network and service evolution.
- NNI standards for IMS inter-connection including mobile and fixed IMS networks in Japan: Kenjiro Arai, NTT [Biography | Abstract | Presentation]

Mr. Kenjiro Arai, NTT, gave an overview of NNI standards for IMS interconnection, including for mobile/fixed IMS networks in Japan. TTC published detailed signalling requirements over NNI and adopted 3GPP TS 29.165 as a basis for future interconnection between Japanese domestic IMS networks. For NNI specification, 3GPP TS 29.165 specifies the SIP/SDP signalling (3GPP usage of SIP and SDP protocols) requirements for both roaming and non-roaming NNI, but this specification focuses only on non-roaming NNI between IMS home networks within a single network. Carrier ENUM/DNS specification is based on demand from operators for standardized number portability. TTC has developed an ENUM/DNS specification, which was published in August 2015. For future commercial IMS interconnection, TTC will carry out a study on alignment with GSMA on NNI (SIP/SDP) profiles to avoid the duplex development of the IMS equipment – TTC aims to finalize this by end 2015, but signalling/IMS are specific to operators.

- KT VoLTE status and commercial interconnected VoLTE service in South Korea: June Young Jeon, Korea Telecom [Biography | Abstract | Presentation]

Mr. June Young Jeon of Korea Telecom gave an overview of VoLTE status and services in Rep. of Korea. In June 2015, Rep. of Korea’s mobile operators announced commercial interconnected VoLTE service. KT launched VoLTE international roaming service with NTT DoCoMo in October 2015, when it completed nationwide VoLTE interoperability. The Korean TTA established a Working Group in 2012/2013 on VoLTE interworking specifications TTA-WG9101 (UICC portability) and TTA-WG9103 (RCS for mobile operators). Since its launch, customer service has been enhanced, with seamless switching between voice and video, and faster connection speeds. Remaining issues include end-to-end codec negotiation and media connection, with operator-specific UE specifications. Further discussions are needed on UNI specifications and global E-NUM for international interworking. In January 2015, KT tested VoLTE roaming services using RAVEL, but couldn’t make video calls due to the lack of a transcoding node, even though KT and CMCC’s devices support the necessary codecs (VGA, H.264 etc.). Further work is needed.

- VoLTE approach of Türk Telekom: Bilgen Kayin, Türk Telekom [Biography | Presentation]

Ms. Bilgen Kayin, Türk Telekom presented the TürkTelekom Group and its VoLTE Approach. The TürkTelekom Group VoLTE Project encompasses: VoLTE, ViLTE, CSFB, E-SRVCC, roaming and ICS-IMS Centralized Services. IMS is the only service for mobile terminated services. Key factors:
- Integration of mobile originated & terminated services (by single or dual mode services).
- Service synchronization (IR.92) between HLR and HSS over a single subscriber database.
- Voice and video interconnection for VoLTE and ViLTE.

Initially, the IMS network can interwork internally with a CS network by MGCF/IM-MGW, and will interconnect with external IMS network via CS network, reusing the existing CS interconnection. In the next phase, for IMS NNI interconnection, the IMS network will be directly interconnected by IBCF/TrGW (I-SBC). RCS is under evaluation – it works technically, but business case is unclear. FMC will be completed in 2015 - NFV seems the best option for this.
Mr. Marcus Brunner of Swisscom presented “VoLTE/VoIP in Swisscom”, the first European carrier to offer VoLTE. Interconnection is at an early stage - most of Swisscom’s peers are not ready to discuss this. For interoperability, there are several approaches to VoLTE roaming and it is unclear which will be used. QoS-enabled IP interconnection is the basis for VoLTE and other IP-based services interconnection. NGN was meant to be access network agnostic – localization requirements should be access network agnostic as well. Short-term solutions are possible for the access network, but not in the long-term due to the high number of different access network technologies available. Most UEs offer GPS and location-based services. Device support for various functions is weak but will come. Interconnection remains an open issue, but there are no standardization challenges as such, with many different options to choose from.

**Questions** focused on the need for improvements to UNI, the relationship between ENUM and international interconnection and whether a global standard is needed. Korean operators are discussing charging and termination rates. In closing, the moderator, Mr. Hischem Besbes, highlighted the experiences of China, Rep. of Korea, Japan, Turkey and Switzerland – it is the regulatory right of the consumer to have interconnection and to have the right to communicate with everyone. In his opinion, the Rep. of Korea is a good example and could be followed.

**Session 2: Analysis of standards**

- Activities of the ITU-T SG11 towards IMS and VoLTE/ViLTE interoperability and interconnection: **Martin Brand**, A1-Telekom Austria AG [Biography | Abstract | Presentation]

Mr. Brand outlined interoperability issues relating to impossibility of terminal equipment to establish e2e voice or video sessions due to incompatible codecs. Interconnection issues arise due to lack of interconnection procedures and different signaling protocols. VoLTE roaming among operators is not guaranteed, due to different options for VoLTE. In his view, international standards are the best tool to help achieve interconnection. Mr. Brand outlined a SIP-IMS Standardization Plan – ITU-T standards can be used to ensure international interoperability, and join efforts with other SDOs to maximize resources. The ITU-T SG11 meeting on 2-11 December 2015 will discuss a “Framework of interconnection of VoLTE/ViLTE-based networks” and collaboration between ITU-T SG11 and ETSI TC INT to develop standards on SIP-IMS, VoLTE interconnection and Internet speed measurement and test specifications.

- Activities of TTC/HATS (Harmonization of Advanced Telecommunication Systems) and APT interoperability issue: **Hideo Himeno**, NEC Corp. [Biography | Abstract | Presentation]

Hideo Himeno of NEC Corp. overviewed the HATS conference and activities of TTC/HATS and APT on VoLTE interoperability, including: testing; VoIP and Visual Communication interoperability; challenges for VoLTE and VoIP interworking testing. There is good cooperation between ITU-T, TTC/HATS and APT, and described standardization activities in Japan. Preliminary interoperability testing found few problems for VoIP, but visual communication via
NGN can suffer from unavailable service, packet loss and frozen video pictures. Challenges persist in LTE and VoIP interworking. New collaboration frameworks and interoperability events can help foster understanding and cooperation among SDOs. TTC and HATS will also be able to contribute to the framework with their experiences.

- Helping mobile operators deliver an All-IP World: Michele Zarri, GSMA [Biography] | Presentation

Michele Zarri of GSMA overviewed the GSMA and its Network 2020 programme. LTE has been launched by 418 operators in 143 countries, reaching 44% of global population. VoLTE & ViLTE are implemented by 36 operators in 23 countries and adapted for 75 devices. Drivers for IP interconnection include enriched customer experience and >$150bn from spectrum refarming. GSMA maintains a knowledge base (www.gsma.com/newsroom/gsmadocuments/). Three roaming models exist for VoLTE and other IMS-based services: (1) Local Breakout with routing by VPLMN (RAVEL); (2) Local break-out with home routing; (3) Home routing via S8 (HRS8). IR.65 on IMS Roaming and Interworking Guidelines provides guidelines for voice roaming for both Local Breakout and S8 Home Routing models. IP interconnection will be a necessity – it is a question of when it will happen, rather than if. International interconnection benefits from the sharing of experiences, and GSMA is working to accelerate international interconnection.

**Questions** centred on respective focus of the work of different standards bodies. In his closing comments, moderator Mr. Hans Gierlich observed that standards offer multiple options, so compliance and conformity with standards does not give interoperable services. The GSMA recognizes the need for further work, but wondered how best to make use of added work at this stage. HATS feeds its test results back into the standards.

**Session 3: Key issues of the implementation of VoLTE/ViLTE services**

- VoLTE device interoperability challenges: Thomas Eyring, Rohde & Schwarz [Biography] | Presentation

Thomas Eyring overviewed standardization efforts. VoLTE Interoperability is challenging in: different EPS bearer configurations; simplification of SIP call flows; and security configuration. Lack of interoperable VoLTE roll-out hampers roaming and creates fragmentation. Implementation of IMS/VOLTE is proprietary and varies between devices. For CSFB and SRVCC, support is needed to cope with handover and roaming. Dual stand-by is needed in selected markets. Emergency Call and LBS services may be needed in some regulatory regimes. Over 30 mobile operators have launched VoLTE services. Mr. Eyring concluded UICC interoperability is not a given due to different VoLTE “dialects”. Support of emergency calls is a challenge. Lessons learned from IR.92 should be considered for IR.94 (ViLTE), VoLTE over WiFi and RCS.
Mr. Hans Gierlich presented “Challenges in VoLTE terminal testing and interworking”. A range of obstacles exist in call handling for 4G. Network providers use their own LTE cell/signalling parameters, which may be unknown. The MNC/MCC settings must be known for roaming and VoLTE connection. The SIP/IMS registration is sensitive to errors or unknown SIP messages. The issues and differences in IMS settings create difficulties in testing, and prevent interworking between operators. One solution is to define a set of IMS settings used in interworking. VoLTE introduces more variability into the quality of communications. For 4G, there is a requirement for round trip delay MTSI < 190 ms, with a performance goal of <150 ms. Clock synchronization is needed to avoid delay drift during testing. Mean delay can increase due to jitter buffer increase. Advanced mobile terminals require advanced and realistic testing procedures.

Mr. Hischem Besbes identified three phases in LTE evolution. Asia-Pacific is the region with the highest absolute number of LTE deployments (launched and planned), followed by Europe, the Americas and Africa. LTE offers higher downlink spectral efficiency and lower latency than UMTS/HSPA or WiMAX. Regulatory challenges include interoperability, interconnection, roaming and QoS/QoE. Successful implementation of VoLTE depends on ensuring no discrimination between users (geographical discrimination, price discrimination, universal service), and end-user satisfaction in term of QoS/QoE. Lack of interoperability risks bringing operators back to an “on-net club”. Regulation will try to overcome all challenges related to VoLTE and ViLTE provision.

Mr. Paul Coverdale of Huawei asked how to ensure interoperability of ViLTE among different service providers? Objective measurement and QoE calculation is faster than subjective testing, but accuracy varies and an understanding of human factors is needed. ITU-T (Rec. P.1201/P.1202) measures the quality degradation due to compression, packet loss and rebuffering. However, user interactions are not considered. There is continuous evolution in requirements for objective video QoE assessment (research method, performance metrics and application scenarios). According to one survey, the top 3 factors affecting user experience are: video source quality (definition, motion and fidelity), video loading speed and viewing experience (erratic display/freeze). Standardized models for predicting video QoE are becoming available in ITU-T SG 12 – the technical community needs to address these issues.
Mr. Doug Makishima overviewed key statistics for VoLTE and GSMA’s Network 2020 initiative. In his view, roaming is becoming a reality. UNI fragmentation impacts NNI for interconnect. Public safety, emergency call, regulatory (e.g. lawful intercept) remain issues. GSMA IR.92, ‘IMS Profile for Voice and SMS’ (VoLTE) and IR.94 (ViLTE) are already the ‘global profile’, but can be improved. 36 operators have launched VoLTE/418 LTE operators, so interoperability needs to be fixed now as launches are accelerating. There are 75 native VoLTE devices and 75 RCS native devices (15 overlap). GSMA is facilitating VoLTE/ViLTE/VoWiFi interoperability through:

- Situation analysis and improvements to IR.92 spec and other PRD specs;
- Outreach, development of test specs and validation through test events;
- Issues registry, problem resolution and implementation guidelines;
- “Lighthouse” implementations e.g. China Task VoLTE Force, Germany RCS Interconnect.

He invited everyone present to contribute to this work.

- **EVS** - Latest state-of-the-art speech and audio communication codec and related interoperability aspects: **Manfred Lutzky**, Fraunhofer Institute [ Biography | Abstract | Presentation ]

Manfred Lutzky of the Fraunhofer Institute presented Enhanced Voice Services (EVS), resulting from a cooperation of 12 companies. EVS offers significant performance gains for clean speech, noisy speech, mixed sound and music. It offers better speech quality and compression efficiency, audio bandwidth, error robustness and seamless switching. It has an integrated AMR-WB interoperable mode, and improved quality and robustness. Handover is possible without transcoding or re-negotiation for SRVCC. EVS transport has been designed for LTE and is interoperable with AMR-WB. In summary, Mr. Lutzky concluded that EVS can enable operators to offer superior voice services compared to legacy, especially in superwideband mode. EVS could become the ‘single codec’ for mobile, fixed and VoWiFi.

**Kaoru Kenyoshi**, Vice-Chairman of ITU-T SG11, Japan moderated this Session. **Questions** focused on how to make testing more compliant with standards and whether narrowing down the standard constitutes an exact service definition. A need was identified for well-understood testing methods, and the risk of moving to an ‘on-net’ club was discussed.

**Session 4: Wrap-up and Action Plan**

**Moderator**: Bilel Jamoussi, Chief, Study Groups Department, TSB/ITU [ Biography ]

- **Hischem Besbes**, INTT, Tunisia [ Biography ]
- **Hans Gierlich**, HEAD acoustics GmbH [ Biography ]
- **Kaoru Kenyoshi**, Vice-Chairman of ITU-T SG11, Japan [ Biography ]

**Closing Remarks**

- **Dr Chaesub Lee**, Director of the Telecommunication Standardization Bureau, ITU [ Biography ]