

# Fortran Resources <sup>1</sup>

Ian D Chivers      Jane Sleightholme

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<sup>1</sup>The original basis for this document was Mike Metcalf's Fortran Information File. The next input came from people on comp-fortran-90. Details of how to subscribe or browse this list can be found in this document. If you have any corrections, additions, suggestions etc to make please contact us and we will endeavor to include your comments in later versions. Thanks to all the people who have contributed.

## Revision history

- March 2017, updated the Oracle entry to have details of the 12.6 beta.
- December 2016, updated the gfortran entry to add details about using the Windows subsystem for Linux option. Thanks to Paul Richard Thomas for the post to comp.lang.fortran about this.
- June 2016, updated the Pathscale compiler entry and added details of their Dogfood IDE in the IDE section
- May 2016, added entries for Nag Fortran Builder for the Windows and Apple Mac operating systems.
- May 2016, added a new section on Object Oriented Programming, in Other Web Links, with link to a site with very good coverage of the subject.
- May 2016, added some entries to the Fortran History section, in Other Web Links.
- May 2016, Minor corrections; added Oracle 12.5 beta
- April 2016, Added PLplot and GTK+ entries
- April 2016, Updated the Nag and Oracle compiler entries. Added a new book. Added a new course under the NAG entry.
- July 2015. Updated the Cray compiler entry - Thanks to Bill Long for providing up to date information. Changed various entries in the course section. Most notable were adding an entry for Sourcery Inc and the Archer service at Edinburgh, and deleting the Hector entry. Added Doctran (cross-platform documentation generation tool for the Fortran) to the Tools section.
- June 2015. Added coverage of free compilers, compilers free for personal use, and Intel's free compiler offer for educational users. Added Chivers and Sleightholme third edition, due 14 August 2015
- 10 March 2015. Corrected missing German ß in an address. Thanks to Rolf Maier for pointing this out.
- 9 March 2015. Added an entry for coarray.org in the Coarray section of the parallel programming entry. Editorial changes: page size; long urls split over two lines; minor setting corrections.
- 30 January 2015. Added an entry for Microsoft Visual Studio 2013 Community Edition. This free version is equivalent to Microsoft Visual Studio 2013 Professional. Updated the Nag entry in the Tools section to provide details of the capability of the Nag compiler. The compiler can now produce call graphs, do a dependency analysis, produce interface modules and pretty print or polish Fortran code.

- 3 September 2014, Added entries for two ides, Code::Blocks and geany. The information came from an interchange on linkedin.
- 10 February 2014, Added an errata entry for the The Fortran 2003 Handbook and an index entry for the same book. Thanks to Dick Hendrickson and John Harper for posting to comp-fortran-90 about these items.
- February 2014, Checked various entries and web links. Missed some urls with leading and trailing spaces in an earlier update, and these have now been fixed. Corrected some spelling.
- November 29 2013. Added one new book entry and updated an existing book entry.
- August 6 2013 Minor changes to the IDE chapter. Also corrected urls that have leading spaces after the opening brace.



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# Chapter 1

## Books

- Version 1.14, April 2016; Added the latest Walt Brainerd book.
- Version 1.13, June 2015; Added the latest Chivers and Sleightholme book.
- Version 1.12, 10 February 2014; Updated the Fortran 2003 Handbook entry.
- Version 1.11, February 2014; Corrected some spelling.
- Version 1.10, November 2013; Added an entry for the Hanson and Hopkins book. Also updated the entry on Adams, Brainerd et al, which is now available from Springer as an ebook in PDF format.
- Version 1.9, May 2013; An errata list for Modern Fortran Explained, Metcalf, Reid and Cohen is now available.
- Version 1.8, January 2013; Added Section 1.1, Metcalf, Reid, Cohen; Thanks to Anton Shterenlikht for pointing out this omission!
- Version 1.7, August 2012; Added Section 1.1, Chivers; Added Section 1.1, Markus;
- Version 1.6, January 2012; Added Section 1.5 Chivers;
- Version 1.5, October 2011; Added Section 1.1 Chivers; Added Section 1.1 Clerman; Added Section 1.1 Gnu Fortran; Added Section 1.1 Rouson; Added Section 1.2 Lakshmivarahan;
- Version 1.4, July 2010; Added Section 1.1 Brainerd; Added Section 1.1 McCormack; Added Section 1.1 Ray; Added Section 1.2 Rajaram; Added Section 1.3 Barlow et al; Added Section 1.4 Chandra et al; Added Section 1.4 Chapman et al;
- Version 1.3, June 2009; Removed invalid web address in Morgan and Schonfelder entry; Corrected spelling in Chinese entry;

- Version 1.2, September 2008; Added Section 1.1, Adams et al; Added Section 1.10, Ciaburro;
- Version 1.1, September 2007; Added Section 1.1, Chapman; Added Section 1.2, Lemmon;

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[http://www.fortran.com/F03HB\\_errata.html](http://www.fortran.com/F03HB_errata.html)

and an additional set of index entries at

<http://homepages.ecs.vuw.ac.nz/~harper/f2003handbookindex>

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- Chivers I.D., Sleightholme J., Introduction to Programming with Fortran: With coverage of Fortran 90, 95, 2003, 2008 and 77. 2012, Springer Verlag. ISBN-10: 0857292323 ISBN-13: 978-0857292322, Second Edition
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- Markus A., Modern Fortran in Practice, 2012, Cambridge University Press, ISBN-10: 1107017904 ISBN-13: 978-1107017900
- McCormack D., Scientific Software Development with Fortran, 2009, ISBN 978-1-4452-5445-6
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`ftp://ftp.numerical.rl.ac.uk/pub/MRandC/edits.pdf`
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- Ray S., A Textbook on Fortran 2003, 2009, Alpha Science International, ISBN 978-1-84265-479-8
- Rouson D., Xia J., Xu X., Scientific Software Design: The Object-Oriented Way Cambridge University Press, 2011. ISBN-10: 0521888131 ISBN-13: 978-0521888134

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- Adams J.C., Brainerd W.S., Martin J.T. and Smith B.T., Fortran Top 95, Ninety Five Key Features of Fortran 95, \$10 The book is only available in PDF form from the Fortran Store,  
  
`http://www.fortran.com/`
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<http://www.fortran.com/>
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- Brooks ., Problem solving with Fortran 90: for scientists and engineers, 1997, Springer. ISBN 0-387-98229-9.



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- Ellis, Philips, Lahey, *Fortran 90 Programming*, 1994, Addison Wesley, ISBN 0-201-54446-6.
- Etter ., *Fortran 90 for Engineers*, 1995, Benjamin/Cummings ISBN 0-201544-46-6.
- Gehrke, *Fortran 90 Language Guide*, 1996, Springer ISBN 3-540-19926-8
- Hahn D.B., *Fortran 90 for Scientists and Engineers*, 1994, Edward Arnold ISBN 0-340-60034-9.
- Huddleston ., *Fortran 90*, 1996, Exchange Publ. Div., ISBN 0-945261-07-1.
- Kerrigan J.F., *Migrating to Fortran 90*, 1993, O'Reilly. ISBN 1-56592-049-X
- Meissner L.P., *Fortran 90*, 1995, PWS Kent ISBN 0-534-93372-6.
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- Redwine ., *Upgrading to Fortran 90*, 1995, Springer-Verlag, ISBN 0-387-97995-6.
- Schick ., Silverman ., *Fortran 90 and Engineering Computation*, 1994, John Wiley, ISBN 0-471-58512-2.
- Smith I.M., *Programming in Fortran 90*, ?, Wiley ISBN 0471-94185-9.
- Wagener ., *Fortran 90 Concise Reference*, 1998, Absoft. ISBN 0-9670066-0-0.

## 1.4 English books on related topics

- *Advanced Scientific Computing* - Wille, Wiley, 1995, ISBN 0471-95383-0.
- *Atlas for Computing Mathematical Functions ... in Fortran 90 and Mathematica* - Thompson, Wiley, 1997, 0-471-18171-4.

- Contemporary Computing for Technical Engineers and Scientists: using Fortran 90 and spreadsheets - Forsythe, PWS, 1997, 0-534-93139-1.
- Numerical Recipes in Fortran 90: The Art of Parallel Scientific Computing, Volume 2 of Fortran Numerical Recipes - Press, Teukolsky, Vetterling and Flannery, Cambridge U. Press, ISBN 0-521-57439-0, 1996. Code can be downloaded (purchased) from

<http://www.nr.com/>

A CDROM is also available (see Web site).

## 1.5 Chinese

- Introduction to Programming with Fortran, with coverage of Fortran 90, 95, 2003 and 77. Ian Chivers and Jane Sleightholme. Posts and Telecom Press and Springer-Verlag London. 2009. ISBN 978-7-115-21227-6. (A translation of Introduction to Programming in Fortran).
- Programming Language Fortran 90 - He Xingui, Xu Zuyuan, Wu Qingbao and Chen Ming yuan, China Railway Publishing House, Beijing, ISBN 7-113-01788-6/TP.187, 1994.
- Fortran 90 - Walter S. Brainerd, Charles H. Goldberg, Jeanne C. Adams, CHEP, Beijing, and Springer, Berlin, 2000, ISBN 7-04-007937-2 (a translation of Programmer's Guide to Fortran 90).

## 1.6 Dutch

- Fortran 90 - W.S. Brainerd, Ch.H. Goldberg, and J.C. Adams, translated by J.M. den Haan, Academic Service, 1991, ISBN 90 6233 722 8.

## 1.7 Finnish

- Fortran 90/95 - Juha Haataja, Jussi Rahola and Juha Ruokolainen. Center for Scientific Computing (Finland), 2001, 339 pages, 3rd edition, ISBN 952-9821-60-3. WWW version:

<http://www.csc.fi/oppaat/f95/>

## 1.8 French

- Fortran 90; Approche par la Pratique - P. Lignelet, Srie Informatique ditions, Menton, 1993, ISBN 2-909615-01-4.
- Fortran 90. Les concepts fondamentaux, the translation of Fortran 90 Explained, M. Metcalf, J. Reid, translated by M. Caillat and B. Pichon, AFNOR, 1993, Paris, ISBN 2-12-486513-7.
- Fortran 90; Initiation partir du Fortran 77 - Aberti, Srie Informatique ditions, Menton, 1992, ISBN 2-909615-00-6.
- Les spcificits du Fortran 90, M. Dubesset et J. Vignes, ditions Technip, 1993 . ISBN 2-7108-0652-5.
- Manuel complet du langage Fortran 90, et guide dapplication, P. Lignelet, Srie Informatique ditions, 1995. ISBN 2-909615-02-2.
- Manuel Complet du Langage Fortran 90 et Fortran 95, Calcul intensif et Gnie Logiciel, P. Lignelet, Masson ditions, Paris, 1996, ISBN 2-225-85229-4.
- Programmer en Fortran 90, C. Delannoy, Eyrolles, 1992, ISBN 2-212-08723-3.
- Traitement des donnes numriques avec Fortran 90, M. Olagnon, Masson ditions, 1996, ISBN 2-225-85259-6.
- Structures des donnes (et leurs algorithmes) en Fortran 90/95, P. Lignelet, Masson ditions, Paris, ISBN 2-225-85373-8.

## 1.9 German

- Fortran 90 Lehrbuch D. Rabenstein, Hanser, 1995, ISBN 3-446-18235-7.
- Die Programmiersprache F W. Gehrke, Springer-Verlag, ISBN 3-540-63376-6.
- Fortran 90 - B.Wojcieszynski and R.Wojcieszynski, Addison-Wesley, 1993, ISBN 3-89319-600-5.
- Fortran 90: eine informelle Einfhrung M. Heisterkamp, BI-Wissenschaftsverlag, 1991, ISBN 3-411-15321-0.
- Fortran 90 Kurs: technisch orientiert - G. Schmitt, Oldenbourg, 1996, ISBN 3-486-23896-5
- Fortran 90, Lehr- und Arbeitsbuch fr das erfolgreiche Programmieren, W.S. Brainerd, C.H. Goldberg, and J.C. Adams, translated by Peter Thomas and Klaus G. Paul, R. Olbenbourg Verlag, Muenchen, 1994, ISBN 3-486-22102-7.
- Fortran 90 Lehr- und Handbuch - T. Michel, BI-Wissenschaftsverlag, 1994.

- Fortran 90 Referenz-Handbuch: der neue Fortran-Standard W. Gehrke, Carl Hansen Verlag, 1991, ISBN3-446-16321-2.
- Programmierung in Fortran 90 - Schobert, Oldenburg, 1991.
- Programmierung mit Fortran 90 - Bumer, Vieweg, Braunschweig, 1997, ISBN 3-528-05208-2.
- Programmieren in Fortran - Erasmus Langer, Springer-Verlag, Wien New York, 1993. ISBN 3-211-82446-4, 0-387-82446-4.
- Software Entwicklung in Fortran 90 - berhuber and Meditz, Springer Verlag, 1993, ISBN 0-387-82450-2.

## 1.10 Italian

- Titolo: Programmare con Fortran versioni 90952003 Autore: Ciaburro Giuseppe  
[http://www.ibs.it/code/9788882336882/ciaburro-giuseppe/  
programmare-con-fortran.html](http://www.ibs.it/code/9788882336882/ciaburro-giuseppe/programmare-con-fortran.html)

## 1.11 Japanese

- Fortran 90 Explained - Metcalf and Reid, translated by H. Nisimura, H. Wada, K. Nishimura, M. Takata, Kyoritsu Shuppan Co., Ltd., 1993, ISSN 0385-6984.
- Interactive Fortran 77, A Hands On Approach - I.D. Chivers and Malcom Clark. Ellis Horwood, 1984. Keigaku Publishing Company, Tokyo.

## 1.12 Russian

- An Explanation of the Fortran 90 Programming Language (translation of Fortran 90 Explained - Metcalf and Reid), translated P. Gorbounov, Mir, Moscow, 1995, ISBN 5-03-001426-8. Available also from Petr.Gorbounov@cern.ch.
- FORTRAN 77 to Fortran 90 Tutorial - Einarsson and Shokin, Russian Academy of Sciences, Novosibirsk, 1995, ISBN 5-85826-013-6.

## 1.13 Swedish

- Fortran 90 - en introduktion - Blom, Studentlitteratur, Lund, 1994, ISBN 91-44-47881-X.

# Chapter 2

## Compilers

- Version 1.10, March 2017. Updated to have details of the Oracle 12.6 beta version.
- Version 1.9, December 2016; Updated the gfortran entry to include details of using the Windows subsystem for Linux option. Thanks to Paul Richard Thomas for the post to comp.lang.fortran bringing this to our attention
- Version 1.8, June 2016; Updated the Pathscale entry
- Version 1.17, May 2016; Minor edits, added the Oracle 12.5 beta.
- Version 1.16, April 2016, Updated the NAG and Oracle entries.
- Version 1.15, July 2015. Updated the Cray entry.
- Version 1.14, June 2015. Added coverage of free compilers, compilers free for personal use, and Intel's free compiler offer for educational users.
- Version 1.13, May 2013. Added an entry for Lahey GNU Shasta compiler. Thanks to Polyhedron Software for this information.
- Version 1.12, January 2013. Added entry for OpenUH. Minor editorial changes. Thanks to Anton Shterenlikht for these updates and corrections.
- Version 1.11, January 2013. Added entry for Nocturnal Aviation Software.
- Version 1.10, August 2012. Updated Nag entry. 5.3 release supports OpenMP. Also updated product availability entry.
- Version 1.9, November 2010. Updated Absoft in response to an email from Wood Lotz.
- Version 1.8, July 2010. Updated Sun to reflect takeover by Oracle. Updated Salford to reflect Silverfrost rebranding.

- Version 1.7, June 2009. Updated the Cray and Intel entries. Added a new section on compilers that are no longer available. This has involved moving the entries on Apogee, Compaq and NA Software into this section. For historical completeness we've also added an entry for EPC to this section.
- Version 1.6, September 2008. Updated the NAG entry with more details of the Fortran Builder IDE.
- Version 1.5, September 2007. Updated Absoft Entry, Compaq, Fortran Company, Fujitsu, Gnu Fortran 95, G95, IBM, Intel, Lahey/Fujitsu, NAG, NA Software, NEC, Pathscale, PGI, Salford/Silverfrost, SGI, Sun.

## 2.1 Introduction

The following is a list of companies and organisations that provide Fortran compilers that conform to the Fortran 90, 95, 2003 and 2008 standards. Fortran Forum has a more or less standing table on compilers that support features from the 2003 and 2008 standards and TS

### 2.1.1 Free compilers for general use

The following compilers are free for general use. We have included short extracts from their web sites.

- g95 - G95 is a stable, production Fortran 95 compiler available for multiple cpu architectures and operating systems. Innovations and optimizations continue to be worked on. Parts of the F2003 and F2008 standards have been implemented in g95.
- gfortran - Gfortran is the name of the GNU Fortran project, developing a free Fortran 95/2003/2008 compiler for GCC, the GNU Compiler Collection.
- HP - Only for OpenVMS. Last update 2007. Requires an Alpha or Itanium processor.
- Oracle - Current Release - Oracle Solaris Studio 12.4; Beta release is 12.5; Provides perpetual no-cost license for production use and the development of commercial applications.

You have to accept the license agreement.

<http://www.oracle.com/technetwork/licenses/solaris-studio-license-169628.html>

### 2.1.2 Free for personal use

The following compilers are free for personal use. License terms have been included.

- Silverfrost - Silverfrost FTN95 can now be used free for personal use. It is strictly for personal use or evaluation purposes. You can use it at home on your own personal projects. You can use it to evaluate FTN95 with the intention of purchasing it later. Any applications you create with it will display a banner announcing that it is the personal edition. This product is not directly supported but you can post questions in our forums.

### 2.1.3 Free for educational use

- Intel - check the conditions in the Intel entry.

## 2.2 Absoft

<http://www.absoft.com/>

Here are some details taken from the Absoft site.

Absoft's Pro Fortran tool suite automates building extremely fast parallel code on multi-core systems. Compiler features include: APO, IPO, PGFDO optimizers and auto vectorization, Absoft's exclusive Dynamic AP load balancing technology - performance increases up to 20% on multi-core systems, SMP graphical code analyzer and OpenMP 3.0 support, Absoft Window Environment (AWE), External Libraries and Tools Plug-in, expanded F2003 & F2008 support and enhanced Fx3 graphical debugger.

Available for Windows, Linux, MacOS Intel and PPC.

## 2.3 Cray

<http://www.cray.com/>

Cray has a fully optimizing Fortran 2008 compiler available for Cray XE, XK, and XC systems. The compiler supports OpenMP, OpenACC, and the enhanced features for interoperating with C described in TS 29113.

## 2.4 Fortran Company

<http://www.fortran.com/>

The Fortran Company offers F, the subset language, for Unix and Windows, some in highly optimizing versions. All of the full professional versions of the F compiler are available free by downloading them from the F anonymous ftp directory.

The Fortran Tools include a Fortran 95 compiler with a graphical user interface that runs on Linux or Windows on a CD. The CD also includes several Fortran books in PDF format and many tools, such as Matran, a matrix computation library that uses the highly tuned Atlas libraries, a plotting package, and a library of routines to create GUIs for your Fortran application programs.

## 2.5 Fujitsu

<http://www.fujitsu.com/global/>

Fortran 95 (Solaris) A powerful, updated development system used for FORTRAN productive applications Current version: Sun Studio 9

The ISO Fortran 95 Standard is fully supported, additionally there are enhancements for Fortran77 such as pointers/structures, binary/octal/hexadecimal constants, etc. High optimization includes automatic parallelization and OpenMP support. A Fortran runtime system optimized for UltraSPARC is now also included in the package. The development environment consists of the following components:

Workbench: An integral development environment for the C/C++ and Fortran compilers, for compiler control, program execution, debugging, performance analysis, coverage etc. with a Motif-based graphical user interface (GUI).

Visual Analyzer: A development and migration tool for C/C++ and Fortran programs. The enclosed Source Analyzer allows the static program structure and the global data relations to be visualized. It contains a class browser, cross references and a calling graph viewer.

Parallel Analyser: Consists of an integrated development environment for the OpenMP programming. It contains a manager, a debugger and a profiler.

Fujitsu also has a Fortran 95 compiler for Linux and a highly optimized, native Fortran 95 compiler, Fortran/VPP and HPF, for its VPP supercomputers.

## 2.6 Gnu Fortran

<http://gcc.gnu.org/wiki/GFortran>

<http://gcc.gnu.org/fortran/>

Gfortran is the name of the GNU Fortran project, developing a free Fortran 9520032008 compiler for GCC, the GNU Compiler Collection. The gfortran development effort uses an open development environment in order to attract a larger team of developers and to ensure that gfortran can work on multiple architectures and diverse environments.

There are several options for installing and using gfortran on a Windows platform. The most recent option for Windows 10 is to use the Windows subsystem for Linux. We are currently updating our gfortran Windows notes to include details on how to do this. Thanks to Paul Richard Thomas for the post to comp.lang.fortran for bringing this to our attention.



## 2.7 g95

<http://www.g95.org/>

g95 is a stable, production Fortran 95 compiler available for multiple cpu architectures and operating systems. Innovations and optimizations continue to be worked on. Parts of the F2003 standard have been implemented in g95.

## 2.8 Hewlett Packard

The web address that describes all of the compilers and supported hardware and operating systems is

[http://h21007.www2.hp.com/dspp/tech/tech\\_TechSoftwareDetailPage\\_IDX/1,1703,6235,00.html](http://h21007.www2.hp.com/dspp/tech/tech_TechSoftwareDetailPage_IDX/1,1703,6235,00.html)

HP's Fortran products are available for multiple platforms: Windows, Tru64 UNIX AlphaServer systems, Linux AlphaServer systems, and HP OpenVMS (Alpha / VAX).

- Visual Fortran for Windows
- Fortran for Linux Alpha
- Fortran for Tru64 UNIX Alpha
- Fortran for HP OpenVMS Alpha
- Fortran for HP OpenVMS Integrity
- Fortran for HP OpenVMS VAX
- Fortran for HP-UX

The Windows product, Compaq Visual Fortran, includes the Microsoft Developer Studio IDE which can be shared with Microsoft Visual C++. Parallel execution using OpenMP-directed decomposition or HPF is included on the Tru64 UNIX platform. On Windows NT, SMP parallel execution using directed decomposition is available through Visual. Compaq Fortran for Linux Alpha Systems is available as a free download under a Technology Enthusiast license for non-commercial use. All Compaq Fortran 95 products include the Compaq Extended Math Library of optimized scientific subroutines and the allocatable array extensions.

## 2.9 IBM

<http://www-306.ibm.com/software/awdtools/fortran/>

<http://www-306.ibm.com/software/awdtools/fortran/xlfortran/features/f2003.html>

XL Fortran Enterprise Edition for AIX XL Fortran Enterprise Edition for AIX provides industry-leading code optimization and tuning features, a full implementation of the OpenMP API Version 2.5, Symmetric Multiprocessing (SMP) APIs,

direct manipulation of the floating-point status and control register, 64-bit enablement, asynchronous I/O, debug memory routines, and many other features.

XL Fortran Advanced Edition for Blue Gene XL Fortran Advanced Edition for Blue Gene is the latest addition to our XL Fortran compiler family. It expands our proven XL Fortran compiler technology to exploit the capabilities of the PowerPC 440 and 440d processors used in IBM Blue Gene/L supercomputers.

XL Fortran Advanced Edition for Linux XL Fortran Advanced Edition for Linux supports your choice of RHEL4, SLES9, and Y-HPC Linux distributions. Advanced optimization technology and VMX support help you create high-performance 32-bit and 64-bit applications that run efficiently on a variety of processor architectures, including IBM's newest POWER5+ and PowerPC 970 processors, and Apple Power Mac G5 and Xserve G5 systems.

VS FORTRAN VS FORTRAN contains features geared to help Fortran programmers develop applications more easily and efficiently, while using the full power of IBM's large systems.

The second web link has details of Fortran 2003 support.

## 2.10 Intel

<http://software.intel.com/en-us/intel-compilers/>

### Intel Fortran Compilers

Performance without compromise on Windows\*, Linux\* and OS X\* Broad support for current and previous Fortran standards, plus popular extensions Intel Math Kernel Library included in suites Optional Rogue Wave\* IMSL\* Fortran Numerical Library on Windows

### Intel Parallel Studio XE 2015

Deliver top C++ and Fortran application performance with less effort Faster code: Boost applications performance that scales on today's and next-gen processors Create code faster: Utilize a toolset that simplifies creating fast, reliable parallel code

Available for Windows, Linux and OS/X.

Students, educators, academic researchers, and open source contributors may qualify for Free Software Tools.

Academic Researcher - For unfunded research (research not funded by grants). Academic researchers doing unfunded research (research not funded by grants) and are in the United States with an \*.edu email address.

Student - For current students at degree-granting institutions. Matriculated students of a higher education institution defined as a public or private vocational school, correspondence school, junior college, college, or university. Students cannot be paid and/or compensated for software development. The products below are currently free for your use under the terms of the Non-Commercial License.

Educator - For use in teaching curriculum. Professors and educators teaching parallelism and high performance computing techniques to students at degree-granting institutions.

Open Source Contributor - For developers actively contributing to open source projects Developers must be actively contributing to an open source project (e.g. GitHub). Agree to terms and conditions of the Intel Non-Commercial License.

## 2.11 Lahey/Fujitsu

<http://www.lahey.com/>

Lahey/Fujitsu Fortran 95 is produced by the Lahey/Fujitsu alliance. LF95 is available in three Windows configurations: Express, Standard, and PRO, and two Linux configurations: Express and PRO. All configurations feature: VAX, IBM, and POSIX language extensions, allocatable array enhancements, etc. The Windows and Linux Express version is command line only and features the compiler, linker and debugger. PRO for Windows adds a Fortran-smart Windows editor, a debugger, an AUTOMAKE make utility, and an enhanced Winteracter Starter kit (WiSK) for creating true Windows programs with Fortran, and a Coverage Analysis Tool that detects unexecuted code and performs range of operation checking. The PRO is compatible with Visual C++, Visual Basic, and Delphi and also includes Fujitsu's SSL2 Math Library and Visual Analyzer (see below). The PRO Linux version offers auto-parallelization, OpenMP compatibility, thread-safe BLAS and LAPACK, WiSK, AUTOMAKE, and Fujitsu's SSL2. All products come with free technical support and are available at:

<http://www.lahey.com/>

Also available is a subset compiler, elf90.

It would appear that the Windows version is no longer under active development. The last update was dated December 2004.

## 2.12 Lahey/GNU Shasta Compiler

<http://www.lahey.com/>

Full Fortran 95/90/77 compliance with extensive support for the Fortran 2003 and 2008 standards; targets 32 and 64-bit Windows. Includes the automatic-parallelizing GFortran compiler, Visual Studio 2012 Shell, Lahey's Exclusive Visual Studio Fortran support, Winteracter WiSK Graphics package, and more! Compatible with Windows 8/7 (32 and 64-bit) and more!

## 2.13 NAG

<http://www.nag.co.uk/nagware.asp>

The NAG Fortran Compiler, derived from the world's first Fortran 90 Compiler from NAG is robust, highly tested, and valued by developers all over the globe for its checking capabilities and detailed error reporting. Available on a wide range of Unix and Windows platforms it accepts fixed or free format Fortran 95 input and many common Fortran 77 extensions are allowed. A large number of Fortran 2003 language features are now available. HPF code is also compiled and checked though only single processor output is generated. The 5.3 release supports a good working subset of OpenMP 3.

The following versions are available.

Apple Intel Mac 64-bit Release 6.1 OS X 10.6-10.9

Apple Intel Mac 32-bit Release 5.2 OS X 10.4-10.5

Apple PowerPC Mac 32-bit Release 5.2 OS X 10.3-10.4

HP PA-RISC 1.1 Release 5.1 HP ANSI C

IBM Power AIX Release 5.1 AIX XL C 6.0

IBM Z9 Linux Release 5.1 gcc 3.4.6

IBM Z9 Open Edition Release 5.2 IBM C

Linux x86-32 Release 6.1

Linux64 Release 6.1

Linux(IA64), Itanium, 5.2, glibc 2.3 or later.

Sun Ultra SPARC Solaris 32-bit Release 5.3 Sun C 5.9

Sun SPARC Solaris 32-bit Release 5.2 Using Gnu C

x86 and x86-64 Windows Release 6.1

An integrated Fortran IDE called Fortran Builder is available for the Windows and Apple Mac operating systems.

<http://www.nag.co.uk/nagware/np/fortranbuilder.asp>

## 2.14 NEC

<http://www.nec.com/>

NEC has a native, optimizing Fortran 95 compiler, FORTRAN90/SX, with an automatic vectorization and parallelization capability, for its supercomputer SX series. HPF/SX V2 provides functions conforming to the specification of HPF1.1 and HPF2.0 and can be used with vector processing functions in SX Fortran and with parallel processing functions using microtasking.

## 2.15 Nocturnal Aviation Software

<http://www.nocturnalaviationsoftware.com/>

[http://www.nocturnalaviationsoftware.com/  
FTranProjectBuilder/](http://www.nocturnalaviationsoftware.com/FTranProjectBuilder/)

The following is taken from their site.

Nocturnal Aviation Software is an indie Mac software developer located in Tallahassee, FL. We have almost 40 years of Fortran programming experience, 26 years of Mac user experience and have been coding for the Mac since the OS X public beta, a decade ago. We wrote these Apps to use in our own programming work because nothing else like them is available. We'd like to say "Providing software solutions since 2011", but that won't sound too impressive for quite a few years. One has to start somewhere.

## 2.16 OpenUH

<http://www2.cs.uh.edu/~openuh/>

The following is taken from their site.

OpenUH is an open source, optimizing compiler suite for C, C++ and Fortran 95. It supports a variety of architectures including IA-32, X86\_64, IA-64. To achieve portability, OpenUH is able to emit optimized C or Fortran 77 code that may be compiled by a native compiler on other platforms. The supporting runtime libraries are also portable - the OpenMP runtime library is based on the portable Pthreads interface while the Coarray Fortran runtime library is based, optionally, on the portable GASNet or ARMCI communications interfaces. OpenUH includes support for a new version of the Dragon tool that gathers and displays static and dynamic information about a user's application.

## 2.17 Oracle - originally Sun

<http://www.oracle.com/us/sun/index.htm>

<http://www.sun.com/>

<http://developers.sun.com/sunstudio/>

<http://developers.sun.com/sunstudio/downloads/express/>

Sun Studio software delivers high-performance, optimizing C, C++, and Fortran compilers for the Solaris OS on SPARC, and both Solaris and Linux on x86/x64 platforms, including the latest multi-core systems.

What's in Sun Studio:

All Compilers - Specify 32-bit or 64-bit Address Model, Auto-parallelization of single-threaded code, Flags, Static data-race and deadlock-detection for x86, Math and Visual Instruction Set Support in SPARC64 VI, Option for Floating-Point, Fused or Multiply-Add Instructions, Option for Thread Analyzer support, Linux Support, OpenMP and OpenMPI support, Support for the directives, clauses and attributes.

Fortran Compiler - Interval arithmetic support on Solaris Intel platform, Faster compilation time for source files, UNSIGNED arguments, Backward compatibility with f77

C Compiler - More options, Auto-parallelization of single-threaded code, GNU C compatibility

C++ Compiler - More options, ABI compatibility, Compiler flags to optimize for multicore architectures, Static linking the standard C++ runtime library.

A beta version is available at

<http://www.oracle.com/technetwork/server-storage/developerstudio/overview/developer-studio-beta-program-3654693.html>

This is the Oracle Solaris Studio 12.6 Beta Program.

Please note that the url has been broken to fit the printed page.

## 2.18 PathScale

<http://www.pathscale.com/>

The following was taken from the Pathscale site.

PathScale's goal is to make it easier to develop and deploy 64-bit applications into clustered environments. PathScale has developed one of the industry's highest-performance C, C++, and Fortran compilers for 64-bit Linux based systems.

They offer 4 products. The content and descriptions are taken from the Pathscale site.

- The EKOPath 6 compiler suite (C, C++, Fortran)
- ENZO 2015 - a complete GPGPU and multi-core solution, which tightly couples the best programming models with highly optimizing code generation for NVIDIA Tesla and AMD FirePro discrete GPU.
- ARMv8 - ARMv8 is an emerging architecture that promises to deliver better performance per watt than your existing HPC and Enterprise hardware solutions for your applications
- DF IDE - DogFood (DF), the intelligent C++/Fortran IDE that delivers productivity without getting in the way of writing, reading and navigating code. DF is not afraid to break the rules and attempt to raise the bar on what an IDE should be. The engineers who work on DF are the engineers who also use DF.

The compiler is available as a free nightly download.

## 2.19 PGI

<http://www.pgroup.com/>

High-performance Optimizing Parallel Compilers For multi-core 64-bit x64 and 32-bit x86 processor-based Linux, Mac OS X and Windows workstations, servers and clusters. PGI Workstation includes a single seat license for PGI's suite of compilers and tools. Also available with a multi-user network floating license (PGI Server). The PGI CDK Cluster Development Kit includes all the software for building and programming a turn-key Linux cluster. PGI Visual Fortran fully integrates PGI parallel Fortran into Microsoft Windows using Microsoft Visual Studio 2005.

## 2.20 Silverfrost, nee Salford Software

<http://www.silverfrost.com/11/ftn95/overview.aspx>

Salford Software markets FTN95, a Fortran 95 compiler for Win32, running on Windows 95/NT/2000/XP PCs. It has announced its Fortran 95 compiler for Microsoft .NET (FTN95 for .NET). This compiler will produce fast executables from source files that may be any combination of Fortran 77, Fortran 90 and Fortran 95. FTN95 for .NET, including integrated Help and Debugger, is supplied bundled with FTN95 for Win32 and, optionally, with Microsoft Visual Studio for .NET. A low-cost, fully-featured personal edition is also available.

## 2.21 SGI

<http://www.sgi.com/products/software/irix/tools/fortran.html>

The following is taken from the SGI site.

### 2.21.1 MIPSpro Fortran Compilers

This 64-bit ANSI Fortran 77 compiler is ideal for systems running IRIX 6.x. It is compatible with VAX/VMS Fortran and supports Cray extensions. The 7.4 version of the MIPSpro Fortran 77 and Fortran 90 compilers now support the OpenMP 2.0 standard. Among the new features introduced in the OpenMP 2.0 specification are:

- WORKSHARE directive
- COPYPRIVATE clause for the broadcast of sequential reads
- Portable timing routines

### 2.21.2 MIPSpro Fortran 90 Compiler

A 64 bit ANSI Fortran 90 compiler with additional support for user-defined multiprocessing directives for systems running IRIX 6.x. Compatible with VAX/VMS Fortran and supports Cray extensions. With the release of version 7.4, Fortran 90 specific support under the OpenMP 2.0 standard are:

- Parallelization of F90 array syntax via the WORKSHARE directive
- Privatization of deferred shape and assumed shape objects

The full Fortran 2.0 specification can be obtained from the OpenMP Web site at:

<http://www.openmp.org>

For more information, read about the MIPSpro compilers.

## 2.22 Sun - see Oracle

## 2.23 No longer available

### 2.23.1 Apogee

<http://www.apogee.com/>

Features of the FORTRAN 77/90 Compiler

No longer available. Originally available for the Solaris/SPARC platforms, the compiler conforms to Sun's Solaris ABI and produces assembler code files acceptable to Sun's Solaris assembler. When used in the FORTRAN 77 compilation mode, the compiler is compliant with the MIL-STD 1753 FORTRAN 77 and accepts most FORTRAN 77 extensions of Sun, IBM, and other F77 compilers. The supported F77 extensions include structures, length qualification on types, additional data and constant types, initializations in type statements, additional statements (END DO, DO WHILE, POINTER, VOLATILE, etc.), computations with aggregates, namelist-directed I/Os, and debugging statements.

When used in the Fortran 90 mode, the compiler is compliant with the ANSI/ISO Fortran 90 standard.

### 2.23.2 Compaq

This compiler is no longer under development. This ceased when Intel bought out the technology from HP. Still widely used with legacy software. Copies for sale can be found on Ebay and similar sites.



### **2.23.3 EPC**

Edinburgh Portable Compilers was an early vendor to produce a Fortran 90 compilation system. A report by Adam Marshall from Liverpool University has a comparison of several early Fortran 90 compilers. It can be found at the address below.

[http://www.liv.ac.uk/HPC/FortranCompilerStudyHTML/  
FortranCompilerStudyHTML.html](http://www.liv.ac.uk/HPC/FortranCompilerStudyHTML/FortranCompilerStudyHTML.html)

### **2.23.4 NA Software**

<http://www.nasoftware.co.uk/home.html>

No longer available.



# Chapter 3

## Debuggers

- Version 1 January 2013. Thanks to Anton Shterenlikht for the initial request for a section on debuggers. Thanks to Wood Lotz, Van Snyder, Bill Long and Tobias Burnus for their contributions.

### 3.1 Introduction

A number of contributors have mentioned the simple inclusion of print statements in your code - which is of course simple and very effective.

### 3.2 Absoft

The following information was provided by Wood Lotz.

Absoft Fx3 debugger

It supports Fortran, C and asm and has been evolving over the past 15 years. During that period it has supported and or sold with, a wide variety of compilers though currently we offer it only as a component bundled with the Absoft Pro Fortran products for Windows, Linux and Mac.

Product overview

[http://www.absoft.com/Absoft\\_FxDebugger.htm](http://www.absoft.com/Absoft_FxDebugger.htm)

### 3.3 DDT

<http://www.allinea.com/products/ddt/>

The following information is taken from the above site.

Allinea DDT is the most advanced debugging tool available for scalar, multi-threaded and large-scale parallel applications. It debugs code on:

workstations GPUs clusters, and... the very largest supercomputers. Comprehensive and easy-to-use Allinea DDT has many features that are missing from ordinary debuggers — such as memory debugging and data visualization. With an acclaimed

user interface that wins praise for ease-of-use and capability, it is quite simply an integral part of efficient software development.

Simplifying debugging at scale. For multi-threaded or OpenMP development, Allinea DDT enables threads to be controlled individually and collectively with advanced capabilities for comparing data across threads.

The Parallel Stack Viewer is a unique way to see the program state of all processes and threads at a glance. You can easily spot rogue processes or threads and even using it to define new control groups, making massive parallel programs far easier to manage. The Allinea DDT interface scales amazingly to provide the same clarity of information at thousands of processes as at a handful. It highlights commonality and differences using summary views and data comparisons to focus your attention.

Allinea DDT has been proven at scale on the most powerful systems - including debugging applications at over 200,000 cores simultaneously. Allinea DDT puts you in control of your application, whether you are working with a workstation or a thousand processor, high-performance cluster.

Debug code on the CPU and GPU from a single tool This powerful combination gives you all the advanced debugging features of Allinea DDT but with the enhanced ability to debug CUDA code. With a single tool, you can debug hybrid MPI, OpenMP and CUDA applications on a single workstation or GPU cluster. Features such as the detection of invalid memory accesses, the visualization of GPU data, and GPU thread control have been designed to help you find the GPU porting bugs quickly and easily.

Allinea DDT supports the NVIDIA CUDA Toolkit and is fully compatible with NVIDIA's Fermi architecture.

## 3.4 gnu gdb

A "-g" without further optimization option (such as -O2) usually disables optimization, which some compiler have otherwise by default. "-g" can also be used with optimization; however, the optimization makes debugging more difficult (even though compilers might try hard to keep some debugging information available).

Additionally, "-g" may or may not have an effect on code generation - especially when used together with optimization (such as -O2); some compiles generate the same code with debug information than without, others allow "-g -O2" but generate slightly different code than with only "-O2". Using "-O1 -g" is often a good compromise between performance and debuggability as it does some optimization but usually no inlining and other debugging unfriendly optimizations.

For GCC:

- \* GCC by default has no optimization (-O0), thus "-g" doesn't change the optimization level.
- \* GCC generates the same code with and without "-g" for all optimization levels [if not, it is a bug]
- \* GCC 4.8 has the new option -Og, which enables optimizations that do not interfere with debugging.

In addition, newer debug formats (DWARF, latest is DWARF4) allow for better debugging support, but require also newer debugging tools. For instance, -gdwarf-4

is the default in GCC with/since 4.8 but requires GDB 7.5, Valgrind 3.8 and elftools 0.154. GCC also supports (since 4.7) a GNU extension (supported by GDB 7.4, proposed for DWARF5) "entry value"/ "call site" which allows - with restrictions - to debug function calls where the argument has been passed in registers. (For completeness: DWARF4 is supported - optionally - since GCC 4.6.)

## 3.5 Intel IDB

## 3.6 LLDB

## 3.7 Microsoft Visual Studio Debugger

## 3.8 totalview

Visit

<http://www.roguewave.com/products/totalview.aspx>

for detailed information.

Here is some information taken from the above site.

TotalView is a GUI-based source code defect analysis tool that gives you unprecedented control over processes and thread execution and visibility into program state and variables.

It allows you to debug one or many processes and/or threads in a single window with complete control over program execution. This allows you to set breakpoints, stepping line by line through the code on a single thread, or with coordinated groups of processes or threads, and run or halt arbitrary sets of processes or threads. You can reproduce and troubleshoot difficult problems that can occur in concurrent programs that take advantage of threads, OpenMP, MPI, GPUs or coprocessors.

TotalView provides analytical displays of the state of your running program for efficient debugging of memory errors and leaks and diagnosis of subtle problems like deadlocks and race conditions. Whether you are a scientific and technical computing veteran, or a software professional new to the development challenges of multi-core or parallel applications, TotalView gives you the insight needed to find and correct errors quickly, validate prototypes, verify calculations and certify code. TotalView works with C, C++ and Fortran applications written for Linux (including the Blue Gene platforms), UNIX and Mac OS X platforms. It includes sophisticated memory debugging and analysis, reverse debugging, Xeon Phi coprocessor and OpenACC / CUDA debugging capabilities.

A tutorial is available at

<https://computing.llnl.gov/tutorials/totalview/>

Here is some additional information from that site.

TotalView is a sophisticated and powerful tool used for debugging and analyzing both serial and parallel programs. TotalView provides source level debugging for serial, parallel, multi-process and multi-threaded codes, and can be used in a variety of UNIX environments, including those with distributed, clustered, stand-alone and SMP machines. TotalView provides both a graphical user interface and command line interface. TotalView has been selected as the Department of Energy's ASC debugger of choice for its HPC platforms.

This tutorial has three parts, each of which includes a lab exercise. Part 1 begins with an overview of TotalView and then provides detailed instructions on how to set up and use its basic functions. Part 2 continues by introducing a number of new functions and also providing a more in-depth look at some of the basic functions. Part 3 covers parallel debugging, including threads, MPI, OpenMP and hybrid programs. Part 3 concludes with a discussion on debugging in batch mode.

Level/Prerequisites: This tutorial is one of the eight tutorials in the 4+ day "Using LLNL's Supercomputers" workshop. It is intended for those who are new to TotalView. A basic understanding of parallel programming in C or Fortran is required. The material covered in the following tutorials would also be beneficial for those who are unfamiliar with parallel programming in MPI, OpenMP and/or POSIX threads:

## 3.9 Valgrind

Visit

<http://valgrind.org/>

for more information. Here is an extract taken from that site.

Valgrind is an instrumentation framework for building dynamic analysis tools. There are Valgrind tools that can automatically detect many memory management and threading bugs, and profile your programs in detail. You can also use Valgrind to build new tools.

The Valgrind distribution currently includes six production-quality tools: a memory error detector, two thread error detectors, a cache and branch-prediction profiler, a call-graph generating cache and branch-prediction profiler, and a heap profiler. It also includes three experimental tools: a heap/stack/global array overrun detector, a second heap profiler that examines how heap blocks are used, and a SimPoint basic block vector generator. It runs on the following platforms:

- X86/Linux,
- AMD64/Linux,
- ARM/Linux,
- PPC32/Linux,

- PPC64/Linux,
- S390X/Linux,
- MIPS/Linux,
- ARM/Android (2.3.x and later),
- X86/Android (4.0 and later),
- X86/Darwin and
- AMD64/Darwin
- Mac OS X 10.6 and 10.7, with limited support for 10.8

Valgrind is Open Source and or Free Software, and is freely available under the GNU General Public License, version 2.

Here is an extract from the Wikipedia entry on Valgrind.

Valgrind is a GPL licensed programming tool for memory debugging, memory leak detection, and profiling. It is named after the main entrance to Valhalla in Norse mythology. Valgrind was originally designed to be a free memory debugging tool for Linux on x86, but has since evolved to become a generic framework for creating dynamic analysis tools such as checkers and profilers. It is used by a number of Linux-based projects.[3] Since version 3.5, Valgrind also works on Mac OS X. The original author of Valgrind is Julian Seward, who in 2006 won a Google-O'Reilly Open Source Award for his work on Valgrind. Several others have also made significant contributions, including Cerion Armour-Brown, Jeremy Fitzhardinge, Tom Hughes, Nicholas Nethercote, Paul Mackerras, Dirk Mueller, Bart Van Assche, Josef Weidenborfer and Robert Walsh. Valgrind is in essence a virtual machine using just-in-time (JIT) compilation techniques, including dynamic recompilation. Nothing from the original program ever gets run directly on the host processor. Instead, Valgrind first translates the program into a temporary, simpler form called Intermediate Representation (IR), which is a processor-neutral, SSA-based form. After the conversion, a tool (see below) is free to do whatever transformations it would like on the IR, before Valgrind translates the IR back into machine code and lets the host processor run it. Even though it could use dynamic translation (that is, the host and target processors are from different architectures), it doesn't. Valgrind recompiles binary code to run on host and target (or simulated) CPUs of the same architecture.

## 3.10 WinDbg

Van

I had been using totalview. With Lahey and Fujitsu 6.20e on Linux, it was the only debugger that understood their defective debugging tables – including the Fujitsu debugger.

But... the license for totalview is expensive. So when we switched from LF95 to Intel, and Intel provided idb, we started using idb.

I wish we still had totalview. idb is difficult to use, especially to view arrays. It's also rather slow.

Bill

A related topic would be corresponding compiler support. Typically compilers will optimize away parts of the code and discard symbol information, making the use of debuggers problematic. An option like "-g" often cures this, but at the expense of turning off most optimization. Options for intermediate cases between -g and (none) would be useful to document.

- 1) Print \*
- 2) Totalview -

[www.roguewave.com/products/totalview.aspx](http://www.roguewave.com/products/totalview.aspx)

- 3) DDT -

[www.allinea.com/products/ddt](http://www.allinea.com/products/ddt)

- 4) gdb and lgdb (parallel version of gdb)

Totalview, DDT, and lgdb support parallel codes, which is increasingly a requirement.

gdb is free and powerful; the user interface has a 'high nerd factor'.



# Chapter 4

## Fortran aware editors and IDEs

- Version 1.9, June 2016; Added an entry for the Pathscale Dogfood IDE for Linux
- Version 1.8, May 2016. Added an entry for Nag Fortran Builder for the Apple Mac and Windows operating systems.
- Version 1.7, January 2015. Added Microsoft Visual Studio 2013 Community Edition.
- Version 1.6, September 2014. Added Code::Blocks and geany entries.
- Version 1.5, October 2011. Updated photran entry.
- Version 1.4, July 2010. Added SunStudio Express entry.
- Version 1.31, April 2006. Added Windows Zeus entry.

### 4.1 Windows

#### 4.1.1 Absoft Editor (ae)

<http://www.absoft.com>

#### 4.1.2 Code::Blocks

<http://www.codeblocks.org/>

#### 4.1.3 CRiSP

[www.crisp.com](http://www.crisp.com)

<http://www.crisp.demon.co.uk>

#### 4.1.4 Compaq Visual Fortran 6.x

No longer available

#### 4.1.5 editeur

[www.studioware.com](http://www.studioware.com)

#### 4.1.6 emacs/xemacs - stand alone

<http://www.gnu.org/software/emacs/emacs.html>

#### 4.1.7 emacs/xemacs - cygwin components

<http://www.cygwin.com/>

#### 4.1.8 Fortran Builder for the Nag compiler

<http://www.nag.co.uk/nagware/NP/fortranbuilder.asp>

#### 4.1.9 geany

<http://www.geany.org/>

#### 4.1.10 gvim/vim - stand alone

<http://www.vim.org/>

#### 4.1.11 gvim/vim - cygwin component

<http://www.cygwin.com/>

#### 4.1.12 jed. wjed (Windows)

<http://www.jedsoft.org/jed/>

#### 4.1.13 lahey ed

<http://www.lahey.com/>

#### 4.1.14 Microsoft Visual Studio 6

No longer available.

### 4.1.15 Microsoft Visual Studio 2013 Community Edition

Microsoft have made Visual Studio 2013 Professional available as a 'Community Edition'.

Visit

<http://www.visualstudio.com/en-us/news/vs2013-community-vs.aspx>

for more details. It is a free download. It includes Microsoft C++, C#, Visual Basic and F#. Here are details of some of the licence conditions. This information has been taken from the Microsoft site.

Any individual developer can use Visual Studio Community to create their own free or paid apps.

Heres how Visual Studio Community can be used in organizations: An unlimited number of users within an organization can use Visual Studio Community for the following scenarios: in a classroom learning environment, for academic research, or for contributing to open source projects.

### 4.1.16 Microsoft Visual Studio.NET

There are a number of vendors that have provided integration with Microsoft Visual Studio .NET. These include

Intel Visual Fortran

[www.intel.com](http://www.intel.com)

Lahey/Fujitsu Fortran

[www.lahey.com](http://www.lahey.com)

Silverfrost Salford FTN95

<http://www.silverfrost.com/11/ftn95/overview.aspx>

### 4.1.17 nedit - cygwin

<http://www.nedit.org/>

### 4.1.18 ntemacs

<http://www.gnu.org/software/emacs/windows/ntemacs.html>

### 4.1.19 photran

<http://www.eclipse.org/photran/>

Photran is an IDE and refactoring tool for Fortran based on Eclipse and the CDT. Photran is a component of the Eclipse Parallel Tools Platform (PTP).

#### 4.1.20 Salford plato

<http://www.silverfrost.com/11/ftn95/overview.aspx>

#### 4.1.21 UltraEdit

[www.ultraedit.com](http://www.ultraedit.com)

#### 4.1.22 xemacs/emacs - stand alone

<http://www.gnu.org/software/emacs/emacs.html>

#### 4.1.23 xemacs/emacs - cygwin components

<http://www.cygwin.com/>

#### 4.1.24 Zeus ide

<http://www.zeusedit.com/fortran.html>

### 4.2 Linux/Unix

#### 4.2.1 Code::Blocks

<http://www.codeblocks.org/>

#### 4.2.2 CRiSP

[www.crisp.com](http://www.crisp.com)

<http://www.crisp.demon.co.uk>

#### 4.2.3 DF - Pathscale Dogfood

<http://www.pathscale.com/DogFood>

#### 4.2.4 emacs/xemacs

<http://www.gnu.org/software/emacs/emacs.html>

#### 4.2.5 geany

<http://www.geany.org/>

#### **4.2.6 jed, xjed (Unix(all flavours)/OpenVMS) wjed (Windows)**

<http://www.jedsoft.org/jed/>

#### **4.2.7 nedit**

<http://www.nedit.org/>

#### **4.2.8 Oracle Solaris Studio Express**

<http://developers.sun.com/sunstudio/downloads/express/>

Requires a Java run time.

#### **4.2.9 photran**

<http://www.eclipse.org/photran/>

Photran is an IDE and refactoring tool for Fortran based on Eclipse and the CDT. Photran is a component of the Eclipse Parallel Tools Platform (PTP).

Requires a Java run time.

### **4.3 Apple OS X**

#### **4.3.1 Absoft Editor**

<http://www.absoft.com/>

#### **4.3.2 BBEdit**

[http://www.apple.com/downloads/macosx/productivity\\_tools/bbedit.html](http://www.apple.com/downloads/macosx/productivity_tools/bbedit.html)

#### **4.3.3 codeblocks**

<http://www.codeblocks.org/>

#### **4.3.4 emacs/xemacs**

pre-installed

#### **4.3.5 Fortran Builder for the Nag compiler**

<http://www.nag.co.uk/nagware/NP/fortranbuilder.asp>

### 4.3.6 Photran

[www.photran.org/](http://www.photran.org/)

### 4.3.7 Smultron

<http://smultron.sourceforge.net/>

### 4.3.8 TextMate

<http://macromates.com/>

### 4.3.9 TextWrangler

[http://www.apple.com/downloads/macosx/productivity\\_tools/textwrangler.html](http://www.apple.com/downloads/macosx/productivity_tools/textwrangler.html)

### 4.3.10 Vim

Pre-installed

### 4.3.11 Xcode

<http://developer.apple.com/>

### 4.3.12 xemacs/emacs

pre-installed

# Chapter 5

## Commercial Courses

- Version 1.6, April 2016. Added a new NAG workshop.
- Version 1.5, July 2015. Deleted John Reid entry. Corrected Mike Metcalf entry. Added Sourcery, Inc entry. Deleted Hector entry, added Archer entry. Updated the Cranfield entry.
- Version 1.4, August 2012. Updated several entries.
- Version 1.3, November 2011. Notified by Shaun Forth at Cranfield of their changes. Also added the HECToR entries.
- Version 1.2, August 2010.
- Version 1.1, September 2008
- Version 1.0, January 2006.

### 5.1 Archer

Archer is the UK National Supercomputing Service.

<http://www.archer.ac.uk/>

The following list is taken from their web stite.

Hands-on Introduction to High Performance Computing  
Introduction to F95  
Message-Passing Programming with MPI  
Multicore Programming  
Shared Memory Programming with OpenMP  
Threaded Programming  
Accelerator programming  
Advanced MPI  
Advanced OpenMP

Efficient Parallel IO on ARCHER  
Performance Programming  
PGAS Programming  
Programming the Xeon Phi

## 5.2 Ian Chivers and Jane Sleightholme

Ian Chivers and Jane Sleightholme are available to do tailored on site courses. Courses include

- Introduction to Modern Programming in Fortran
- Advanced Features of Modern Fortran

See

<http://www.fortranplus.co.uk>

## 5.3 Cranfield University

Cranfield University, in conjunction with ISO Fortran Convener John Reid, offers two Fortran programming courses to groups of 6 or more when commissioned by an organisation:

- Introduction to Programming in Fortran 2003 (3 days)

<https://www.cranfield.ac.uk/courses/training/fortran-introduction-to-programming-in-fortran-2003.html>

- Intermediate Programming in Fortran 2003 (3 days) -

<https://www.cranfield.ac.uk/courses/training/fortran-intermediate-programming-in-fortran-2003.html>

These may be taken at the University's Shrivenham Campus or may be delivered at an organisation's site.

## 5.4 The Fortran Company

<http://www.fortran.com/>

Follow training links.



## 5.5 Lahey

<http://www.lahey.com/>

The Fortran 95 Workshop is a six-session, hands-on, Fortran 95 workshop led by Thomas M. Lahey, CEO, Lahey Computer Systems, Inc.

## 5.6 Michael Metcalf

formerly of CERN, Switzerland, and an ex-member of J3 and WG5, offers a Fortran 95 course that lasts for six 75-minute sessions. There is an F version too. He is happy to negotiate holding either version anywhere in the world. These courses are suitable for graduates, or equivalent level, and are a useful way kick-start a Fortran 90/95 or an F activity at a given site. Contact at [michael.metcalf@t-online.de](mailto:michael.metcalf@t-online.de), or Manfred von Richthofen Straße 15, 12101 Berlin, Germany, +0049.30.78952573.

## 5.7 Nihon NAG, Numerical Algorithms Group Japan

Offers a Fortran Introduction course and Fortran consultancy. Their top page is

<http://www.nag-j.co.jp/>

They also have online material for their Fortran Introduction course, starting from

<http://www.nag-j.co.jp/fortran/index.html>

NAG also offer a two day workshop. Here is a short description.

This two day computational science-focused practical hands on workshop is aimed at Fortran programmers who want to write modern code, or modernise existing codes, to make it more readable and maintainable by encouraging good software engineering practices. Adopting good software practices makes codes more amenable to optimisation and parallelisation, and the path to making it a community code a whole lot easier.

Topics will include:

- Software engineering for computational science;
- Modern Fortran standards and how to write optimised and efficient Fortran;
- NetCDF and HDF5 file formats for data sharing;
- GNU Automake to automate the build process;
- pFUnit unit testing framework;

- Doxygen for code documentation;
- Git version control for collaborative code development;
- In-memory visualisation using PLplot;
- Fortran interoperability with C, Python and R;
- Introduction to parallelism for Fortran.

You need to contact

Wadud Miah [wadud.miah@nag.co.uk]

for further information.

## 5.8 PTR Associates

Currently offer two Fortran courses.

<http://www.ptr.co.uk/fortran-conversion-course.html>

<http://www.ptr.co.uk/fortran-programming.html>.

## 5.9 Purple Sage Computing Solutions, Inc

is offering three Workshops to Fortran programmers: The Fortran Modernization, Optimization and Parallelization Workshop; The Parallelization for Fortran Programmers Workshop; and The fthreads Workshop. Contact dnagle@erols.com or

<http://users.erols.com/dnagle>.

Also on offer is a one day workshop on the new features of Fortran 2000. See

<http://users.erols.com/dnagle/wsf2000.html>.

for more details.

## 5.10 Sourcery, Inc

<http://www.sourceryinstitute.org/>

Offer a range of courses. The following is taken from their web site.

Sourcery Inc training courses cover a range of topics relating to legacy and modern Fortran code development for computational science.

Parallel programming in Modern Fortran

Parallel numerical libraries for modern Fortran.

Parallel performance tuning and analysis with TAU.

Mixed Fortran/C/C++ programming

Software development methods, including

Agile development

Test-driven development and unit testing

Literate programming

Programming by contract

Object-Oriented Analysis, Design, and Programming

Best practices in Object-Oriented Design (patterns)

## 5.11 France

Simulog, attn. Mr. E. Plestan,

1 rue James Joule, F-78286 Guyancourt Cedex, France

Tel: +33 1 30 12 27 80 fax: +33 1 30 12 27 27

[info@simulog.fr](mailto:info@simulog.fr)

## 5.12 Japan

### 5.12.1 Nihon NAG, Numerical Algorithms Group Japan

Offers a Fortran Introduction course and Fortran consultancy. Their top page is

<http://www.nag-j.co.jp/>

They also have online material for their Fortran Introduction course, starting from

<http://www.nag-j.co.jp/fortran/index.html>

A Japanese company offering courses and conversion consultancy is SofTek Systems, Inc. (see above).



# Chapter 6

## On Line Training Material

- Version 1.1 August 2012. Removed Edinburgh entry - no longer available. Removed Manchester entry - no longer available.
- Version 1.0 January 2006

### 6.1 CERN

<http://wwwinfo.cern.ch/asdoc/f90.html>

### 6.2 Paul Dubois

<http://prdownloads.sourceforge.net/pyfortran/OBF90.zip>.

lecture notes and class materials on Object Based Programming in Fortran 90 (In WinZip, on the Options—Configuration menu, turn off tar smart convert CR/LF.)

### 6.3 Linkoping University

<http://www.nsc.liu.se/~boein/f77to90/f77to90.html>

Fortran 77 to 90 Conversion Course

### 6.4 Liverpool University

<http://www.liv.ac.uk/HPC/HPCpage.html>

Covers f90 and HPF, with Java-enhanced Web pages.

## 6.5 French

Support de cours Fortran 90 IDRIS - Corde & Delouis

[www.idris.fr/data/cours/lang/fortran/choix\\_doc.html](http://www.idris.fr/data/cours/lang/fortran/choix_doc.html)

# Chapter 7

## Graphics and Windows Programming

- Version 1.4, April 2016, added GTK+, PLplot
- Version 1.3, January 2013, added pgplot
- Version 1.2, August 2012, updated various entries
- Version 1.1, June 2009; updated web links.
- Version 1.0, January 2006.

### 7.1 Introduction

This can be broken down into

- Simple graphics programming using a library
- visual interface via raw windows programming
- visual interface via visual development environment

Here are some of the library and development offerings.

### 7.2 dislin

DISLIN is a high-level plotting library for displaying data as curves, polar plots, bar graphs, pie charts, 3D-color plots, surfaces, contours and maps.

<http://www.dislin.de/>

<http://www.mps.mpg.de/dislin/>

<http://www.mps.mpg.de/dislin/contents.html>

### 7.2.1 Worked examples

<http://www.mps.mpg.de/dislin/examples.html>

## 7.3 gino

GINO is a suite of high-end development tools for creating complex 2D and 3D graphics and GUI applications. The products are ideally suited for aerospace, defence, utilities and other leading engineering organizations. The GINO products are available for Fortran, C/C++, VB, Delphi and .NET programming environments.

<http://www.gino-graphics.com>

<http://www.polyhedron.co.uk/>

<http://www.polyhedron.com/gino-ginomain0html>

### 7.3.1 Documentation

The software is supplied with on-line manuals in a variety of formats depending on the environment it is running (Windows Help, HTMLHelp, HTMLHelp2, PDF) and Printed Manuals are available at an additional cost.

<http://www.gino-graphics.com/downloads/manuals.htm>

### 7.3.2 Worked examples

None

## 7.4 ginomenu

GINOMENU is a subroutine toolkit for developing GUI applications under Windows. It provides extensive window and widget building modules allowing professional user-interfaces to be created under Windows 9x/NT/2000/XP without the need to get involved in MFC, API or mixed-language programming.

<http://www.gino-graphics.com/support.html>

<http://www.polyhedron.co.uk/>

<http://www.polyhedron.com/gino-ginomain0html>

### 7.4.1 Documentation

Windows HTML Help, PDF and printed documentation

<http://www.gino-graphics.com/support.html>



## 7.5 **GTK+**

<http://www.gtk.org/>

The following is taken from their site.

GTK+, or the GIMP Toolkit, is a multi-platform toolkit for creating graphical user interfaces. Offering a complete set of widgets, GTK+ is suitable for projects ranging from small one-off tools to complete application suites

There are only partial Fortran bindings.

## 7.6 **interacter**

<http://www.polyhedron.co.uk/>

INTERACTER is our original multi-platform user-interface and graphics subroutine library for Fortran 77/9x developers.

### 7.6.1 **Documentation**

None

### 7.6.2 **Worked examples**

None

## 7.7 **opengl**

OpenGL is the premier environment for developing portable, interactive 2D and 3D graphics applications. Since its introduction in 1992, OpenGL has become the industry's most widely used and supported 2D and 3D graphics application programming interface (API), bringing thousands of applications to a wide variety of computer platforms. OpenGL fosters innovation and speeds application development by incorporating a broad set of rendering, texture mapping, special effects, and other powerful visualization functions. Developers can leverage the power of OpenGL across all popular desktop and workstation platforms, ensuring wide application deployment.

<http://www.opengl.org/>

### 7.7.1 **Documentation**

None

### 7.7.2 Worked examples

None

f90gl is a public domain implementation of the official Fortran 90 bindings for OpenGL.

<http://math.nist.gov/f90gl/>

Precompiled f90gl libraries are available for some compilers. Lahey LF90, LF95 and ELF90:

<http://www.lahey.com> (search for OpenGL)

Compaq CVF (formerly DVF):

<http://www.compaq.com/fortran/>

(click on "Downloads" and search for f90GL)

Intel Visual Fortran:

<https://premier.intel.com/>

(Registered users log in, select File Downloads and search for f90gl.)

### 7.7.3 Documentation

<http://math.nist.gov/f90gl/documentation.html>

### 7.7.4 Worked examples

Some precompiled libraries may not include the example programs or the source code for the examples. The following files contain the examples subdirectory from the f90gl distribution.

Unix: fglexamp.tar.gz gzipped tar file (73K) Win32: fglexamp.zip zip file (134K)

## 7.8 pgplot

<http://www.astro.caltech.edu/~tjp/pgplot/>

The following is taken from the pgplot site.

The PGPLOT Graphics Subroutine Library is a Fortran- or C-callable, device-independent graphics package for making simple scientific graphs. It is intended for making graphical images of publication quality with minimum effort on the part of the user. For most applications, the program can be device-independent, and the output can be directed to the appropriate device at run time.

The PGPLOT library consists of two major parts: a device-independent part and a set of device-dependent “device handler” subroutines for output on various terminals, image displays, dot-matrix printers, laser printers, and pen plotters. Common file formats supported include PostScript and GIF.

PGPLOT itself is written mostly in standard Fortran-77, with a few non-standard, system-dependent subroutines. PGPLOT subroutines can be called directly from a Fortran-77 or Fortran-90 program. A C binding library (cpgplot) and header file (cpgplot.h) are provided that allow PGPLOT to be called from a C or C++ program; the binding library handles conversion between C and Fortran argument-passing conventions.

PGPLOT has been tested with UNIX (most varieties, including Linux, SunOS, Solaris, HPUX, AIX, Irix, and MacOS X/Darwin) and OpenVMS operating systems. I am unable to provide support for DOS, Microsoft Windows, but I do distribute code provided by users for use with these operating systems.

## 7.9 PLplot

<http://plplot.sourceforge.net/>

The following is taken from the PLplot site.

PLplot is a cross-platform software package for creating scientific plots whose (UTF-8) plot symbols and text are limited in practice only by what Unicode-aware system fonts are installed on a user’s computer. The PLplot software, which is primarily licensed under the LGPL, has a clean architecture that is organized as a core C library, separate language bindings for that library, and separate device drivers that are dynamically loaded by the core library which control how the plots are presented in noninteractive and interactive plotting contexts.

The PLplot core library can be used to create standard x-y plots, semi-log plots, log-log plots, contour plots, 3D surface plots, mesh plots, bar charts and pie charts. Multiple graphs (of the same or different sizes) may be placed on a single page, and multiple pages are allowed for those device formats that support them.

PLplot has core library support for plot symbols and text specified by the user in the UTF-8 encoding of Unicode. This means for our many Unicode-aware devices that plot symbols and text are only limited by the collection of glyphs normally available via installed system fonts. Furthermore, a large subset of our Unicode-aware devices also support complex text layout (CTL) languages such as Arabic, Hebrew, and Indic and Indic-derived CTL scripts such as Devanagari, Thai, Lao, and Tibetan. Thus, for these PLplot devices essentially any language that is supported by Unicode and installed system fonts can be used to label plots.

### 7.9.1 Documentation

<http://plplot.sourceforge.net/documentation.php>

## 7.9.2 Worked examples

<http://plplot.sourceforge.net/examples.php>

## 7.10 realwin

RealWin lets a Fortran programmer create full-featured applications for Microsoft 32-bit Windows platforms.

<http://www.indowsway.com/home.htm>

<http://www.indowsway.com/>

### 7.10.1 Documentation

Visit

<http://plplot.sourceforge.net/documentation.php>

### 7.10.2 Worked examples

Visit

<http://plplot.sourceforge.net/examples.php>

## 7.11 toolmaster

[http://www.avs.com/software/soft\\_t/toolm.html](http://www.avs.com/software/soft_t/toolm.html)

Toolmaster agX is a cross-platform graphics library. For FORTRAN programmers, AVS offers FGL/AGL, which provides equivalent functionality to the agX C library.

### 7.11.1 Documentation

None

### 7.11.2 Worked examples

[http://www.avs.com/software/soft\\_t/toolm.html](http://www.avs.com/software/soft_t/toolm.html)

## 7.12 winteracter

<http://www.polyhedron.co.uk/>

Winteracter is a modern GUI toolset for the Fortran 90/95 programming language. It consists of various visual development tools and a substantial subroutine library. Versions are available for most Fortran 9x compilers.

### 7.12.1 Documentation

None

### 7.12.2 Worked examples

None

## 7.13 Microsoft Windows graphics programming

This can be done in a variety of ways.

The following is a good book with examples of doing this using Compaq Visual Fortran.

Norman Lawrence, *Compaq Visual Fortran: A Guide to Creating Windows Applications*.

He also has coverage of `opengl`.

It is also possible to develop the visual interface using Visual Basic and call fortran dlls.

If you have Compaq Visual Fortran then the on-line Programmers Guide has coverage of mixed language programming with examples.

The following compilers offer intergrated support for Windows programming under .NET.

### 7.13.1 Lahey/Fujitsu

<http://www.lahey.com/>

PRO for Windows adds a Fortran-smart Windows editor, a debugger, an AUTOMAKE make utility, and an enhanced Winteracter Starter kit (WiSK) for creating true Windows programs with Fortran, and a Coverage Analysis Tool that detects unexecuted code and performs range of operation checking. The PRO is compatible with Visual C++, Visual Basic, and Delphi and also includes Fujitsu's SSL2 Math Library and Visual Analyzer (see below).

### 7.13.2 Salford Software

<http://www.silverfrost.com/11/ftn95/overview.asp>

FTN95 for .NET, including integrated Help and Debugger, is supplied bundled with FTN95 for Win32 and, optionally, with Microsoft Visual Studio for .NET. A low-cost, fully-featured personal edition is also available.

# Chapter 8

## Parallel Programming

- Version 1.9, March 2015, added entry for the opencoarray project
- Version 1.8, January 2013. Minor updates pointed out by Anton Shterenlikht
- Version 1.7, January 2013. Added section on examples of combinations of compilers and MPI libraries that work, or have worked in the past.
- Version 1.6, August 2012; Updated several entries; Added several books;
- Version 1.5, October 2011; Updated gfortran mpi entry; updated Intel coarray entry; updated NAG openmp entry
- Version 1.4, August 2010; Updated coarray, mpi and openmp entries.
- Version 1.3, July 2010; Added g95 entry. Modified gfortran entry.
- Version 1.2, June 2009; Corrected and updated several web addresses.
- Version 1.1, January 2006.

### 8.1 Introduction

The Fortran language has been standardised a number of times

- Fortran 66
- Fortran 77
- Fortran 90
- Fortran 95
- Fortran 2003
- Fortran 2008

and Fortran 2008 was completed in 2010.

The Fortran 90 standard added whole array features and a WHERE construct that were aimed at parallel programming.

The Fortran 95 standard added the FORALL construct, and PURE and ELEMENTAL procedures to help with parallel programming.

Fortran 2008 added coarrays.

Independently of the Fortran Standards Committees there have been a number of other developments aimed at parallel programming including

- HPF
- MPI
- OpenMP
- Posix Threads

and each of these is covered in more depth below.

Two tutorials on parallel programming are given below.

[http://www.mhpcc.edu/training/workshop/parallel\\_intro/MAIN.html](http://www.mhpcc.edu/training/workshop/parallel_intro/MAIN.html)

and

<http://users.actcom.co.il/~choo/lupg/tutorials/parallel-programming-theory/parallel-programming-theory.html>

### 8.1.1 Books

- Rainer Keller (Editor), David Kramer (Editor), Jan-Philipp Weiss (Editor), Facing the Multicore-Challenge II: Aspects of New Paradigms and Technologies in Parallel Computing (Lecture Notes in Computer Science / Theoretical Computer Science and General Issues) Springer, 2012, ISBN-10: 364230396X, ISBN-13: 978-3642303968
- K. De Bosschere (Author), E. H. D'Hollander (Author), G. R. Joubert (Author), D. Padua (Author), F. Peters (Author), Applications, Tools and Techniques on the Road to Exascale Computing, 2012, IOS Press, ISBN-10: 1614990409 ISBN-13: 978-1614990406
- Kristjn Jnasson (Editor), Applied Parallel and Scientific Computing: 10th International Conference, PARA 2010, 2012, Springer, ISBN-10: 3642281508, ISBN-13: 978-3642281501
- Victor Malyskin (Editor), Parallel Computing Technologies: 11th International Conference, PaCT 2011, Kazan, Russia, September 19-23, 2011, Proceedings (Lecture Notes in ... Computer Science and General Issues), 2012, Springer, ISBN-10: 3642231772 ISBN-13: 978-3642231773



## 8.2 Automatic

By this is meant automatic parallelisation of the code without source code modification.

## 8.3 Coarray Fortran

Coarray Fortran is a small extension to Fortran 2003. It is a simple, explicit notation for data decomposition, such as that often used in message-passing models, expressed in a natural Fortran-like syntax. The syntax is architecture-independent and may be implemented not only on distributed memory machines but also on shared memory machines and even on clustered machines.

Coarray Fortran was the major component of the Fortran 2008 standard.

### 8.3.1 `opencoarrays.org`

The following

<http://www.opencoarrays.org/>

provides details of an open-source software project for developing, porting and tuning transport layers that support coarray Fortran compilers.

The current developer version of GNU Fortran (GFortran), which is part of GCC 5, is OpenCoarrays-compatible.

## 8.4 HPF

The High Performance Fortran Forum (HPFF), a coalition of industry, academic and laboratory representatives, works to define a set of extensions to Fortran 90 known collectively as High Performance Fortran (HPF). HPF extensions provide access to high-performance architecture features while maintaining portability across platforms.

Harvey Richardson has provided a historical perspective on HPF. Visit

<http://www.zeenty.com/HPF/HPF-intro.pdf>

**Requires source code modification.**

## 8.5 MPI

MPI is a library specification for message-passing, proposed as a standard by a broadly based committee of vendors, implementors, and users.

<http://www-unix.mcs.anl.gov/mpi/>

<http://www-unix.mcs.anl.gov/mpi/mpich/>

[http://en.wikipedia.org/wiki/Message\\_Passing\\_Interface](http://en.wikipedia.org/wiki/Message_Passing_Interface)

### 8.5.1 Books

- Aoyama, Yukiya; Nakano, Jun (1999) RS/6000 SP: Practical MPI Programming, ITSO. Available as a pdf.

<http://www.redbooks.ibm.com/abstracts/sg245380.html>

- Gropp, William; Lusk, Ewing; Skjellum, Anthony (1999a). Using MPI, 2nd Edition: Portable Parallel Programming with the Message Passing Interface. Cambridge, MA, USA: MIT Press Scientific And Engineering Computation Series. ISBN 978-0-262-57132-6.
- Pacheco, Peter S. (1997) Parallel Programming with MPI.[1] 500 pp. Morgan Kaufmann ISBN 1558603395.
- Yiannis Cotronis (Editor), Anthony Danalis (Editor), Dimitris Nikolopoulos (Editor), Jack Dongarra (Editor) Recent Advances in the Message Passing Interface: 18th European MPI Users' Group Meeting, EuroMPI 2011, Santorini, Greece, September 18-21, 2011. ... / Programming and Software Engineering), 2011, Springer, ISBN-10: 3642244483, ISBN-13: 978-3642244483

### 8.5.2 Courses

In the UK the Hector service

<http://www.hector.ac.uk/>

provide various parallel programming courses. Details of their courses can be found at

<http://www.hector.ac.uk/cse/training/>

Cambridge University provide an MPI Course, offered by Nick Maclaren. See

<http://www-uxsup.csx.cam.ac.uk/courses/MPI/>

### 8.5.3 Requirements

Requires the installation of the MPI library (some compiler companies offer a bundle of compiler and MPI library) and source code modification.

## 8.6 OpenMP

The OpenMP Application Program Interface (API) supports multi-platform shared-memory parallel programming in C/C++ and Fortran on all architectures, including Unix platforms and Windows NT platforms. Jointly defined by a group of major computer hardware and software vendors, OpenMP is a portable, scalable model that gives shared-memory parallel programmers a simple and flexible interface for developing parallel applications for platforms ranging from the desktop to the super-computer.

<http://www.openmp.org/>

<http://en.wikipedia.org/wiki/OpenMP>

### 8.6.1 Books

- R. Chandra, R. Menon, L. Dagum, D. Kohr, D. Maydan, J. McDonald, Parallel Programming in OpenMP. Morgan Kaufmann, 2000. ISBN 1558606718
- Parallel Programming in OpenMP, Chandra et al, 2007, Morgan Kaufmann, ISBN 978-1-55860-671-5
- B. Chapman, G. Jost, R. van der Pas, D.J. Kuck (foreword), Using OpenMP: Portable Shared Memory Parallel Programming. The MIT Press (October 31, 2007). ISBN 0262533022
- Using OpenMP, Chapman et al, 2007, MIT Press, ISBN 978-0262533027
- Barbara Chapman (Editor), Federico Massaioli (Editor), Matthias S. Miller (Editor), Marco Rorro (Editor), OpenMP in a Heterogeneous World: 8th International Workshop on OpenMP, IWOMP 2012, Rome, Italy, June 11-13, 2012. Springer, ISBN-10: 3642309607 ISBN-13: 978-3642309601
- Barbara M. Chapman (Editor), William D. Gropp (Editor), Kalyan Kumaran (Editor), Matthias S. Miller (Editor), OpenMP in the Petascale Era: 7th International Workshop on OpenMP, IWOMP 2011, Chicago, IL, USA, June 13-15, 2011, Springer, ISBN-10: 364221486X ISBN-13: 978-3642214868

### 8.6.2 Courses

In the UK the Hector service

<http://www.hector.ac.uk/>

provide various parallel programming courses. Details of their courses can be found at

<http://www.hector.ac.uk/cse/training/>

### 8.6.3 Resources

<http://www.openmp.org/wp/resources/>

<http://www.openmp.org/wp/resources/openmp-compilers>

<http://openmp.org/wp/openmp-specifications/>

### 8.6.4 Requirements

Requires source code modification.

## 8.7 Posix Threads

Posix Threads is a library specification for multithreading, proposed as a standard by a broadly based committee of vendors, implementors, and users.

<http://www.llnl.gov/computing/tutorials/pthreads/>

Requires the installation of a threading library. Many operating systems come with a threading library pre-installed.

Also requires source code modification.

<http://www.llnl.gov/computing/tutorials/pthreads/>

## 8.8 Notes on the table below

Here is a quote from an email from Bill Long of Cray.

These interchanges took place on comp-fortran-90 at

<http://www.jiscmail.ac.uk/lists/comp-fortran-90.html>

The archives go back to 1997 and can be searched.

```
{
BEGIN QUOTE
>>
>>Erik Schnetter wrote:
>>
>>>
>>>Since MPI and threads are implemented as libraries, they work with
>>>every compiler. They are on a rather low level. HPF and OpenMP are,
>>>in a way, language extensions that are translated into MPI or threads
>>>by the compiler.
>>>
>>>
```

```

>>>
>>Perhaps a bit simplistic to say "they work with every compiler".
>>Whether MPI or threads (and what kind of threads) work is generally
>>independent of the compiler, but not of the operating system.  HPF,
>>OpenMP, and some forms of automatic parallelization often involve
>>compiler generated calls to library routines, but
>>not necessarily to MPI or POSIX threads library routines.
>>A vendor might opt for something more efficient.
>>
>>For many of the entries in Ian's list, there is an
>>implied combination of compiler, OS, and hardware.
>>For such a combination it is reasonable to talk
>>about support for MPI or pthreads.
>>Perhaps it would be helpful to be more explicit
>>about that combination.  Most of the parallel
>>programming schemes depend on more than just the compiler.
>>
>>Cheers,
>>Bill
>>
END QUOTE

```

Here is a quote from an email from Malcolm Cohen of NAG

```

BEGIN QUOTE
>>
>>Erik Schnetter said:
>>> The IBM Fortran compiler supports Posix threads:
>>
>>As I suspect do most.  Certainly the NAG compiler does.
>>
>>Cheers,
>>--
>>.....
>>Malcolm Cohen, Nihon NAG, Tokyo, Japan.
>>(malcolm@nag-j.co.jp)
>>
END QUOTE

```

In the light of these comments I've added a 'C' category which means that you will need to check your

- hardware
- operating system version

- compiler version
- MPI version or Posix Threads version

to see if the combination works.

The Y entry normally means that the compiler supplier provide a bundled or fully supported offering.

## 8.9 Table of compilers and supported parallel options

	Automatic	Co Array	HPF	MPI	OpenMP	Posix Threads
Absoft				Y	Y	C
Cray						
PVP	Y			Y	Y	C
T3E		Y		Y		C
X1		Y		Y	Y	C
Fujitsu						
Sparc				C	Y	C
g95						
		P				
gfortran						
		P		Y	Y	
HP						
HP-UX				C	Y	C
Tru64 Unix			Y	C	Y	C
Openvms						
Alpha				C		C
Openvms						
Integrity				C		C
Openvms						
VAX				C		C
CVF						
Windows				C		C
IBM						
XL	Y			C	Y	Y
Intel						
	Y	Y		C	Y	C
Lahey/Fujitsu						

Pro Linux	Y		C	Y	C	
NAG						
Apple			C	Y	C	
HP PA-RISC 1.1			C		C	
IBM Power AIX			C		C	
IBM Z9 Linux			C		C	
IBM Z9						
Open Edition			C		C	
Linux x86-32			C	Y	C	
Linux64			C	Y	C	
Sun SPARC Solaris			C		C	
Sun SPARC Solaris			C		C	
x86 and x86-64						
Windows			C	Y	C	
NEC						
SX	Y		C		C	
Pathscale						
	Y		Y	Y	C	
Portland Group						
	Y	Y	C	Y	C	
SGI						
IRIX	Y		C	Y	C	
SUN						
	Y		Y	Y	C	
		Automatic Co Array	HPF	MPI	OpenMP	Posix Threads

Please see the following for up to date details of compiler conformance to the Fortran 2003 and 2008 standards, and hence support for coarrays.

[http://www.fortranplus.co.uk/resources/fortran\\_2003\\_2008\\_compiler\\_support.pdf](http://www.fortranplus.co.uk/resources/fortran_2003_2008_compiler_support.pdf)

## 8.10 Parallelisation Tools

### 8.10.1 Crescent Bay Software

Offer a range of parallelisation tools.

[http://www.crescentbaysoftware.com/end\\_user.html](http://www.crescentbaysoftware.com/end_user.html)

VAST-F/Parallel (for Fortran) and VAST-C/Parallel (for C), from Crescent Bay Software, are automatic parallelizing preprocessors that can significantly improve the performance of your important applications on shared memory parallel platforms.

[http://www.crescentbaysoftware.com/vast\\_parallel.html](http://www.crescentbaysoftware.com/vast_parallel.html)

VAST/toOpenMP from Crescent Bay Software is a parallelizing optimizer that adds OpenMP directives to Fortran programs. Translated programs have portable parallelism that can execute efficiently on a variety of SMP parallel systems from multi-cpu PCs to Supercomputers.

[http://www.crescentbaysoftware.com/vast\\_toOpenMP.html](http://www.crescentbaysoftware.com/vast_toOpenMP.html)

### 8.10.2 Parallel Software Products

Offer a tool to help parallelise Fortran 77, Fortran 90 or Fortran 95 code.

Their web address is

<http://www.parallelspace.com/index.htm>

The tool can generate either MPI calls or OpenMP calls.

## 8.11 Compiler and MPI combinations

The following is a list of combinations of compilers and MPI library versions that are known to work or have worked in the past.

The list is not exhaustive, and other combinations do work.

### 8.11.1 IBM

hardware: IBM Power4 64-bit systems or compatible  
 operating system: AIX v5.3 or compatible  
 Fortran compiler: XL Fortran v9.1 or compatible  
 MPI: IBM Parallel Operating Environment  
 v4.1.1 or compatible

### 8.11.2 Apple

hardware: Apple G4/G5 Power Macintosh  
 operating system: Mac OS X 10.3.9, Mac OS X 10.4.5  
 Fortran compiler: GNU g77 3.4.5  
 (needs linker found in cctools-528.5.dmg or later  
 see <ftp://gcc.gnu.org/pub/gcc/infrastructure/>)  
 C compiler: Apple bundled gcc compiler (4.0.0 or 3.3)  
 or FSF gcc 3.4.5 or FSF gcc 4.0.2  
 or IBM XLC compiler 6.0  
 and compatible compilers  
 MPI: MPICH2 version 1.0.3 compatible



### 8.11.3 Nag

hardware: AMD64  
operating system: 64-bit Linux  
Fortran compiler: NAGWare f95 Release 5.0 and compatible  
C compiler: gcc 3.3 and compatible  
MPI: MPICH 1.2.6 and compatible

### 8.11.4 PGI

hardware: AMD64  
operating system: 64-bit Linux  
Fortran compiler: Portland Group pgf77 6.0-5 and compatible  
C compiler: Portland Group pgcc 6.0-5 and compatible  
MPI: MPICH 1.2.6 and compatible

### 8.11.5 Oracle

hardware: Sun Fire V890+, UltraSPARC IV+, 1500MHz, 24 cores  
operating system: Solaris 10 Update 3  
Fortran compiler: Sun Studio 11 Fortran 95 8.2  
compiler options: -fsimple=1 -xvector=no -ftrap=%none  
-KPIC -xarch=v9a -dalign -stackvar -O4  
C compiler: Sun Studio 11 C Compiler 5.8  
compiler options: -DAdd\_ -xarch=v9a -KPIC -O  
MPI: Sun ClusterTools 7  
BLAS: Sun Studio 11 Sun Performance Library

### 8.11.6 Intel

hardware: Intel EM64T systems and compatible (including AMD64)  
operating system: Linux for x86-64 with glibc-2.5 and compatible  
Fortran compiler: Intel(R) Fortran Intel(R) 64 Compiler  
Version 11.0 and compatible  
C compiler: Intel(R) C Intel(R) 64 Compiler  
Version 11.0 and compatible  
MPI: Intel(R) MPI Library 3.2 for Linux  
ScaLAPACK: Intel(R) Math Kernel Library 10.1 for Linux  
BLAS/LAPACK: Intel(R) Math Kernel Library 10.1 for Linux



# Chapter 9

## Fortran Software Tools

- Version 1.5, July 2015. Added Doctran entry. It is cross-platform documentation generation tool for the Fortran
- Version 1.4. Updated the entry for Nag. The compiler can now produce call graphs, do a dependency analysis, produce interface modules and pretty print or polish Fortran code
- Version 1.3, May 2013: Added Visustin Flow charting software. Updated various entries.
- Version 1.2, 2011; Added refactoring as part of title; Add Photran entry;
- Version 1.1, June 2009; Added web address for convert; Added web address for for\_struct; Updated Nag entry - tools no longer available, being incorporated into the compiler.
- Version 1.0, January 2006.

### 9.1 Refactoring

Wikipedia has a detailed coverage of code refactoring that is a good place to start. Have a look at

[http://en.wikipedia.org/wiki/Code\\_refactoring](http://en.wikipedia.org/wiki/Code_refactoring)

Here is their first paragraph.

Code refactoring is disciplined technique for restructuring an existing body of code, altering its internal structure without changing its external behavior, undertaken in order to improve some of the nonfunctional attributes of the software. Typically, this is done by applying series of refactorings, each of which is a (usually) tiny change in a computer program's source code that does not modify its functional requirements. Advantages include improved code readability and reduced complexity to improve the maintainability of the source code, as well as a more expressive internal architecture or object model to improve extensibility.

Photran is listed in the Wikipedia entry as a Fortran refactoring tool.

## 9.2 Convert

Fortran 77 to Fortran 90 converter by Mike Metcalf.

<http://www.nag.co.uk/nagware/Examples/convert.f90>

## 9.3 Doctran

The following is taken from their web site.

Doctran is a cross-platform documentation generation tool for the Fortran programming language. Its purpose is to take free-format Fortran files, and produce a collection of linked html files documenting their contents.

Doctran can currently create documentation from source codes that contain constructs from the Fortran 95 standard and object oriented constructs from the Fortran 2003 standard.

<http://www.doctran.co.uk/>

## 9.4 Forcheck

A Fortran analyzer and programming aid, here is an extract describing the product.

- is the oldest and most comprehensive Fortran verifier on the market. It performs a full static analysis of an entire Fortran program or a separate analysis of one or more subprograms. detects more anomalies in your program than the compiler. Because it locates bugs as early in the development phase as possible, it saves you time and helps you to produce more reliable programs.
- is ideally suited to get a fast insight in existing and legacy programs. It composes optimal documentation with a call-tree and cross-reference tables both on the program-unit as on the program level.
- can be used as a software engineering tool in the various stages of the development process.
- can verify the conformance to the Fortran standards. Moreover it supports many language extensions of all popular compilers. FORCHECK is fully configurable so you can tune the analysis and output to your needs.
- can store the global information of the analyzed program-units in libraries. You can reference these libraries in subsequent FORCHECK runs to verify the consistency of all references and common-blocks.
- is very suitable as a cross-platform development tool.
- is available on many platforms from PC to supercomputer. It supports most Fortran extensions of all popular compilers.

- is sold with full guarantee and support.

<http://www.forcheck.nl/>

## 9.5 FOR\_STRUCT

<http://www.cobalt-blue.com/fs/fsmain.htm>

Restructures FORTRAN into Clean, Maintainable Code.

## 9.6 FOR\_STUDY

Analyzes and Documents your FORTRAN code.

<http://www.cobalt-blue.com/>

## 9.7 Fortran90-lint

For Fortran 90 program analysis

<http://www.cleanscape.net/products/downloads/ftpflint.html>

## 9.8 NAG

The Nagware tools provided users with the ability to analyse and transform Fortran 77 and Fortran 95 code. They have been withdrawn as an individual product and the functionality is being added to the compiler.

The following options are currently supported:

- =callgraph - Produce a callgraph of the Fortran routines in the source files.
- =depend - Produce a dependency analysis of the Fortran source files.
- =interfaces - Produce a module or include file containing procedure interfaces.
- =polish - Pretty-print (polish) the Fortran source files.

<http://www.nag.co.uk/>

## 9.9 photran

Photran is an Integrated Development Environment (IDE) for Fortran 77, 90, 95, and 2003 based on Eclipse and the CDT. The project is maintained by the University of Illinois at Urbana-Champaign and IBM.

<http://www.eclipse.org/photran/>

## 9.10 plusFORT

The following is taken from their web site.

plusFORT, from Polyhedron Software, is a multi-purpose suite of tools for analyzing and improving Fortran programs. It combines restructuring and reformatting with global static analysis, dynamic analysis and many other features in a single powerful package. plusFORT is a one-stop solution for programmers, project managers, and quality assurance engineers working with Fortran source code.

SPAG - Fortran source code restructuring, Quality Assurance using plusFORT, GXCHK - Global Static Analysis, Dynamic Analysis, Coverage Analysis.

<http://www.polyhedron.com/>

## 9.11 VAST/77to90

Fortran 77 to Fortran 90 translator

[http://www.crescentbaysoftware.com/vast\\_77to90.html](http://www.crescentbaysoftware.com/vast_77to90.html)

## 9.12 Visustin

Automated flowcharting software. The following is taken from their web site.

Visustin is an automated flow chart program for software developers and document writers. Save documentation efforts with automatic code visualization. Visustin reverse engineers your source code to flow charts or UML Activity Diagrams. Visustin reads the if and else statements, loops and jumps and builds a diagram fully automated.

No manual drawing is required. Visustin flowcharts ABAP, ActionScript, Ada, ASP, several assembly languages, BASIC, .bat files, C, C++, C Sharp, Clipper, COBOL, ColdFusion, Delphi, Fortran, Java, JavaScript, JCL (MVS), JavaServer Pages, LotusScript, Matlab, MXML, Pascal, Perl, PHP, PL/I, PL/SQL, PowerBuilder, PowerScript, PureBasic, Python, QB, REALbasic, REXX, Ruby, SAS, Unix shell script (bash, csh, tcsh, ksh, sh), Tcl, TSQL, VB, VBA, VBScript, VB.Net, Visual FoxPro and XSLT.

<http://www.aivosto.com/visustin.html>

# Chapter 10

## Fortran Electronic Lists

- Version 1.3, August 2012. Added LinkedIn.
- Version 1.2, November 2011. Expanded comp.lang.fortran entry with more information about usenet.
- Version 1.1, January 2006.

### 10.1 comp-fortran-90

Jiscmail hosted. Restricted to questions about Fortran since the publication of the Fortran 90 standard. Can either browse on-line or subscribe and get postings via email. Postings are archived and go back to 1997.

<http://www.jiscmail.ac.uk/lists/comp-fortran-90.html>

### 10.2 comp.lang.fortran

Usenet news hosted Fortran list. Covers all aspects of Fortran.

Usenet is a worldwide distributed Internet discussion system. Users read and post messages (called articles or posts, and collectively termed news) to one or more categories, known as newsgroups. Discussions are generally threaded with modern news reader software.

Usenet is distributed amongst a large, changing set of servers that store and forward messages to one another in so-called news feeds. Individual users may read messages from and post messages to a local server operated by their Internet service provider, university, or employer.

Newsreader clients

Newsgroups are typically accessed with special client software that connects to a news server. Newsreader clients are available for all major operating systems.

Web accessible newsgroups

Web front ends to newsgroups mean that many people now no longer need to use download and install or configure a news reader client Google Groups is one such web based front end and web browsers can access Google Groups.

Free usenet news service

<http://www.ets.net>

Welcome to news.ets.net news.ets.net is a private project providing free access to text-only Usenet News. The server has a 100MBit connection to several Internet backbones and is integrated into the Usenet via more than 60 peers.

Free access to the news server news.ets.net provides free read and write access to all text newsgroups. It requires a registration that can be done online.

<http://groups.google.co.uk/group/comp.lang.fortran?lnk=lr>

<http://groups.google.ca/group/comp.lang.fortran>

## 10.3 LinkedIn

LinkedIn is a social networking website for people in professional occupations. As of June 2012, LinkedIn reports more than 175 million registered users in more than 200 countries and territories.

<http://www.linkedin.com/>

The Fortran Programmers Group has 1697 members as of August 2012.

The site is available in English, French, German, Italian, Portuguese, Spanish, Dutch, Swedish, Romanian, Russian, Turkish, Japanese, Czech, Polish, Korean, Bahasa Indonesia, and Bahasa Malaysia.

## 10.4 Compiler specific

Some of the compiler suppliers provide electronic list support. Some provide an email address for technical support.

### 10.4.1 Absoft

<http://forums.absoft.com/>

[support@absoft.com](mailto:support@absoft.com)

### 10.4.2 Apogee

[info@apogee.com](mailto:info@apogee.com)



### 10.4.3 Compaq

### 10.4.4 Cray

### 10.4.5 Fortran Company

You can subscribe to an e-mail list by sending e-mail to [majordomo@fortran.com](mailto:majordomo@fortran.com) with the following in the body of the message:

subscribe f-interest-group@fortran.com

### 10.4.6 Fujitsu

### 10.4.7 Gnu Fortran 95

You can reach us at the [fortran@gcc.gnu.org](mailto:fortran@gcc.gnu.org) mailing list; for details please refer to our mailing lists page.

<http://gcc.gnu.org/lists.html>

### 10.4.8 G95

<http://groups.google.com/group/gg95>

### 10.4.9 Hewlett Packard

[vf-support@hp.com](mailto:vf-support@hp.com)

### 10.4.10 IBM

Requires registration.

### 10.4.11 Intel

Requires registration.

<https://premier.intel.com/WhatsNew.aspx>

### 10.4.12 Lahey Fujitsu

Requires registration.

<http://www.lahey.com/support.htm>

<http://www.laheyforum.com/>

### 10.4.13 NAG

Requires registration.

[support@nag.co.uk](mailto:support@nag.co.uk)

### 10.4.14 NA Software

### 10.4.15 NEC

<http://www.nec.com/global/support/index.html>

### 10.4.16 Pathscale

Requires registration.

<http://pathscale.com/support.html>

[support@pathscale.com](mailto:support@pathscale.com)

### 10.4.17 PGI

Various offerings.

<http://www.pgroup.com/support/index.htm>

### 10.4.18 Salford Software

Various options.

<http://www.silverfrost.com/22/ftn95/support/index.asp>

### 10.4.19 SGI

Various options.

<http://www.sgi.com/support/customerservice.html>

### 10.4.20 SUN

<http://forums.sun.com/category.jspa?categoryID=113>

# Chapter 11

## Fortran Standard Bodies

- Version 1.1, August 2012; Updated J3 entry to reflect organisation within the US
- Version 1.0, January 2006.

### 11.1 Introduction

There are two main Fortran standards bodies and these are WG5 and PL22.3 (formerly J3). Each is covered in turn below.

### 11.2 WG5

Their home page is:-

`http://www.nag.co.uk/sc22wg5/`

Their document ftp site is at:-

```
ftp://ftp.nag.co.uk/sc22wg5/  
\end{verb
```

The following

```
\begin{verbatim}http://www.nag.co.uk/sc22wg5/links.html
```

has links to documents relating to the following standards: Fortran 66, Fortran 77, Fortran 90, Fortran 95, Fortran 2003 and Fortran 2008.

### 11.3 PL22.3

Task Group PL22.3 (formerly J3) is responsible for the development and interpretation of the United State and International standards for Programming Language Fortran.

This technical committee is the U.S. TAG to ISO/IEC JTC1 SC22/WG5

Current participants (August 2012) include

Bierman,	Emeritus
Brainerd,	Emeritus
Cray Inc,	Bill Long
Hendrickson,	Emeritus
Hirschert,	Emeritus
IBM Corporation,	Daniel Chen
Intel Corporation,	Stan Whitlock
Jet Propulsion Laboratory,	Van Snyder
Lahey,	Emeritus
Maine,	Emeritus
Martin,	Emeritus
Meissner,	Emeritus
National Center for Atmospheric Research,	
North,	Emeritus
Oracle,	Robert Corbett
Smith,	Emeritus
The Numerical Algorithms Group Ltd,	Malcolm Cohen
United States Dept of Energy,	
Wagener,	Emeritus

<http://standards.incits.org/a/public/group/pl22.3>

The PL22.3 - J3 home page is:-

<http://www.j3-fortran.org/>

Their list of members (August 2012) is given below.

```
\begin{verbatim}
Voting Principals
=====
```

Daniel Chen,	IBM Corp.
Malcolm Cohen,	Nihon Numerical Algorithms Group K.K.

Robert Corbett,	Oracle America
William Long,	Cray Inc.
Dan Nagle	Chair PL22.3
Craig E. Rasmussen,	Los Alamos National Laboratory
Van Snyder,	Jet Propulsion Laboratory
Stan Whitlock,	Intel Corporation

## Voting alternatives

=====

Aleksandar Donev	- Craig Rasmussen
Steve Lionel	- Stan Whitlock
Kelvin Li	- Daniel Chen
Lorri Menard	- Stan Whitlock
Toon Moene	- Craig Rasmussen
John K. Reid	- Dan Nagle
Damian Rouson	- Craig Rasmussen
C. R. Schult	- William Long
Dr. John Wallin	- Dan Nagle
Rafik Zurob	- Daniel Chen

Their version of the working draft is at:-

<http://www.j3-fortran.org/doc/standing/links/007.pdf>



# Chapter 12

## Other Web Links

- Version 1.3, May 2016; Added a link to Brian Meek's personal history of the development of the Fortran 90 standard; Added Malcolm Cohen's personal history of the development of the first Fortran 90 compiler.
- Version 1.2, June 2009; Updated several web links.
- Version 1.1, September 2008
- Version 1.0, January 2006

### 12.1 Fortran History

#### 12.1.1 A brief history of FORTRAN-Fortran

<http://www.ibiblio.org/pub/languages/fortran/ch1-1.html>

#### 12.1.2 The Fortran (not the foresight) saga: the light and the dark

An article written by Brian Meek in 1990 on the development of Fortran 90.

[http://www.fortranplus.co.uk/resources/brian\\_meeks\\_fortran\\_saga.pdf](http://www.fortranplus.co.uk/resources/brian_meeks_fortran_saga.pdf)

#### 12.1.3 A Personal History of the NAG Fortran compiler, Malcolm Cohen, Tokyo, October 2004

Pre History

The year was 1988. The revision of the Fortran standard had fallen into turmoil.

The committee which was revising the language standard for ISO, X3J3 (the U.S. Fortran committee, which has since changed its name to J3), was split roughly into three warring factions:

- 1 The progressives: those who wanted to very greatly modernise the language (mostly users).
- 2 The traditionalists: those who wanted to freeze the language, or perhaps just adopt extremely minor extensions (mostly vendors).
- 3 The moderates: those who wanted to modernise the language, but not by as much as the first group (some users, some vendors).

After the end of the public consultation period in 1987, these three groups could not agree on how to proceed. The traditionalists were saying that the proposed new language could not be implemented. Each moderate was saying that the proposed language was too complicated, and besides was missing his favourite feature (a different one for each person). The progressives were saying that the others just wanted to ruin the new language by taking away the good bits. (Note: In reality it was a good deal more complicated than this, but this is a reasonable simplification which gives some idea of the problem at the time.)

The issue came to a head in the middle of 1988, at the meeting in Paris of the ISO working group on Fortran (this committee rejoices in the name of ISO/IEC JTC1/SC22/WG5). This working group has the responsibility for revising the Fortran standard, though then as now the technical work was essentially delegated to the American committee. Due to the impasse on the American committee, WG5 decided that it was its responsibility to decide what should be in the new language, and therefore discussed the competing proposals.

In response to the traditionalists' claim that the language was so complex and unwieldy that it could never be implemented, at this meeting Julian Tilbury of Salford Software and myself presented a front-end for Fortran 8x (the working name for the language revision) suitable for building software tools or indeed a compiler. It was significant that this demonstration (which analysed the complete, supposedly non-implementable, language) had taken only 3 months to write from scratch. (The demonstration did not quite go without a hitch, because the keyboard was French but the software treated it as English. So when typing in examples I had to close my eyes - or stare fixedly at the screen - and type where I remembered the keys ought to be instead of looking at the keyboard.)

In the event, WG5 decided on a relatively progressive modernisation of the language which would address the concerns expressed by the international community, and specified what new features the language should contain. In more hope than expectation that the work could be quickly done WG5 suggested that the new language be called Fortran 88, and this then became Fortran 90 after the work took longer than hoped.

NAG has built its reputation on a number of fine products, but by far the most important in terms of customers was its numerical library in Fortran. It was clear to NAG that Fortran continued to offer the best facilities for writing numerical software, and that NAG had an interest in Fortran maintaining its market share. It was also believed that Fortran would simply wither away if it were not quickly modernised,



which is why NAG supported the efforts of the standards committees by attending these meetings (and also in helping to produce the demonstration in Paris '88).

NAG needed to have early access to Fortran 90 compilers, so that it could develop its products ready for when the compilers became widely available. Furthermore, having made extensive successful use of Fortran (66, then 77) software tools in the development and quality assurance of its Fortran (66/77) library, it wanted also to have access to Fortran 90 software tools. It was also thought that NAG producing a compiler would act as a spur to the other compiler vendors, and also ensure that even if a native vendor compiler was not available for some particular machine, we would have our own that we could use.

It was in the late spring of 1990, in conversation with one of the directors of NAG about the future of Fortran, that it was suggested that I might be able to write a compiler for the new language. I replied that naturally I thought I could do such a thing, having had a long-standing interest in programming language design and implementation, and indeed had designed a language of my own and written a compiler for it while I was at college (a much smaller language than Fortran 90, though!).

Perhaps I should not have been surprised at the turn of events ... first my manager asked me how long I thought it would take me to write a compiler (I answered "definitely more than a year; say about fifteen months?"). The next thing I knew was that had become my assigned task and I had a deadline set at fifteen months! Needless to say, during that development period I worked harder and longer than ever before on a single product.

The first decisions to be taken were the target machine or language, and the implementation language. I decided both to write the compiler in C, and to produce C (as a portable assembler). Some of the reasons being

- I was sufficiently familiar with C to be able to write highly portable code.
- C compilers were widely available (if less so than now).
- It would allow the compiler to be very quickly ported to new systems.
- I could use the C compiler optimiser, reducing the amount of optimisation that the Fortran compiler needed to do itself.

Most of the Fortran 90 features were familiar to me, as I had encountered similar features in other programming languages. One problem was simply the number of features and their interactions. It is possible to put on an extra burst of energy to reach the top of a hill that is within sight, but maintaining that level of output when climbing a mountain is not so easy. One gets to the top of one peak, only to be greeted with the sight of additional vistas opening before you.

The largest feature that I was relatively unfamiliar with was the array syntax and the whole array operations. Since for the first release in particular, correctness was a much more important goal than performance, I took a very simple approach to handling array expressions. Since I was unsure exactly how to evaluate a whole array

expression at once, but knew how to evaluate any single array operation, every array expression was broken down into single operations producing a temporary array result. This approach was very successful in guaranteeing the right answer, but unfortunately also quite successful in not providing good performance. (This is why, in release 2.0 a couple of years later, the array expression handling was completely rewritten.)

Another major problem was that of testing the compiler. For the subset that was in Fortran 77 there were existing test suites we could (and did) use. For numerical accuracy we had our own tests and library. But for all the new features there was, of course, virtually no code in existence - just a few examples in the standard itself and in books such as Mike Metcalf and John Reid's "Fortran 90 Explained" (we found this book so clear in its explanations of the new language that we decided to use it as the compiler manual).

I wrote many individual feature test programs myself during development, but this was not sufficient to ensure that features would work when used together. We knew that Brian Smith and others were writing a test suite, so in exchange for use of the prototype compiler to test their test programs, we got bug reports back when the compiler went wrong. This proved to be invaluable, and doubtless without this it would have taken many months longer to bring the compiler to a releasable quality.

By the spring of 1991 I found that I needed a break from doing the compiler all day, so in the evenings I decided to build a car (a Caterham Super Seven). It seems that cars must be simpler than compilers though, as I finished the (high performance) car first!

And so, after many trials and tribulations, the compiler was finally released (as the world's first Fortran 90 compiler) in September 1991, at virtually the same time that the standard saw publication.

For all my hard work in producing the compiler I was rewarded with the tasks not only of supporting and maintaining it, but to extend and enhance it to encompass new language standards (HPF, then Fortran 95 and now Fortran 2003), user requests for extensions (many, mostly historical "dusty-deck" style language), greater performance, and even more facilities for detecting errors in programs both at compile time and execution time. As I write, the current release of the compiler already includes a substantial number of Fortran 2003 features, and work is underway on further improvements.

### **Additional history of the Nag compiler**

The following is taken from an interchange with Malcolm Cohen of Nag.

Yes there was DEC VAX/VMS, and later DEC Alpha OpenVMS. We also did DEC Alpha Unix.

The VMS support stopped before 2002, but release 4.2 still supported DEC Alpha Unix, DEC Alpha Linux, HP 9000/700, IBM RS6000, SGI Irix 5 and 6, Itanium Linux, Sun 4.0 and 5.x, IBM OS/390 Open Edition, Linux x86, FreeBSD x86, and very basic support for Windows (no gui or debugger, command line only).

### **12.1.4 Computer Languages History (preview)**

<http://www.levenez.com/lang/history.html>

### **12.1.5 Computer Languages History**

<http://www.levenez.com/lang/>

### **12.1.6 Fortran A few historical details**

No longer available.

### **12.1.7 Open Directory - Fortran Tutorials Fortran 90 and 95**

[http://www.dmoz.org/Computers/Programming/Languages/Fortran/Tutorials/Fortran\\_90\\_and\\_95/](http://www.dmoz.org/Computers/Programming/Languages/Fortran/Tutorials/Fortran_90_and_95/)

### **12.1.8 Open Directory - Fortran**

<http://dmoz.org/Computers/Programming/Languages/Fortran/>

### **12.1.9 The Fortran (not the foresight) saga**

[http://www.fortranplus.co.uk/resources/brian\\_meeks\\_fortran\\_saga.pdf](http://www.fortranplus.co.uk/resources/brian_meeks_fortran_saga.pdf)

## **12.2 Computer Arithmetic**

### **12.2.1 What every computer scientist should know about floating point arithmetic**

<http://www.validlab.com/goldberg/paper.pdf>

### **12.2.2 IEEE 754r - Wikipedia, the free encyclopedia**

[http://en.wikipedia.org/wiki/IEEE\\_754r](http://en.wikipedia.org/wiki/IEEE_754r)

### **12.2.3 IEEE 754 Standard for Binary Floating-Point Arithmetic**

<http://grouper.ieee.org/groups/754/>

### **12.2.4 IEEE Standard 754 Floating-Point**

<http://stevehollasch.com/cgindex/coding/ieeefloat.html>

### 12.2.5 William Kahan

<http://www.cs.berkeley.edu/~wkahan/>

### 12.2.6 IEEE 754 floating-point test software

<http://www.math.utah.edu/~beebe/software/ieee/>

### 12.2.7 Interval FAQ from Alejandro Casares – What machines support IEEE 754

<http://www.mscs.mu.edu/~georgec/IFAQ/casares1.html>

### 12.2.8 Decimal Arithmetic - FAQ 1

<http://www2.hursley.ibm.com/decimal/decifaq1.html#emphasis>

### 12.2.9 General Decimal Arithmetic

<http://www2.hursley.ibm.com/decimal/>

## 12.3 Object Oriented Programming

Here is a link to a site that has a very good coverage of object oriented programming. Here is a snapshot of the content on that site.

- General Resources on Object Oriented Programming
- Online
- Books
- Object Modeling and UML
- OO Resources by Language
  - C-Based Languages
  - Common Lisp
  - Erlang
  - F#
  - Fortran
  - Go
  - Java
  - JavaScript

- PHP
  - Python
  - Ruby
  - Smalltalk
- On the Other Hand...
  - Bottom Line on OOP

<http://www.whoishostingthis.com/resources/oo-programming/>

## 12.4 Programming

### 12.4.1 Calling FORTRAN and C from Java

<http://www.csharp.com/javacfort.html>

### 12.4.2 CS 267 Applications of Parallel Computers

<http://www.cs.berkeley.edu/~yozo/cs267.sp05/>

### 12.4.3 Hillside.net - Design Patterns Book - DP Book

<http://hillside.net/patterns/DPBook/DPBook.html>

### 12.4.4 Hillside.net - Design Patterns Book - Source

<http://hillside.net/patterns/DPBook/Source.html>

### 12.4.5 Home page of Les Hatton

<http://www.leshatton.org/>

### 12.4.6 Parallel Programming - Basic Theory For The Unwary

<http://users.actcom.co.il/~choo/lupg/tutorials/parallel-programming-theory/parallel-programming-theory.html>

### 12.4.7 Putting a Java Interface on your C, C++, or Fortran Code

<http://www.math.ucla.edu/~anderson/JAVAclass/JavaInterface/JavaInterface.html>

### **12.4.8 Teach Yourself Programming in Ten Years**

<http://www.norvig.com/21-days.html>