Computer Audio Research Laboratory Progress Report
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1. Summary

The summer of 1980 was mainly dedicated to the creation of basic instrumentation for the CARL system. This instrumentation is divided below into hardware instrumentation and software instrumentation. A concerted effort to produce the CARL Phase I system has resulted in the implementation of most of the planned hardware for digital audio recording and playback, as well as much of the needed software for general sound synthesis and processing. The operating system has been shaken down considerably, with the result that the general reliability of the CARL computing system is now quite high. In addition, a number of users have become acquainted with the system through the learn programs and programming seminar.

CARL personnel for the summer have included the author (FRM, CARL Director, fulltime from 7/1/80 to 8/31/80), D. Gareth Loy (DGL, CARL Manager, fulltime), Rusty Wright (RUSTY, CARL Systems Programmer, halftime from 7/1/80 to 8/31/80), Julius O. Smith (JOS, CARL Consultant, fulltime from 8/4/80 to 8/24/80), Monica Polowy (MONICA, CME Administrative Officer, fulltime), Richard Zvonar (RZ, Graduate Assistant, halftime from 7/1/80 to 8/31/80), Ann Hankinson (ANN, Graduate Assistant, halftime from 7/1/80 to 8/31/80). and David Felder (DCF, Graduate Assistant, halftime from 7/1/80 to 8/31/80).

2. Instrumentation - Hardware

The hardware at the beginning of the summer consisted of:

a) The Vax11/780 computer with 1.25 MB of memory, floating point accelerator, RM03 disc drive, and TE16 magnetic tape, and

b) A small number of terminals, including 3 Visual 200s, a VT-55 graphics terminal, and a Diablo 1620 hardcopy terminal.

The following hardware has been added to the CARL system over the summer:

1) (frm, dgl, rusty) A CDC 9766 300 MB disc drive, with a Xylogics dual UNIBUS-ported controller. The drive was delivered in the early part of the summer, and the controller arrived about 3 weeks after the disc drive. The controller was installed immediately on the VAX UNIBUS by the CARL staff, with the assistance of members of the Chemistry computing department. The disc drive required 208 volt, single phase power, which necessitated a change in power connectors emanating from the power system. The connector was changed by the installer of the power system, and the disc subsystem hardware became operational in mid-August. This disc drive can be accessed from either the VAX computer system or the (planned) PDP11/55 computer which will support realtime activities such as control of the analog-to-digital converters.

2) (frm, dgl, rusty) The automatic calling unit (ACU) was specified and ordered from VADIC, which will allow the VAX subsystem to place telephone calls as well as receive them. These units support one full duplex ACU, and one full duplex dial-in modem, both running at 300 baud. When they are installed, all 8 terminal lines will be committed, making it essential to obtain an additional 8 lines (a DZ-11B) soon for additional terminals.

3) (frm, dgl) The analog-to-digital converters (ADCs) and the digital-to-analog converters (DACs) were built to CARL specifications by Digital Sound Corporation (DSC) in Santa Barbara. The specified system will support 4 channels of DACs, and 2 channels of ADCs, all running at 48 K Hertz (K = 1024). The DACs use a 16 bit linear quantization (equivalent to approximately 96 dB of signal-to-noise ratio and the same dynamic range). The originally available ADCs used a 14 bit quantization floated over a 16 bit dynamic range (equivalent to approximately 84 dB of SNR and 96 dB of dynamic range); during the summer, however, a design improvement allowed full 16 bit linear quantization to be used in the ADCs as well. The DSC-supplied software for the conversion system has been delayed. The hardware, however, is complete.

4) (frm) Considerable progress has been made on the acquisition of the PDP11/55 computer which will control realtime operations in the CARL system. The acquisition of this machine currently depends on actions of both the Ford Foundation and of the Digital Equipment Corporation, which has expressed a very encouraging desire to attempt to support our work. (A grant from the Ford Foundation has been pending for

approximately one year.) The computer system has been precisely specified and at the time of this writing is awaiting final approval by a combination of Ford and DEC.

3. Instrumentation - Software

A great deal of software development took place over the summer, including:

1) (rusty) The installation and successful operation of the third released version of Berkeley Virtual Vax UNIX, which is an improved system relative to the Bell Labs Version 7 UNIX on which it is based. Specific improvements include the addition of full virtual memory capabilities to the Bell Labs version, improvements to the system kernel, and a very useful screen editor which is capable of exploiting the plethora of intelligent terminals now available on the market. In addition, much useful software has been added to UNIX, including the "C-shell", which allows system commands to be given in a command language with syntax similar to the C programming language. A particularly welcome and useful feature of the CARL system is now an automatic restart capability, which has already automatically operated successfully after some minor power failures on the campus.

2) (frm) The initial music synthesis program, CMUSIC, was written. CMUSIC is based on the well-promulgated MUSIC V program, but with many improvements and extensions. MUSIC V conventions are used where possible to permit experienced users to use CMUSIC as quickly and effectively as possible. Improvements and extensions to MUSIC V include the fact that CMUSIC is written entirely in C, it is entirely dynamic in its use of memory, it allows an arbitrary number of notes to be played simultaneously on one instrument, instruments and functions are more flexible, a macro preprocessor is used on the score, numerical expressions may be given, new mnemonic commands for setting the sampling rate, etc., are provided, variable length functions may be defined and used, and the size of io blocks is under user control. This program will act as the main software synthesis program for the CARL system until the realtime hardware is constructed. It has also attracted the attention of the computer music community as an attractive program for widespread distribution.

3) (dgl) The sound file system was written to support a highly flexible and powerful digital audio storage, synthesis, editing, and processing system. The sound file system resides on the 300 MB disc drive and packs, and features separate ASCII header files which can be used to retain arbitrary information about each sound file. The sound files themselves may be either contiguously stored cylinder-wise for realtime access or noncontiguously for flexible variation in size. Sound files themselves contain multiplexed sample values in either 16 bit binary fractional

format, or 32 bit floating point format. Arbitrary multiplexing and data formats are supported.

4) (rusty, frm) Initial plotting software for the VT-55 graphics terminal was implemented. This software allows the display of waveform and spectral data in the relatively simple manners supported by the VT-55.

5) (jos, frm) A great deal of signal processing software was implemented, including programs to arbitrarily filter, analyze, and change the sampling rate of sound files. The entire IEEE package, which contains over 30 extremely powerful programs for digital signal processing, was obtained and is the basis for much of the signal processing software at CARL. Additional programs have been supplied and implemented by JOS, including interactive programs for FIR filter design and use. JOS has documented these programs and their use in a special "help" system that promises to be of general utility.

6) (frm, dgl, rusty, rz) Generally useful software have been added to the system, including a program to continuously monitor the activity of the system on a screen terminal, a general purpose reverse polish expression program, a typing command to aid in the preparation of documents, and software to support communication with other computer systems. Initial learn scripts to help beginning users become quickly acquainted with the basics of computing were developed.

4. Other Activities

A number of other activities relevant to the CARL system included:

1) (frm) An intensive programming seminar was held June 23-26. The seminar met for two hours per day in a lecture/demonstration session, and included hands-on exercise in the use of the CARL system in general and the C programming language in particular. Attendants included Richard Zvonar, Ann Hankinson, David Felder, Tom Vollmer, Paul Tydelski, and Scott Makeig.

2) A significant technical interchange with the department of chemistry was initiated. Chemistry department computing staff has assisted considerably in the installation of the operating system and disc drive, in return for which they have received computing time on a noninterference basis.

3) The CARL recharge system has been worked out and submitted to UCSD administration for approval. The computer accounting system has been turned on, and software written to categorize and summarize CARL system use.