

Workshop on Acquisition of Advanced EDA Benchmark Datasets

Sponsored by the IEEE Circuits and Systems Society CANDE Technical Committee

Held at SIA Headquarters, San Jose, CA, November 11-12, 1998

Executive Summary

A workshop was held in conjunction with ICCAD 98 in San Jose to discuss project proposals for the introduction of Advanced Benchmark Datasets for use by the EDA community. Funding for the workshop and for projects to be sponsored is provided under a grant from The IEEE Circuits and Systems Society, (CAS), based on a proposal to the CANDE group, initiated by Steve Grout of SEMATECH. The workshop was organized by Justin Harlow of SRC and Steve Grout of SEMATECH.

The workshop resulted in tentative agreement to proceed with two initial EDA benchmark dataset acquisition projects:

1. A joint effort of Carnegie-Mellon University and Mitre Corporation to remove proprietary content from two signal processing designs. The designs will be released as benchmark datasets in the second and third quarters of 1999. Herman Schmit of CMU and Roberto Landrau of Mitre will submit a full proposal to the SRC. This proposal will then be reviewed by the workshop attendees and an *ad hoc* industry advisory board, and submitted in its final form to CAS for approval. The project will be funded by CAS, and work performed under an SRC contract.
2. A Request For Proposals will be formulated by representatives of the workshop group and distributed by the SRC for a new, public-domain, cell library, to address the needs of researchers developing EDA tools for the 250 and 180 nm technology generations. Detailed plans are not yet firm, but the intent is to fund the development of a specification for such a library based on trends defined in the National Technology Roadmap for Semiconductors (NTRS), with actual implementation of cells being performed by those chosen from respondents to the RFP. Distribution and licensing of the cell libraries is proposed to be modeled after procedures in use by the Free Software Foundation. The funding model for this project has not been worked out.

Introduction

Earlier in 1998, in response to a proposal from the IEEE CANDE technical committee, IEEE- CAS approved funding of an effort to generate advanced benchmark datasets and place them in the public domain for use by researchers and commercial organizations. The original proposal is available at [the CANDE web site](#).¹ The proposed funding model was to be as follows:

- IEEE CAS issues a purchase order to SRC to act on their behalf as a contract management agency.
- SRC sponsors a workshop, and solicits proposals from industry and academia to provide large, EDA benchmark datasets that are “sanitized” of all proprietary intellectual property (IP).
- Student interns are funded by the SRC, using CAS funds, to work in industry or universities as appropriate, and remove intellectual property and proprietary information from the datasets in question.
- The resulting datasets are placed in the public domain and disseminated through a suitable web server.

A preliminary “Birds of a Feather” (BOF) session was held on November 10 at ICCAD, followed by the workshop on November 11-12 in San Jose, CA. The workshop attendees were as follows:

Justin Harlow, SRC harlow@src.org

Steve Grout, SEMATECH steve.grout@sematech.org

Herman Schmit, CMU herman@ece.cmu.edu

Fran Brglez, North Carolina State University brglez@cbl.ncsu.edu

Andrew Kahng, UCLA abk@cs.ucla.edu

¹ This web site is password protected. Please contact the authors of this report for access information.

Chuck Alpert, IBM alpert@austin.ibm.com
Massoud Pedram, USC massoud@zugros.usc.edu
Nikil Dutt, UC Irvine dutt@ici.uci.edu
Bill Joyner, SRC joyner@src.org
Jason Cong, UCLA cong@cs.ucla.edu
Hilary Kahn, University of Manchester hkahn@cs.man.ac.uk
Scott Davidson, Sun Microsystems scott.davidson@eng.sun.com
Sury Maturi, LSI Logic smaturi@lsil.com
Roberto Landrau, Mitre Corporation landrau@mitre.org
Jacob Abraham, University of Texas jaa@cerc.utexas.edu
Dennis Brophy, Mentor Graphics dennis_brophy@mentorg.com

Workshop Objectives

This workshop was held as the first concrete step in the process of confirming goals, discussing approaches, and identifying candidate benchmark datasets. The objectives were to:

- Learn about past experiences in creating large scale benchmark datasets.
- Learn about two specific designs proposed as new benchmark datasets.
- Discuss general and specific needs and requirements for advanced benchmark datasets.
- Discuss the specific proposed projects
- Reach first-order consensus on project plans and scope.

The workshop was organized in three modules:

- Presentations about prior successes and proposed projects.
- Presentations from the university community and prospective users of advanced benchmarks.
- Roundtable discussion among attendees to clarify goals and establish an agenda.

Summary of Presentations

Details and presentation materials are available under <http://www.eda.org/benchmrk>.

Highlights and main points of the presentations were as follows:

Chuck Alpert, IBM

Chuck spoke as one who has successfully released benchmark datasets based on large industrial designs.

- Successfully “laundered” 18 IBM datasets and released them as partitioning benchmarks at ISPD 98.
- Datasets are available from <http://vlsicad.cs.ucla.edu/~cheese/ispd98.html>
- Major hurdles were not technical; actual processing of the datasets was done using straightforward converters and scripts.
- Successfully worked the system to wrest agreement from internal decision makers.
- Keys to future success:
 - Limit scope; determine must-haves for datasets
 - Be precise: define *exactly* what formats, models, etc. are important.
 - Consider a consensus Benchmarking Charter to guide future efforts. Make it easy for people to say “yes” by providing answers up-front to key concerns.

Herman Schmit, CMU

Herman spoke as a potential supplier of a new dataset as a candidate for the public domain.

- “Vertical” benchmarks are useful (and in many cases essential) in studying the system level impact of individual EDA tools and processes.

- CMUDSP is a DARPA-funded signal processor modeled on a commercial DSP product. Fabricated in 0.5 μm MOSIS process. Used mostly commercial tools in a somewhat eccentric flow, but the entire flow is available to interested parties.
- Verilog at all levels is available. Used a commercial compiler/simulator; provide binary translator for object code. Currently being used in class work and research to study low power design, testability, verification, manufacturability, etc. See <http://www.ece.cmu.edu/research/lowpower> for information.
- Alpha release will be ready by end of 1998. Issues proposed for CAS funding:
 - Flow currently includes many “niche” tools that are not necessarily useful for general benchmark application. Need to clean up and regularize flow.
 - References to proprietary Cascade libraries need to be converted to something in the public domain (MOSIS?).
 - Decomposition of the design into “composable” units.
- Future proposed projects: ARM design; this is a CMU project getting under way which could be tailored for use as a benchmark dataset, given funding.

Roberto Landrau, Mitre Corporation

Roberto also spoke as a “supplier”

- Mitre FIR filter chip
 - 1.5 million transistors, HP 0.5 μm process, 6 B operations per second, 60 M samples/sec, 60 MHz clock, 352 pin TBGA package.
 - 15K lines of synthesizable VHDL (RTL, clock-accurate)
 - 275K lines of generated gate level VHDL
 - Contains references to Cascade libraries too. Like CMU chip, needs to be remapped.
 - Need agreement from customer (US government) to release.
- There may be issues with placing this chip in the public domain. Conceivably, anyone could reverse engineer the original intent of the design and sell it commercially. Some alteration or concealment of its function may be necessary in order to obtain approval from Mitre and the customer to release it.

Nikil Dutt, UC Irvine

Nik presented his viewpoint on the value of benchmark datasets (for understanding performance of relatively mature algorithms), and also of Design Drivers (for exploration of tradeoffs and concepts in the early stages of research). The key distinction between benchmark datasets and design drivers is that drivers do not necessarily have to be either large or realistic; benchmarks, on the other hand, do need to be realistic in scale, technology, and architecture.

Jason Cong, UCLA

Jason focused on his “wish list” for new benchmarks. Highlights:

- Technology–related data, SPICE decks, RLC parameters, simplified design rules.
- Technology parameters for 250, 180 nm processes and beyond.
- DSM library abstraction: bounding box, pins, timing characterization.
- Forward projection of current parameters, using NTRS data.
- RTL description, hierarchy, constraints, test vectors
- Netlist and timing in EDIF, SDF
- Layout information: cell locations, global and detailed routing, etc.
- Where data is not available, use synthetic models with realistic properties.
- Public domain parsers for VHDL, Verilog, etc.
- Plug-and-Play design flow
- Develop a set of interconnect benchmarks for each of the NTRS nodes for use in development of parasitic and timing EDA tools.

Franc Brglez, NC State

Franc gave a short tutorial on the merits of Design of Experiments when using benchmarks to evaluate EDA heuristics. It is crucial that equivalence classes of datasets with known invariant properties be used, rather than isolated datasets, so as to determine whether perceived improvements are due to the algorithms or to chance. These techniques have been used to date only on “point” tools rather than flows. Reference datasets for equivalence classes need not be large to be useful.

Hilary Kahn, U Manchester

The STEED project aims to establish a repository of benchmarks. A major portion of the project is the development of metrics, characteristics of the data, and complexity measures. A search engine locates datasets with specified characteristics, to be used in designing experiments. The most difficult part has been simply getting the data promised by sponsors and industry. Datasets developed under the proposed project(s) resulting from this workshop would be included in the repository; these datasets may provide useful material for further research on design properties.

Andrew Kahng, UCLA

Benchmarks can be flawed by the details. It is very important to have not only the benchmark datasets, but reference implementations of the kinds of algorithms for which the datasets are targeted. We need some metrics and standards for how to measure and report benchmark results. Many results deal with non-problems and poor implementations of algorithms, rather than actual advances. Most results are nonreproducible as a result. One suggestion is that we arrange to have designs from MARCO become new benchmarks, and use the tools developed in the MARCO center as reference implementations.

Scott Davidson, Sun Microsystems

Scott discussed the effort begun at the International Test Conference which has resulted in some new benchmarks for test and testability problems. Current results, documentation, mail archives, etc. are at <http://www.cerc.utexas.edu/itc99-benchmarks/bench.html>. This effort is supported by the University of Texas, University of Delft, and Sun Microsystems.

Discussion

An open discussion was held on the second day of the workshop to clarify the issues and decide on an action plan. The group rapidly converged on two topics:

1. **Benchmark Datasets**. This was the original purpose of the workshop; it became clear that both the CMU dataset and the Mitre dataset have a lot in common in terms of design and tool flow, as well as the effort required to convert them to benchmarks. It was decided to structure a single project, with Herman Schmit as PI, to do the necessary work on both datasets. The activities to be covered, and the process, are as follows:
 - Herman Schmit and Roberto Landrau will author a proposal to SRC for the specific work to be done.
 - The group at this workshop will act as an *ad hoc* review board for the proposal evaluation.
 - Following feedback from the group and whatever changes are recommended, the SRC will submit the final proposal to CAS for review and funding approval.
 - Following CAS approval, SRC will initiate a contract with CMU for the actual work, and will perform all contract management activities on behalf of CAS.
2. **Common Library**. It became evident in the discussions that a major stumbling block for large scale benchmark generation is the lack of a realistic, submicron, public-domain cell or macro library. In fact, the lack of such a library is a major impediment to EDA research as a whole. The group agreed that it is necessary that we pursue such a library as a second project in support of the benchmark effort, as well as to support research in general. Several interesting alternatives were discussed, which are summarized below.

- ❑ There are commercial enterprises which will develop complete libraries for a fee, and grant full rights to the purchaser. This would cost something on the order of \$200K, but a well-designed, characterized library would result. No one knows who would fund this.
- ❑ Commercial EDA vendors have libraries that are used internally for software regression testing and customer evaluation. We could approach Synopsys, Mentor, Cadence, *et al.* to determine whether they might release such a library under some sort of open license for research use. In the same vein, IC manufacturers are likely to have obsolete libraries which might be candidates for release to the public domain. Dennis Brophy of Mentor and Sury Maturi of LSI Logic agreed to look into these avenues and report back to the group.
- ❑ The DARPA-sponsored Mississippi State University cell library is now obsolete, but we could approach the MSU participants to see whether they would develop a new generation library under contract. Franc Brglez agreed to provide the name of a contact at MSU.
- ❑ It might be possible to reverse-engineer MOSIS libraries from publicly available electrical and performance specifications.
- ❑ A university could conceivably develop a “plausible” library based on predicted NTRS data; such a library would not be useful for fabrication, but would have the advantage of representing advanced processes which are not yet available to researchers (*e.g.* 90 nm).

While all of these approaches have merit, the group appears to favor something like the last option. The skeleton of a project was discussed; a subgroup of the workshop attendees will form a committee to draft the requirements for a public domain cell library. This effort may require limited funding of meetings, travel, and possibly university participation. When the requirements document is complete, the SRC will publish it in a Request for Proposals. The RFP will solicit proposals from universities to design particular cells in conformance with the guidelines under contract; this funding may be feasible under the original CAS grant, or possibly other sources (*e.g.* ACM-SIGDA, SRC). In any event, funding details still need to be worked out. It is likely that, once the momentum is established for such an effort, other universities and interested groups would develop additional cells and contribute them to the library. The hope is that an open, self-sustaining community effort could be created along the lines used to develop, distribute, and maintain Linux, Perl, the Gnu software, and similar public domain community efforts.

It was decided that we should adopt a development and licensing policy modeled on the Free Software Foundation’s (FSF) [Gnu Public License](#), which allows free use and distribution of its software, so long as all credits and source code are always distributed with any release. The cell libraries would be overseen by a body which has not yet been identified (conceivably, this could be operated as a new subdivision of FSF itself). Minimal responsibilities of such a body would be to perform limited quality assurance, and web publication. Many details of such an arrangement will need to be worked out, but the group was in general agreement that such an approach is feasible and the project would be vital to design and EDA.

Action Items

1. Herman Schmit, Roberto Landrau: Jointly develop a proposal to SRC.
2. Justin Harlow: Coordinate formation of a library specification working group.
3. Dennis Brophy: Approach Mentor Graphics about release of internal test library.
4. Sury Maturi: Approach LSI Logic about release of an obsolete library.
5. Franc Brglez: Supply name of MSU cell library development people to SRC.
6. SRC: Draft a consensus Benchmarking Charter to guide future efforts.
7. Steve Grout: Pursue other sources of industrial benchmark datasets and additional funding options (see appendix)

Loose Ends

There are always some things that are left unspecified after a workshop like this. The following items were discussed, and need to be addressed:

1. Organization: Should this group be the nucleus of a standing organization? Should there be a follow-up meeting? A regular series of meetings?

2. Cell library project: A lot of work needs to be done to flesh out the ideas produced at the workshop. I ([Justin Harlow](#)) will volunteer to pull together a small group to work on the details and get the project started. Anyone interested in working on this please contact me.
3. Should this activity be driven by public RFPs, or can we legitimately use the seed money from CAS to target the specific people in the current proposal, without open competition? In my humble opinion, we should proceed as rapidly as possible with this effort in the spirit of a proof of concept; later work can, and should, be done via an open process. In any event, I will review this issue with SRC and CAS authority figures before proceeding.

Appendix

There are several related “loose ends” which were not discussed at the workshop due to lack of time. Nonetheless, they need to be addressed as extensions of the AEBM project:

1. Acquiring and sanitizing some additional large industry benchmark datasets.
2. Where to reposit the resulting benchmark datasets.
3. Setting up the rest of the www.eda.org web site to support this effort.
4. Beginning to plan a phase-2 AEBM program to be tentatively done with ACM SIGDA funding. Need to identify a chair and *ad hoc* sub-working group to begin this planning.
5. Review the several ideas brought up at the ICCAD98 BOF, including especially the suggestion by John Darringer of a 100M transistor Design Driver.
6. Should the notion of a benchmark charter or agreement, which could be used to sign up companies to provide benchmarks, be developed? (Perhaps more will be learned about the advisability of this as we proceed with the CMU/Mitre examples.)
7. Coat-tailing on design contests at HDL-Con, ISPD99 (none is currently considered), DAC, ICCAD, IP99 (is there one?), etc. That is, a contest at each of the main points of an overall flow.
8. A search within industry, say by raising this issue with the EDA Industry Council, getting Gary Smith and Richard Goering to write articles urging companies to consider donating sanitized datasets, getting it into the DAC99 keynote, etc.
9. Proposing one or more panels for upcoming major design and CAD conferences, discussing the importance of benchmarks, and communicating some of the initial steps we are pursuing.
10. Communicating it through The Institute (the IEEE newspaper that comes with Spectrum)
11. Promote benchmarking projects via SRC and SEMATECH advisory boards.