Chapter 1

Introduction

In July 1990, Study Group XV of the then CCITT decided to set up a group to deal with the development of common software tools to help in the development of speech coding standards. In the same period, cooperation was requested with SG XII Speech Quality Experts Group (SQEG), and a group called 'User's Group on Software Tools' (UGST) was initially established with almost 20 corresponding members. The basic means of interaction were the then incipient electronic mail (e-mail) messages, for the exchange of files and experiences – UGST was actually one of the pioneer groups in ITU collaborating via electronic means. In addition to this, there were meetings held mainly during regular Working Party XV/2 (Signal Processing) sessions, where most of the decisions were made.

As result of that very intensive work, several software tools evolved forming the '*1992 ITU-T Software Tool Library*' (STL92) which included, as its first application, the Qualification Test for a Speech Coder at 8 kbit/s. After this initial release, another release was approved by ITU-T Study Group 15 in May, 1996, and called STL96. The STL96 introduced substantive improvement and new features to the STL92. In November 2000, ITU-T Study Group 16 approved an updated version to the STL, the STL2000. In 2005, another updated version of the STL, STL2005, was accepted. In 2009, a new version of the STL, (**STL2009**) was developed. STL2009 corrects bugs and brings revisions (such as G.722 codec software, basic operators C-code, or reverberation tool), and adds new tools (new FIR filters, new EID tool, and a stereo operator tool). STL2009 is described in this document. Terms and conditions on the usage of the ITU-T STL are found in ITU-T Recommendation G.191 [1].

The remaining chapters of this document describe the principles that guided the generation of the ITU-T STL, as well as the description of its organization. The various tools are described in separate chapters. These descriptions have the following general outline:

a. technical description of the method or algorithm involved;

b. description of the algorithm implementation in this release (including prototypes, parameters, returned value, etc.); and

c. testing, applications and examples.

All the STL2000 modules had their portability tested for MS-DOS/Windows and several Unix flavors. In MS-DOS, all modules were tested with the MS-DOS port of the GNU `gcc` compiler (a.k.a. DJCPP) and with at least one of these Borland compilers: Turbo C 2.0, Turbo C++ 2.0, or Borland C++ 3.1. In the Windows environment, the code was tested using MS Visual C version 6.1 SP3 as well as using the gcc compiler available in the Cygnus

CYGWIN development environment (www.cygnus.com). The VAX/VMS environment was fully supported in the STL96 (VAXC and gcc), however it was not possible to continue it for the STL2000 due to operational reasons; nevertheless, compilation under gcc should provide the expected results, and some tools were tested for Ultrix. For the Unix operating system, portability was verified for three workstation platforms: Sun Solaris 5.7 (SPARC or Intel CPUs, using gcc), HP 9000 Series 700 HP-UX 9.05 or 10.20 (using gcc), and Silicon Graphics. On Silicon Graphics systems, the standard cc compiler was used.
The tools of the STL2005 were compiled and tested with a Windows environment using MS Visual C++ 6.0. The new tools and the revised portions of the STL2009 were compiled and tested with a Windows environment using MS Visual C++ 8.0, and in Cygwin with gcc (version 3.4.4).

1.1 Organization of the Software Library

Each tool of the STL has been produced as a stand-alone module, such that it may be linked to a user's program, application or system. In the present version, there are several of these modules:

1. **G.711**: The 64 kbit/s PCM algorithm with A and μ law of ITU-T Rec. G.711.
2. **G.711-PLC**: The high-quality, low complexity packet-loss concealment specified in ITU-T Rec. G.711 Appendix I *(revised in STL2009)*.
3. **G.726**: The 40, 32, 24, and 16 kbit/s ADPCM algorithm of ITU-T Rec. G.726.
4. **G.727**: The 40, 32, 24, and 16 kbit/s embedded ADPCM algorithm of ITU-T Rec. G.727.
5. **G.728**: The 40, 32, 24, and 16 kbit/s ADPCM algorithm of ITU-T Rec. G.727 *(new in STL2005)*.
6. **G.722**: The 64, 56, and 48 kbit/s wideband speech ADPCM algorithm of ITU-T Rec. G.722 *(revised in STL2009)*.
7. **RPE-LTP**: The 13 kbit/s RPE-LTP algorithm of the full-rate GSM system (GSM Rec. 06.10).
8. **RATE-CHANGE:** An up- and down-sampling algorithm with embedded filtering:
   - ITU-T Rec. G.712 filter for factors of 1:2, 2:1 and 1:1
   - High-quality filter for factors 1:2, 2:1, 1:3, and 3:1
   - IRS send-side weighting filter, for several sampling rates: 8, 16, and 48 kHz. This includes the "full-IRS" as in ITU-T Rec. P.48 as well as the "modified" IRS as in Annex D of ITU-T Rec. P.830.
   - Modified-IRS receive-side filter is also available for 8 and 16 kHz sampled data.
   - Δ_{SM} weighting filter for near-to-far field conversion
   - Psophometric weighting filter of ITU-T Rec. O.41 for noise measurements

- ITU-T P.341 weighting filter for wideband signal (50-7000 Hz)
- 100-5000 Hz bandpass filter
- 50-14000 Hz bandpass filter (P341 extension for super-wideband signal)
- 20-20000 Hz bandpass filter *(new in STL2009)*
- MUSHRA anchors (1.5 kHz, 3.5 kHz, 7 kHz, 10 kHz, 12 kHz and 14 kHz low-pass filters) *(new in STL2009)*.

9. **EID**: Error insertion algorithm, with routines for generation of bit error patterns (random or burst) as well as random and burst frame erasure *(revised in STL2009)*.
10. **MNRU**: The modulated noise reference unit of ITU-T Rec. P.810 (formerly ITU-T Rec. P.81).
11. **SVP56**: The Speech Voltmeter for measuring the active speech level (which skips over silence in a utterance) of ITU-T Rec. P.56.
12. **REVERB**: Tool to add reverberation to speech *(revised in STL2009)*.
13. **TRUNCATE**: Bitstream truncation tool.
14. **FREQRESP**: Frequency response measurement tool *(revised in STL2009)*.
15. **STEREOOP**: Stereo processing tool *(new in STL2009)*.
16. **BASOP**: The set of basic digital signal processing (DSP) operators that represent the set of instructions typically available in digital signal processors *(revised in STL2009)*.
17. **UTILITIES**: Tools that have been developed to assure proper interfacing between the various tools. These tools do not relate to any ITU-T Recommendation. Included are tools for conversion between float and short data representations, between parallel and serial (bit-stream) formats, and for scaling of data.

It should be noted that C code is available for a number of codecs as a normative part of the respective standards, e.g. ITU-T G.711.0, G.711.1, G.718, G.719, G.722.1, G.722.2; 3GPP extended AMR Wideband codec, G.723.1, G.729, G.729.1, enhanced aacPlus general audio codec; ETSI GSM-HR, GSM-EFR, GSM-AMR; TIA IS-641, IS-127, IS-96A, among others. These source codes are not appropriate for inclusion in the ITU-T STL for a number of reasons: they are an integral part of the respective standards, are maintained within the scope of the respective standards development organizations (SDOs), are protected by copyrights, and are openly available. Parties interested in acquiring these source codes should contact the appropriate SDO.

1.2 Whom to contact

In case of problems with any of the tools, please contact the ITU-T Study Group 16 secretariat at `<tsbsg16@itu.int>`. Please provide a precise description of the problem with proper reference to the C-code, and possible solution(s), if known.

1.3 Acknowledgements

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