

HAC

HAC Ada Compiler

From an abandoned teaching project to a usable
script-like Ada tool

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HAC's history

1990's: Looking for a small, quick Ada compiler. Found SmallAda, an abandoned project with an operational compiler, including a programmable type system (arrays, records), nested subprograms, tasks.

1999: First attempt to translate SmallAda from Pascal to Ada, using **P2Ada**.

2009: Improved **P2Ada** to translate the full SmallAda sources.

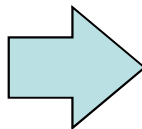
2013: January 24th: **Day Zero** of **HAC**. Hello World, Fibonacci, sorting demos and few other tests work!

2020: After a long sleep, the real development of **HAC** begins!

HAC's project goals

- **General motivation:** provide a simple, quick compiler
 - users: beginners, non IT specialists, or even IT specialists
 - focus: teaching, small programs such as text parsers, file converters, shell scripts launching applications, code generators, numerical simulations, ...
- **Former goal:** make it work. Have an Ada compiler that produces “Hello world!” with a tiny object code size.

```
with HAL;  
procedure Hello is  
begin  
  HAL.Put ("Hello world!");  
end Hello;
```

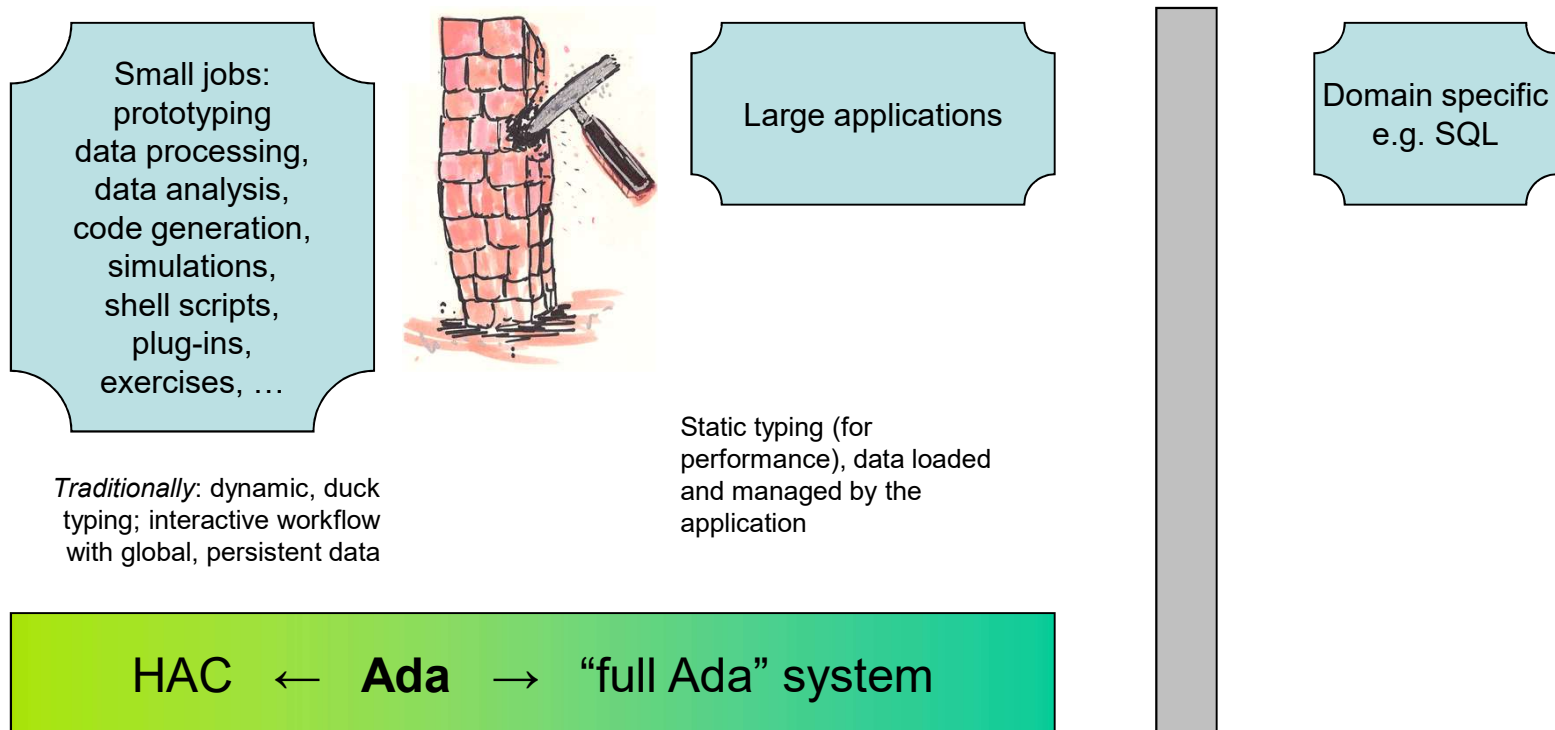


Position: Opcode	Approx source location
0: K_PUSH_TWO_DISCRETE_LITERALS	4 Hello
1: K_PUSH_TWO_DISCRETE_LITERALS	4 Hello
2: K_FILE_I_O	4 Hello; SP_PUT; "Hello world!"
3: K_HALT_INTERPRETER	5 [-- The Universe --]



HAC's project goals

- **New goal:** break the language wall between the “script” world and the “compiled” world



HAC's development in 2020 .. 2022

- Ada compatible
- Exception trace-backs
- HAL (HAC Ada Library) package with lots of goodies
- Variable-length strings (type HAL.VString)
- Text files (type HAL.File_Type)
- Subtypes
- Range checks
- Modularity (library-level packages, procedures and functions)

Behind the scenes:

- Regression test suite with 51 tests (36 thanks to [Advent of Code](#))
- Compiler: global variables replaced by OO
- Parser, VM interpreter were split into child packages

HAC's development in 2020 .. 2022

Behind the scenes (continued):

Before (e.g. in 2014):

A screenshot of the HAC development environment. The interface shows a menu bar at the top with options like File, Edit, Navigate, Find, Code, VCS, Build, SPARK, Analyze, Debug, View, Window, and Help. Below the menu bar is a toolbar with various icons. On the left side, there is a project tree with a 'Hac' folder containing several files: hac.ads, hac-compiler.adb, hac-compiler.ads, hac-data.adb, hac-data.ads, hac-parser.adb (highlighted), hac-parser.ads, hac-pcode.adb, hac-pcode.ads, hac-pcode-interpretter.adb, hac-pcode-interpretter.ads, hac-scanner.adb, hac-scanner.ads, hac-uerrors.adb, hac-uerrors.ads, and hac_test.adb. Below the project tree is an 'Outline' panel. The main editor window displays the contents of 'hac-parser.adb', showing several procedures: 'Term', 'Factor', and 'StandFct'. The code is written in a SPARK-like language with comments and type declarations. The status bar at the bottom indicates 'HAC.Parser.Block.TYP' and '551:22'.

HAC's development in 2020 .. 2022

Behind the scenes (continued):

Even before (Pascal-S, 1973):



```
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var y:item; op:symbol;

procedure term(fsys:symset; var x:item);
  var y:item; op:symbol; ts:typset;

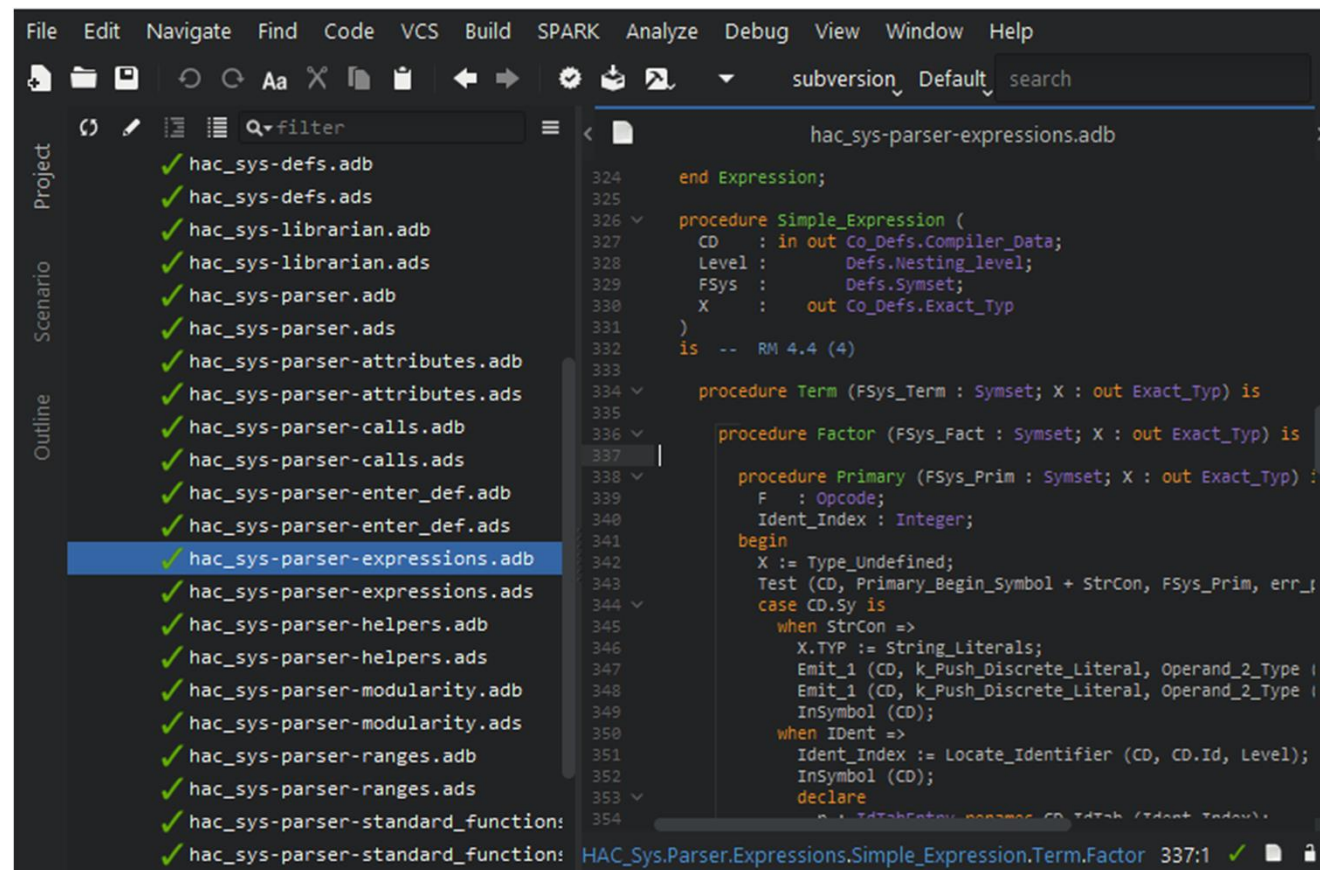
  procedure factor(fsys:symset; var x:item);
    var i,f: integer;

    procedure standfct(n: integer);
      var ts: typset;
    begin (*standard function no. n*)
      if sy = lparent then insymbol else error(9);
      if n < 17 then
        begin expression(fsys+[rparent],x);
          case n of
(*abs,sqr*)      0,2: begin ts := [ints,reals];
                     tab[i].typ := x.typ;
                     if x.typ = reals then n := n+1
                     end ;
(*odd,chr*)      4,5: ts := [ints];
(*ord*)          6:   ts := [ints,bools,chars];
(*succ,pred*)    7,8: ts := [chars];
(*round,trunc*)  9,10,11,12,13,14,15,16:
(*...*)          17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100,101,102,103,104,105,106,107,108,109,110,111,112,113,114,115,116,117,118,119,120,121,122,123,124,125,126,127,128,129,130,131,132,133,134,135,136,137,138,139,140,141,142,143,144,145,146,147,148,149,150,151,152,153,154,155,156,157,158,159,160,161,162,163,164,165,166,167,168,169,170,171,172,173,174,175,176,177,178,179,180,181,182,183,184,185,186,187,188,189,190,191,192,193,194,195,196,197,198,199,200,201,202,203,204,205,206,207,208,209,210,211,212,213,214,215,216,217,218,219,220,221,222,223,224,225,226,227,228,229,230,231,232,233,234,235,236,237,238,239,240,241,242,243,244,245,246,247,248,249,250,251,252,253,254,255,256,257,258,259,260,261,262,263,264,265,266,267,268,269,270,271,272,273,274,275,276,277,278,279,280,281,282,283,284,285,286,287,288,289,290,291,292,293,294,295,296,297,298,299,300,301,302,303,304,305,306,307,308,309,310,311,312,313,314,315,316,317,318,319,320,321,322,323,324,325,326,327,328,329,330,331,332,333,334,335,336,337,338,339,340,341,342,343,344,345,346,347,348,349,350,351,352,353,354,355,356,357,358,359,360,361,362,363,364,365,366,367,368,369,370,371,372,373,374,375,376,377,378,379,380,381,382,383,384,385,386,387,388,389,390,391,392,393,394,395,396,397,398,399,400,401,402,403,404,405,406,407,408,409,410,411,412,413,414,415,416,417,418,419,420,421,422,423,424,425,426,427,428,429,430,431,432,433,434,435,436,437,438,439,440,441,442,443,444,445,446,447,448,449,450,451,452,453,454,455,456,457,458,459,460,461,462,463,464,465,466,467,468,469,470,471,472,473,474,475,476,477,478,479,480,481,482,483,484,485,486,487,488,489,490,491,492,493,494,495,496,497,498,499,500,501,502,503,504,505,506,507,508,509,510,511,512,513,514,515,516,517,518,519,520,521,522,523,524,525,526,527,528,529,530,531,532,533,534,535,536,537,538,539,540,541,542,543,544,545,546,547,548,549,550,551,552,553,554,555,556,557,558,559,560,561,562,563,564,565,566,567,568,569,570,571,572,573,574,575,576,577,578,579,580,581,582,583,584,585,586,587,588,589,590,591,592,593,594,595,596,597,598,599,600,601,602,603,604,605,606,607,608,609,610,611,612,613,614,615,616,617,618,619,620,621,622,623,624,625,626,627,628,629,630,631,632,633,634,635,636,637,638,639,640,641,642,643,644,645,646,647,648,649,650,651,652,653,654,655,656,657,658,659,660,661,662,663,664,665,666,667,668,669,670,671,672,673,674,675,676,677,678,679,680,681,682,683,684,685,686,687,688,689,690,691,692,693,694,695,696,697,698,699,700,701,702,703,704,705,706,707,708,709,710,711,712,713,714,715,716,717,718,719,720,721,722,723,724,725,726,727,728,729,730,731,732,733,734,735,736,737,738,739,740,741,742,743,744,745,746,747,748,749,750,751,752,753,754,755,756,757,758,759,760,761,762,763,764,765,766,767,768,769,770,771,772,773,774,775,776,777,778,779,780,781,782,783,784,785,786,787,788,789,790,791,792,793,794,795,796,797,798,799,800,801,802,803,804,805,806,807,808,809,810,811,812,813,814,815,816,817,818,819,820,821,822,823,824,825,826,827,828,829,830,831,832,833,834,835,836,837,838,839,840,841,842,843,844,845,846,847,848,849,850,851,852,853,854,855,856,857,858,859,860,861,862,863,864,865,866,867,868,869,870,871,872,873,874,875,876,877,878,879,880,881,882,883,884,885,886,887,888,889,890,891,892,893,894,895,896,897,898,899,900,901,902,903,904,905,906,907,908,909,910,911,912,913,914,915,916,917,918,919,920,921,922,923,924,925,926,927,928,929,930,931,932,933,934,935,936,937,938,939,940,941,942,943,944,945,946,947,948,949,950,951,952,953,954,955,956,957,958,959,960,961,962,963,964,965,966,967,968,969,970,971,972,973,974,975,976,977,978,979,980,981,982,983,984,985,986,987,988,989,990,991,992,993,994,995,996,997,998,999,1000,1001,1002,1003,1004,1005,1006,1007,1008,1009,1010,1011,1012,1013,1014,1015,1016,1017,1018,1019,1020,1021,1022,1023,1024,1025,1026,1027,1028,1029,1030,1031,1032,1033,1034,1035,1036,1037,1038,1039,1040,1041,1042,1043,1044,1045,1046,1047,1048,1049,1050,1051,1052,1053,1054,1055,1056,1057,1058,1059,1060,1061,1062,1063,1064,1065,1066,1067,1068,1069,1070,1071,1072,1073,1074,1075,1076,1077,1078,1079,1080,1081,1082,1083,1084,1085,1086,1087,1088,1089,1090,1091,1092,1093,1094,1095,1096,1097,1098,1099,1100,1101,1102,1103,1104,1105,1106,1107,1108,1109,1110,1111,1112,1113,1114,1115,1116,1117,1118,1119,1120,1121,1122,1123,1124,1125,1126,1127,1128,1129,1130,1131,1132,1133,1134,1135,1136,1137,1138,1139,1140,1141,1142,1143,1144,1145,1146,1147,1148,1149,1150,1151,1152,1153,1154,1155,1156,1157,1158,1159,1160,1161,1162,1163,1164,1165,1166,1167,1168,1169,1170,1171,1172,1173,1174,1175,1176,1177,1178,1179,1180,1181,1182,1183,1184,1185,1186,1187,1188,1189,1190,1191,1192,1193,1194,1195,1196,1197,1198,1199,1200,1201,1202,1203,1204,1205,1206,1207,1208,1209,1210,1211,1212,1213,1214,1215,1216,1217,1218,1219,1220,1221,1222,1223,1224,1225,1226,1227,1228,1229,1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230,2231,2232,2233,2234,2235,2236,2237,2238,2239,2240,2241,2242,2243,2244,2245,2246,2247,2248,2249,2250,2251,2252,2253,2254,2255,2256,2257,2258,2259,2260,2261,2262,2263,2264,2265,2266,2267,2268,2269,2270,2271,2272,2273,2274,2275,2276,2277,2278,2279,2280,2281,2282,2283,2284,2285,2286,2287,2288,2289,2290,2291,2292,2293,2294,2295,2296,2297,2298,2299,2300,2301,2302,2303,2304,2305,2306,2307,2308,2309,2310,2311,2312,2313,2314,2315,2316,2317,2318,2319,2320,2321,2322,2323,2324,2325,2326,2327,2328,2329,2330,2331,2332,2333,2334,2335,2336,2337,2338,2339,2340,2341,2342,2343,2344,2345,2346,2347,2348,2349,2350,2351,2352,2353,2354,2355,2356,2357,2358,2359,2360,2361,2362,2363,2364,2365,2366,2367,2368,2369,2370,2371,2372,2373,2374,2375,2376,2377,2378,2379,2380,2381,2382,2383,2384,2385,2386,2387,2388,2389,2390,2391,2392,2393,2394,2395,2396,2397,2398,2399,2400,2401,2402,2403,2404,2405,2406,2407,2408,2409,2410,2411,2412,2413,2414,2415,2416,2417,2418,2419,2420,2421,2422,2423,2424,2425,2426,2427,2428,2429,2430,2431,2432,2433,2434,2435,2436,2437,2438,2439,2440,2441,2442,2443,2444,2445,2446,2447,2448,2449,2450,2451,2452,2453,2454,2455,2456,2457,2458,2459,2460,2461,2462,2463,2464,2465,2466,2467,2468,2469,2470,2471,2472,2473,2474,2475,2476,2477,2478,2479,2480,2481,2482,2483,2484,2485,2486,2487,2488,2489,2490,2491,2492,2493,2494,2495,2496,2497,2498,2499,2500,2501,2502,2503,2504,2505,2506,2507,2508,2509,2510,2511,2512,2513,2514,2515,2516,2517,2518,2519,2520,2521,2522,2523,2524,2525,2526,2527,2528,2529,2530,2531,2532,2533,2534,2535,2536,2537,2538,2539,2540,2541,2542,2543,2544,2545,2546,2547,2548,2549,2550,2551,2552,2553,2554,2555,2556,2557,2558,2559,2560,2561,2562,2563,2564,2565,2566,2567,2568,2569,2570,2571,2572,2573,2574,2575,2576,2577,2578,2579,2580,2581,2582,2583,2584,2585,2586,2587,2588,2589,2590,2591,2592,2593,25
```

HAC's development in 2020 .. 2022

Behind the scenes (continued):

Currently:



The screenshot shows the HAC development environment. On the left, a project list is displayed with a search filter. The list includes files like `hac_sys-defs.adb`, `hac_sys-librarian.adb`, `hac_sys-parser.adb`, and `hac_sys-parser-expressions.adb`, all marked with green checkmarks. The file `hac_sys-parser-expressions.adb` is selected. On the right, the code editor shows the implementation of the `Simple_Expression` procedure, including nested procedures `Term` and `Factor`. The code is written in a Pascal-like syntax. The status bar at the bottom indicates the current position in the code: `HAC.Sys.Parser.Expressions.Simple_Expression.Term.Factor 337:1`.

HAC's characteristics

- **Build time** of the full HAC compiler & VM interpreter, by GNAT: 7.8 seconds (i7-9700 CPU @ 3.00GHz, using 8 cores)
- **Build time** of test/floats.adb (346 lines), by HAC: 0.003 second; by GNAT: 1.2 second
- **System dependency:** none
- **Ada source input:** any stream (file, editor data, web stream, zip archive, ...)
- **Target:** Virtual Machine (p-code with ad-hoc extensions)

HAC's future

- **More Ada features**
- **Interfacing (HAC \leftrightarrow native “full Ada”)**
- **Built-in libraries:**
 - SQLite
 - Some portable graphical toolkit
 - Ada.*

Where to find **HAC** ?

HAC is free, open-source (MIT license)

- **SourceForge:**

- Home page: <https://hacadacompiler.sourceforge.io/>
- Project page: <https://sourceforge.net/projects/hacadacompiler/>

- **Github:** <https://github.com/zertovitch/hac>

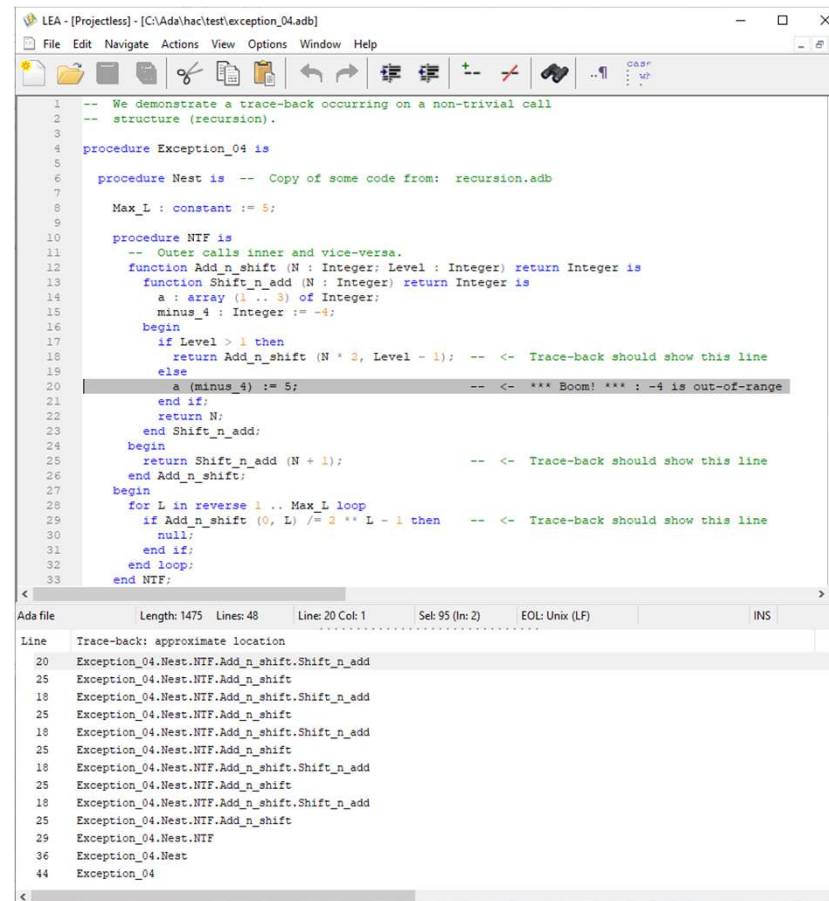
Projects related to **HAC**

LEA:

Lightweight Editor for Ada

- <https://sourceforge.net/projects/l-e-a/>
- <https://github.com/zertovitch/lea>

LEA embeds HAC.



The screenshot shows the LEA editor window titled "LEA - [Projectless] - [C:\Ada\hac\test\exception_04.adb]". The editor displays an Ada program with the following code:

```
1  -- We demonstrate a trace-back occurring on a non-trivial call
2  -- structure (recursion).
3
4  procedure Exception_04 is
5
6      procedure Nest is -- Copy of some code from: recursion.adb
7
8          Max_L : constant := 5;
9
10         procedure NTF is
11             -- Outer calls inner and vice-versa.
12             function Add_n_shift (N : Integer; Level : Integer) return Integer is
13                 function Shift_n_add (N : Integer) return Integer is
14                     a : array (1..5) of Integer;
15                     minus_4 : Integer := -4;
16                 begin
17                     if Level > 1 then
18                         return Add_n_shift (N * 2, Level - 1); -- <- Trace-back should show this line
19                     else
20                         a (minus_4) := 5; -- <- *** Boom! *** : -4 is out-of-range
21                     end if;
22                     return N;
23                 end Shift_n_add;
24                 begin
25                     return Shift_n_add (N + 1); -- <- Trace-back should show this line
26                 end Add_n_shift;
27             begin
28                 for L in reverse 1 .. Max_L loop
29                     if Add_n_shift (0, L) /= 2 ** L - 1 then -- <- Trace-back should show this line
30                         null;
31                     end if;
32                 end loop;
33             end NTF;
34 end Exception_04;
```

The bottom of the window shows a table with the following columns: "Ada file", "Length: 1475", "Lines: 48", "Line: 20 Col: 1", "Set: 95 (In: 2)", "EOL: Unix (LF)", and "INS". The table lists the following trace-back locations:

Line	Trace-back: approximate location
20	Exception_04.Nest.NTF.Add_n_shift.Shift_n_add
25	Exception_04.Nest.NTF.Add_n_shift
18	Exception_04.Nest.NTF.Add_n_shift.Shift_n_add
25	Exception_04.Nest.NTF.Add_n_shift
18	Exception_04.Nest.NTF.Add_n_shift.Shift_n_add
25	Exception_04.Nest.NTF.Add_n_shift
18	Exception_04.Nest.NTF.Add_n_shift.Shift_n_add
25	Exception_04.Nest.NTF.Add_n_shift
18	Exception_04.Nest.NTF.Add_n_shift.Shift_n_add
25	Exception_04.Nest.NTF.Add_n_shift
29	Exception_04.Nest.NTF
36	Exception_04.Nest
44	Exception_04

Pascal-to-Ada

- <https://sourceforge.net/projects/p2ada/>
- <https://github.com/zertovitch/pascal-to-ada>

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