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**European digital cellular telecommunications system;
Half rate speech;
Part 7: ANSI-C code for the GSM half rate speech codec
(GSM 06.06)**

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Foreword

This final draft European Telecommunication Standard (ETS) has been produced by the Special Mobile Group (SMG) Technical Committee of the European Telecommunications Standards Institute (ETSI), and is now submitted for the Voting phase of the ETSI standards approval procedure. A 3.5 inch diskette is attached to the back cover of this final draft ETS, this diskette contains clause 5, the bit-exact ANSI-C code for the GSM half rate codec.

This final draft ETS specifies the half rate speech traffic channels for the European digital cellular telecommunications system. This ETS corresponds to GSM technical specification, GSM 06.06, version 4.0.2 and is part 7 of a multi-part ETS covering the half rate speech traffic channels as described below:

GSM 06.02	ETS 300 581-1: "European digital cellular telecommunications system; Half rate speech Part 1: Half rate speech processing functions".
GSM 06.20	ETS 300 581-2: "European digital cellular telecommunications system; Half rate speech Part 2: Half rate speech transcoding".
GSM 06.21	ETS 300 581-3: "European digital cellular telecommunications system; Half rate speech Part 3: Substitution and muting of lost frames for half rate speech traffic channels".
GSM 06.22	ETS 300 581-4: "European digital cellular telecommunications system; Half rate speech Part 4: Comfort noise aspects for half rate speech traffic channels".
GSM 06.41	ETS 300 581-5: "European digital cellular telecommunications system; Half rate speech Part 5: Discontinuous Transmission (DTX) for half rate speech traffic channels".
GSM 06.42	ETS 300 581-6: "European digital cellular telecommunications system ; Half rate speech Part 6: Voice Activity Detection (VAD) for half rate speech traffic channels".
GSM 06.06	prETS 300 581-7: "European digital cellular telecommunications system; Half rate speech Part 7: ANSI-C code for the GSM half rate speech codec".
GSM 06.07	prETS 300 581-8: "European digital cellular telecommunications system ; Half rate speech Part 8: Test vectors for the GSM half rate speech codec".

NOTE: TC-SMG has produced documents which give the technical specifications for the implementation of the European digital cellular telecommunications system. Historically, these documents have been identified as GSM Technical Specifications (GSM-TS). These TSs may have subsequently become Interim European Telecommunication Standards (I-ETs), (Phase 1), or European Telecommunication Standards (ETs), (Phase 2), whilst others may become ETSI Technical Reports (ETRs).

Proposed transposition dates	
Date of latest announcement of this ETS (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this ETS (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

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1 Scope

This European Telecommunication Standard (ETS) part 7 contains an electronic copy of the ANSI-C code for the GSM half rate codec. The ANSI-C code is necessary for a bit exact implementation of the half rate speech transcoder (GSM 06.20 (ETS 300 581-2) [2]), Voice Activity Detection (GSM 06.42 (ETS 300 581-6) [6]), comfort noise (GSM 06.22 (ETS 300 581-4) [4]), Discontinuous Transmission (GSM 06.41 (ETS 300 581-5) [5]) and example solutions for substituting and muting of lost frames (GSM 06.21 (ETS 300 581-3) [3])

2 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

- [1] GSM 01.04 (ETR 100): "European digital cellular telecommunication system (Phase 2); Abbreviations and acronyms".
- [2] GSM 06.20 (ETS 300 581-2): "European digital cellular telecommunications system; Half rate speech Part 2: Half rate speech transcoding".
- [3] GSM 06.21 (ETS 300 581-3): "European digital cellular telecommunications system; Half rate speech Part 3: Substitution and muting of lost frame for half rate speech traffic channels".
- [4] GSM 06.22 (ETS 300 581-4): "European digital cellular telecommunications system; Half rate speech Part 4: Comfort noise aspects for half rate speech traffic channels".
- [5] GSM 06.41 (ETS 300 581-5): "European digital cellular telecommunications system; Half rate speech Part 5: Discontinuous transmission (DTX) for half rate speech traffic channels".
- [6] GSM 06.42 (ETS 300 581-6): "European digital cellular telecommunications system; Half rate speech Part 6: Voice Activity Detector (VAD) for half rate speech traffic channels".
- [7] GSM 06.07 (prETS 300 581-8): "European digital cellular telecommunications system; Half rate speech Part 8: Test vectors for the GSM half rate speech codec".
- [8] American National Standards Institute ANSI 9899 (1990): "Programming Language - C (ISO)".

3 Definitions and abbreviations

3.1 Definitions

Definition of terms used in this ETS can be found in GSM 06.20 (ETS 300 581-2) [2], GSM 06.21 (ETS 300 581-3) [3], GSM 06.22 (ETS 300 581-4) [4], GSM 06.41 (ETS 300 581-5) [5] and GSM 06.42 (ETS 300 581-6) [6]

3.2 Abbreviations

For the purpose of this ETS the following abbreviations apply.

ANSI	American National Standards Institute
DS-HD	Double Sided High Density
ETS	European Telecommunication Standard
GSM	Global System for Mobile communications

I/O Input/Output
 ROM Read Only Memory

For abbreviations not given in this subclause see GSM 01.04 (ETR 100) [1].

4 C code structure

This clause gives an overview of the structure of the bit-exact C code and provides an overview of the contents and organization of the 3.5 inch diskette attached to this ETS.

The C code has been verified on the following systems:

- Sun Microsystem's ¹⁾ workstations and Sun Microsystems acc;
- IBM ²⁾ PC/AT compatible computers and Borlands Turbo-C ³⁾ compiler;
- VAX ⁴⁾ and Digital Equipment Corporations CC.

ANSI-C 9899 [8] was selected as the programming language because portability was desirable. The data medium for the code dissemination is MS-DOS ⁵⁾ formatted 3.5 inch DS-HD floppy disk.

4.1 Directory structure

A listing of the directories is given in table 1.

Table 1: Directory structure listing

Directory name	Contents	Size (bytes)
\c	C files and headers	1 178 651
\d	example binary data input and output files	72 400
\exec	executables and makefiles	5 752
\utils	utility programs and the 'reid' program	49 531
readme.txt	usage description of files	9 116

The C code diskette has one main directory and four subdirectories. The top directory has in it the file readme.txt which explains the installation procedure, along with some miscellaneous descriptive information regarding the code.

Below this directory, are the four subdirectories. The "c" subdirectory contains all the source code and header files. This directory alone is essential, the others aid in the building, or testing of the code. All ROM data is in this source directory. After installation, this directory can be made read only.

1) Registered trade mark of Sun Microsystems
 2) Registered trade mark of International Business Machines
 3) Registered trade mark of Borland
 4) Registered trade mark of Digital Equipment Corporation
 5) Registered trade mark of Microsoft

The "d" subdirectory contains all the speech coder installation verification data files. All of the data files are written/read as 16 bit words, so these may require byte swapping on the target platform. All data and text files are formatted such that they are correct for an IBM PC/AT compatible.

Final verification is to be performed using the GSM half rate test sequences described in GSM 06.07 (prETS 300 581-8) [7].

The "utils" subdirectory contains miscellaneous utilities which may be useful in the installation of the software. Two programs are provided to transform text files: topcwild and tosnwild. The program topcwild takes UNIX ⁶⁾ text files and converts them to pc text files. tosnwild does the opposite. The program swapbin is also in this directory. This performs byte swapping on a binary data file. A fourth program, reid, is also contained in this sub directory. This is the residual error insertion program which also provides the format conversion between the encoder output file format and the decoder input file format.

The "exec" subdirectory contains the makefiles for the various platforms. Once the software is installed, this directory will have a compiled version of gsm_hr (the bit-exact C executable), programs from the "utils" directory, and all the object files.

The program gsm_hr is the name of the GSM half rate codec executable file.

4.2 Program execution

The GSM half rate speech codec is implemented as two separate programs:

- (gsm_hr) speech codec;
- (reid) encoder/decoder interface.

The gsm_hr program operates in one of two modes:

- (0) encoding only;
- (1) decoding only.

For encoding, the input is a binary speech file (*.inp) and the output is a binary encoded parameter file (*.cod). For decoding, the input is a binary parameter files (*.dec) and the output is a binary synthesized speech file (*.out). Note that the format for the parameter input file required for decoding (*.dec) is not the same as the format of the parameter output file generated by encoding (*.cod). The reid program will translate an *.cod file into an *.dec file (select error-free mode, EP0).

See the file readme.txt for more information on how to run the gsm_hr and reid programs.

4.3 Code hierarchy

Figures 1 to 7 are call graphs that show the functions used in the speech codec.

The encode call graph is broken down into six separate call graphs. Those sections, which are large, are separated from the primary encode call tree and given their own call tree. Each vertical column represents a call level. For example, main() is at level 0, encode() at level 1, speechEncoder() at level 2, openLoopLagSearch() at level 3, getCCThreshold() at level 4, etc. The basic operations are not counted as extending the depth, therefore the deepest level is this software is level 6.

Some items have been omitted from this call graph. All standard C functions: printf(), fwrite(), etc. have been omitted. Also, no basic operations (add(), L_add(), mac(), etc.) or double precision extended operations (e.g. L_mpy_ls()) appear in the graphs.

6) Registered trade mark of [tba]

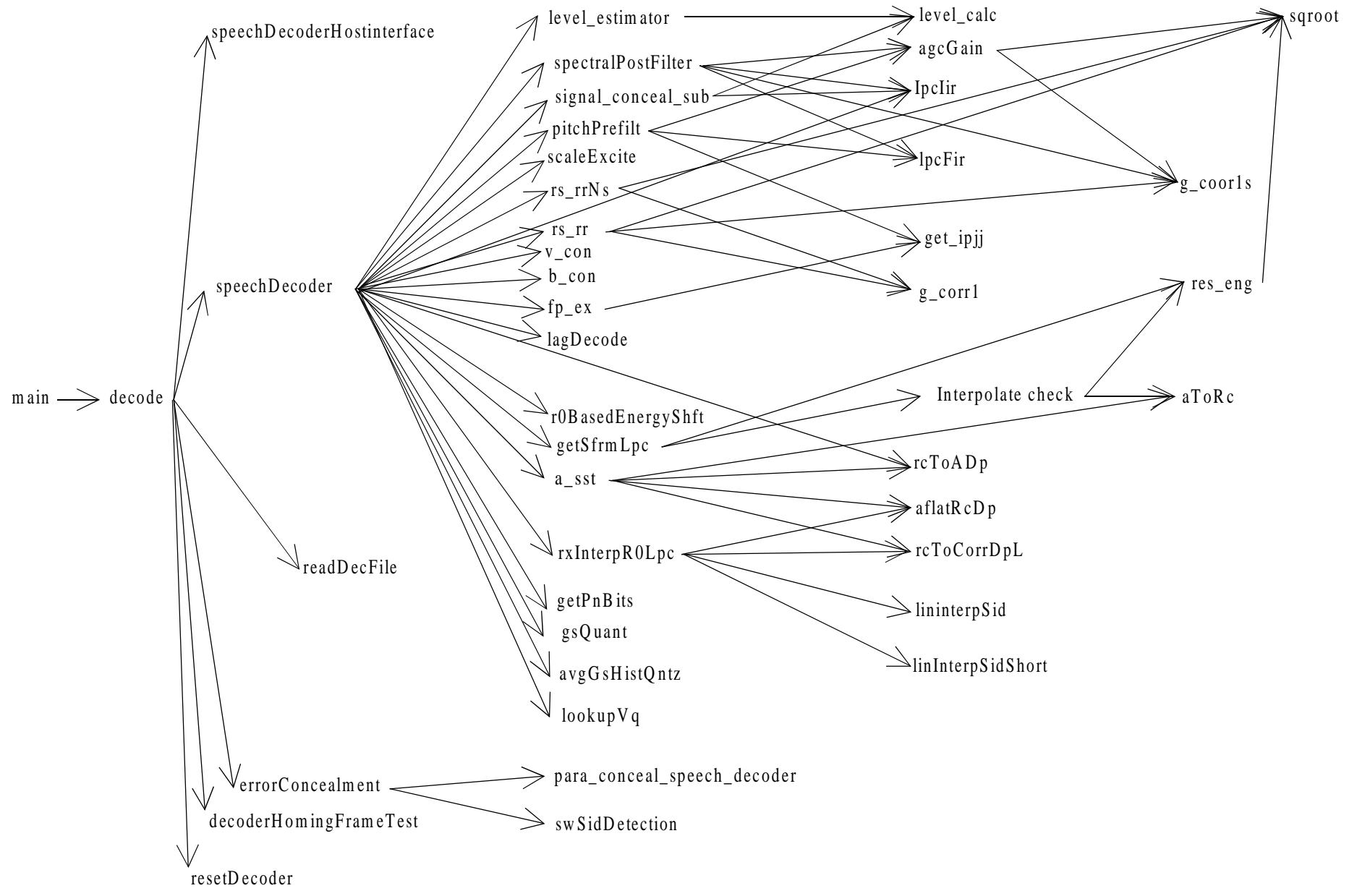
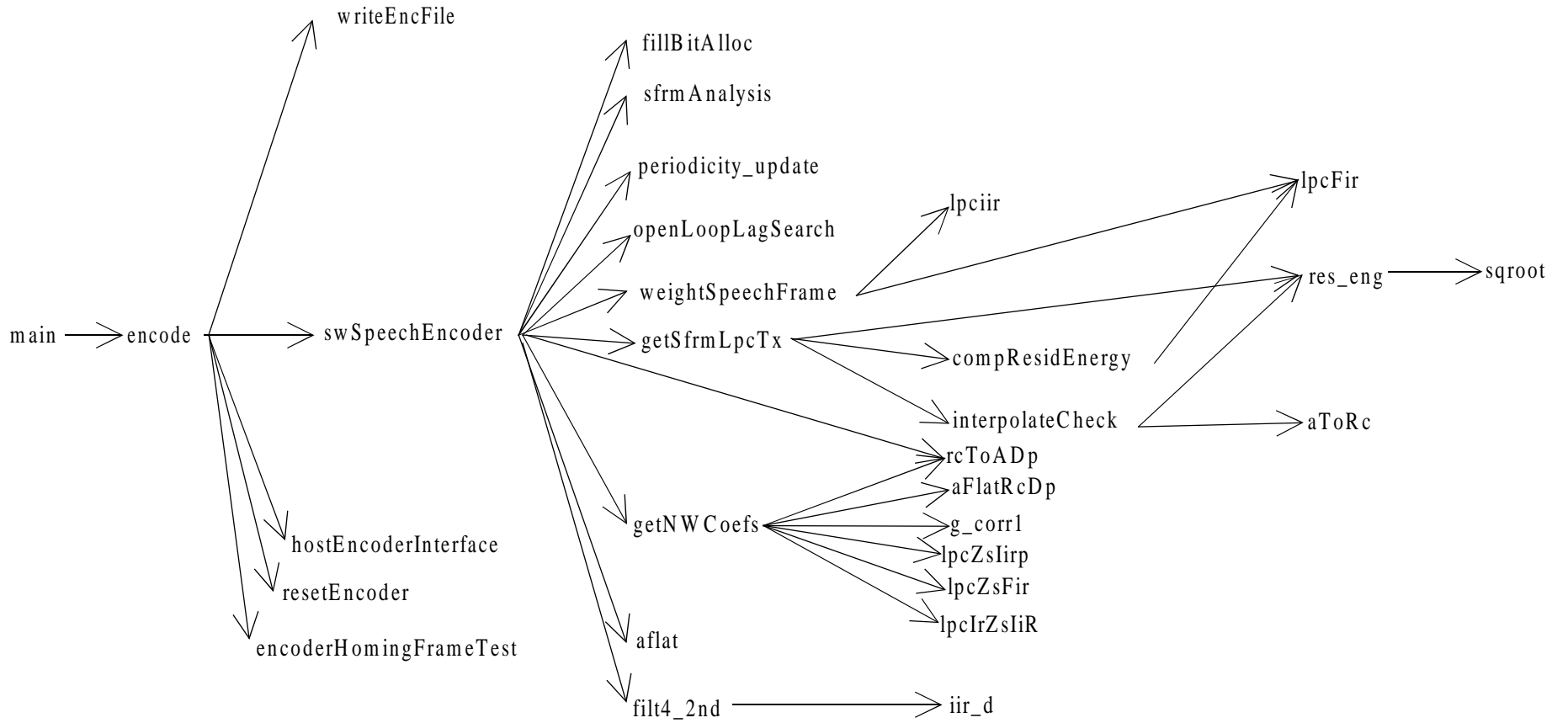


Figure 1: Speech decoder call graph

Figure 2: Speech encoder call graph



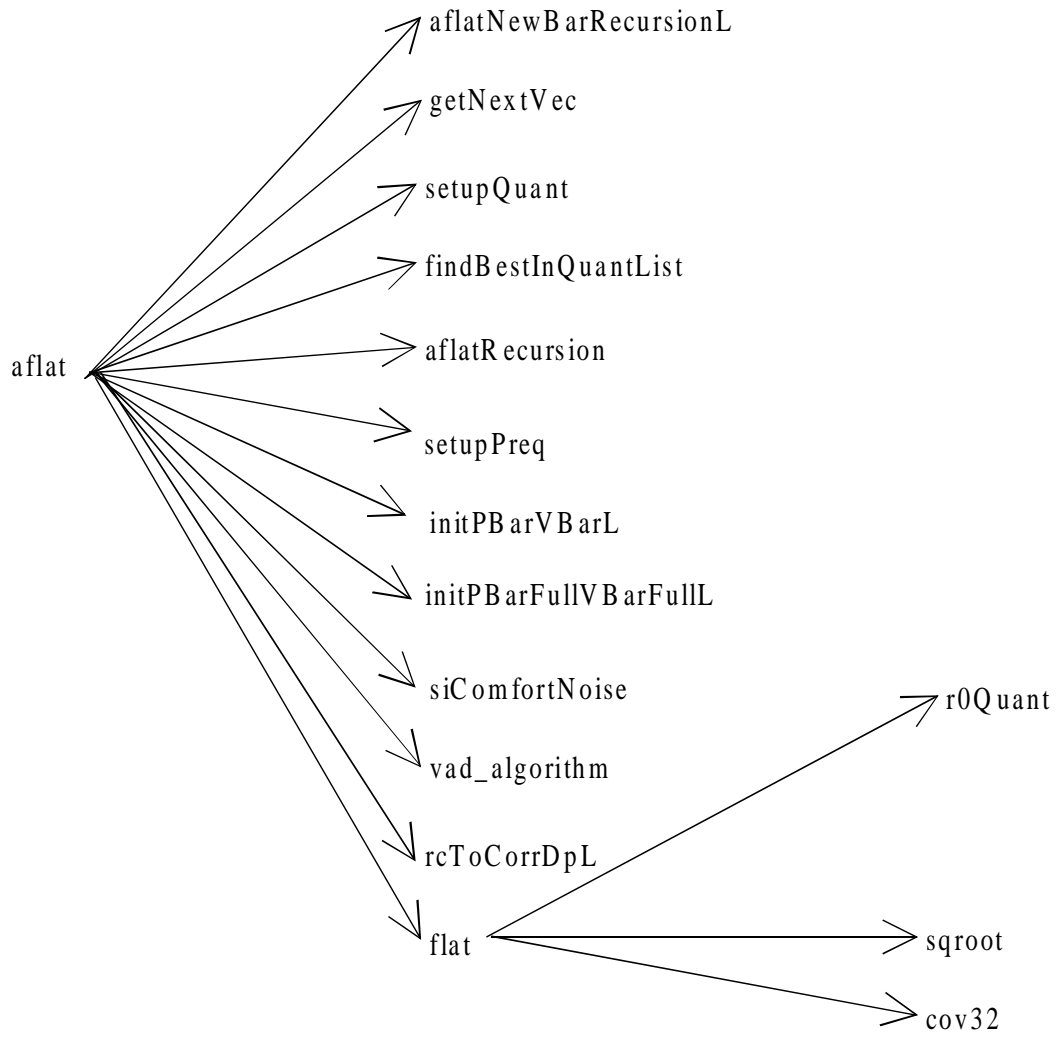


Figure 3: Speech encoder LPC quantisation call graph

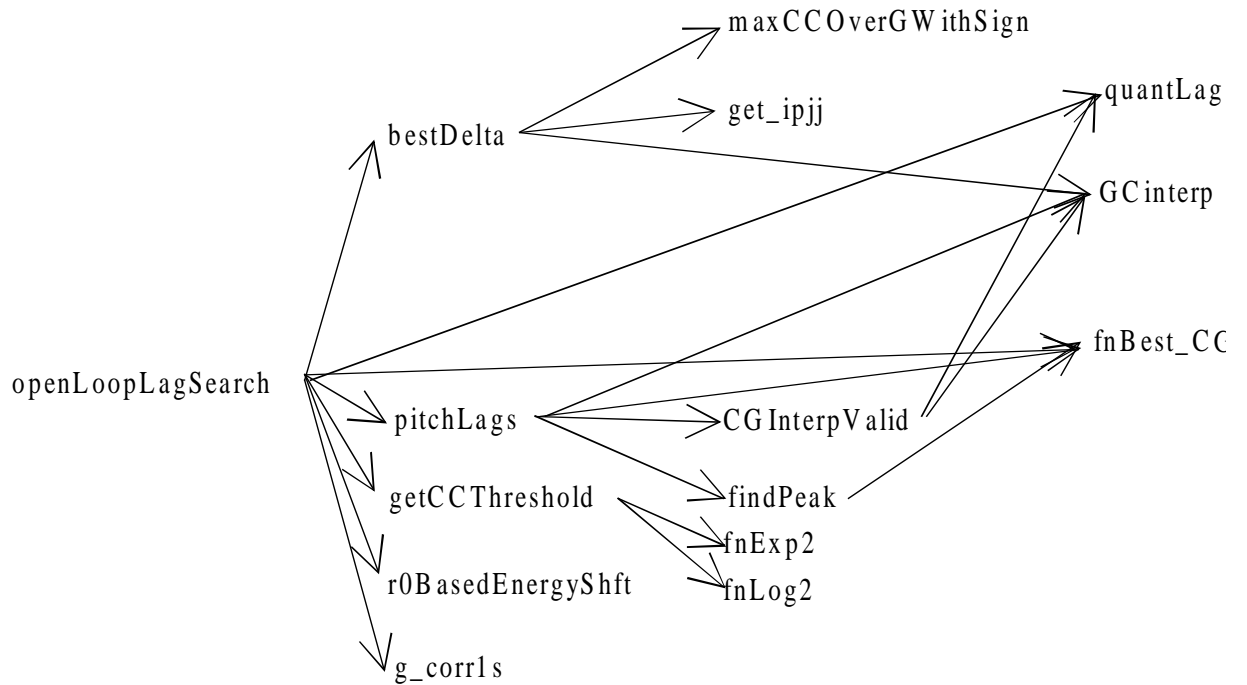


Figure 4: Speech encoder open-loop lag search call graph

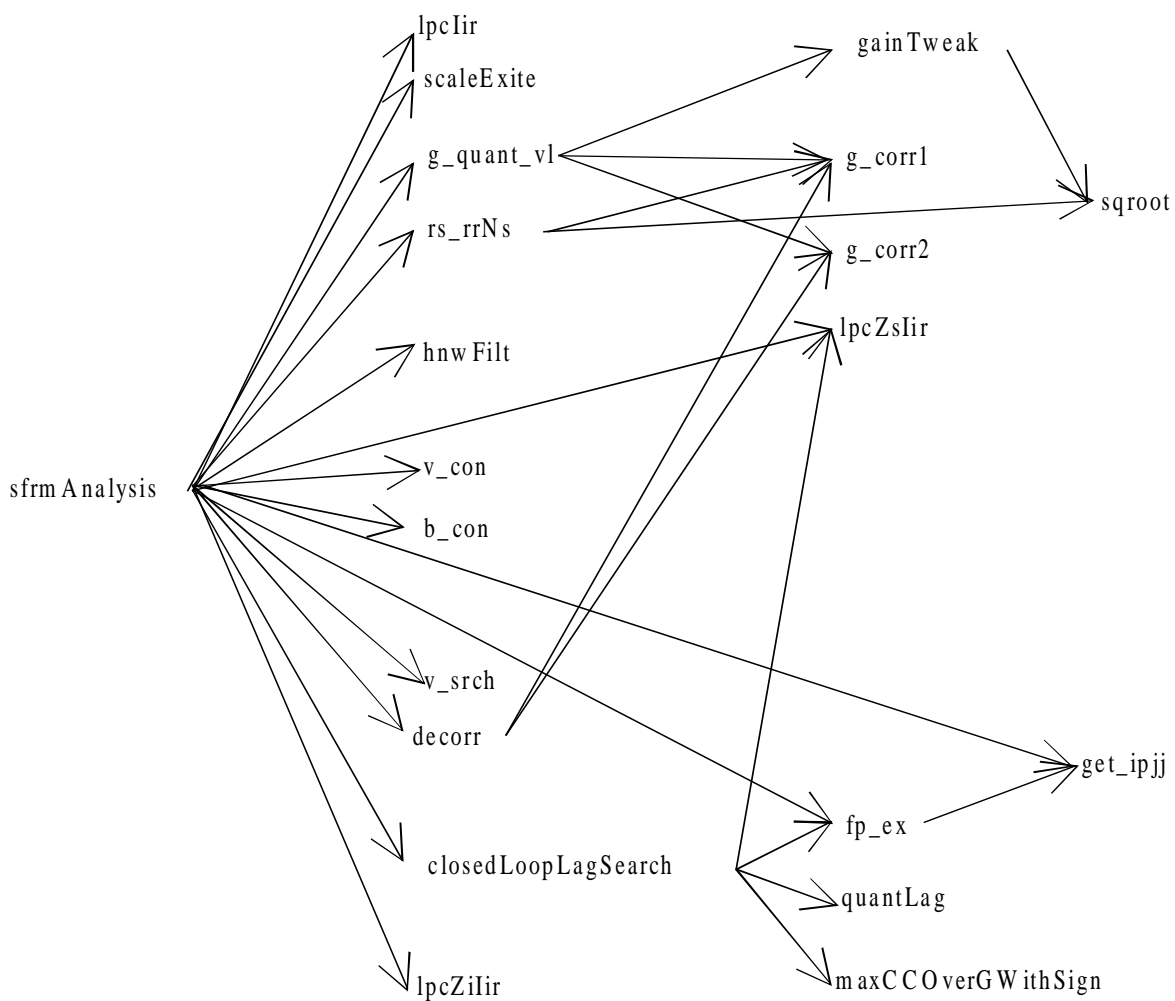


Figure 5: Speech encoder subframe processing call graph

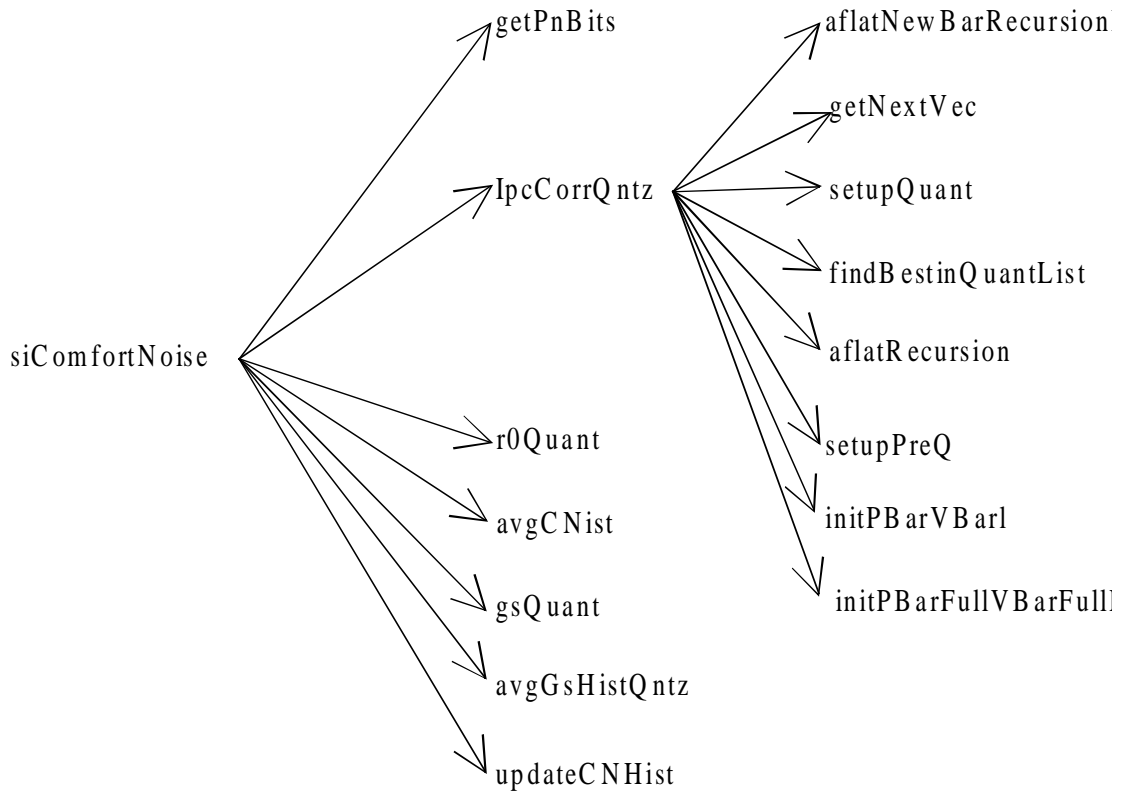


Figure 6: Comfort noise call graph

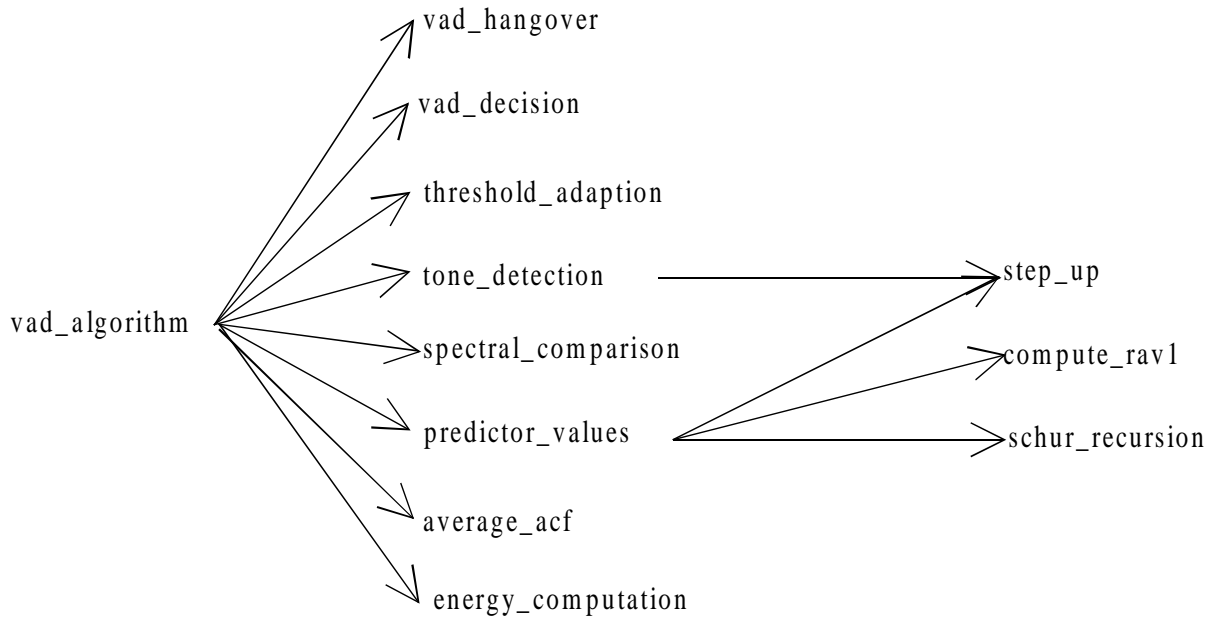


Figure 7: Voice Activity Detector (VAD) call graph

History

Document history	
April 1995	Public Enquiry PE 82: 1995-04-10 to 1995-09-01
November 1995	Vote V 92: 1995-11-27 to 1995-01-19
November 1995	Converted into Adobe Acrobat Portable Document Format (PDF)