

# axiom™



## The 30 Year Horizon

<i>Manuel Bronstein</i>	<i>William Burge</i>	<i>Timothy Daly</i>
<i>James Davenport</i>	<i>Michael Dewar</i>	<i>Martin Dunstan</i>
<i>Albrecht Fortenbacher</i>	<i>Patrizia Gianni</i>	<i>Johannes Grabmeier</i>
<i>Jocelyn Guidry</i>	<i>Richard Jenks</i>	<i>Larry Lambe</i>
<i>Michael Monagan</i>	<i>Scott Morrison</i>	<i>William Sit</i>
<i>Jonathan Steinbach</i>	<i>Robert Sutor</i>	<i>Barry Trager</i>
<i>Stephen Watt</i>	<i>Jim Wen</i>	<i>Clifton Williamson</i>

Volume 6: Axiom Command

January 31, 2019

36326d620b73709fd7ca49dad2be97c3cd43487

Portions Copyright (c) 2005 Timothy Daly

The Blue Bayou image Copyright (c) 2004 Jocelyn Guidry

Portions Copyright (c) 2004 Martin Dunstan

Portions Copyright (c) 2007 Alfredo Portes

Portions Copyright (c) 2007 Arthur Ralfs

Portions Copyright (c) 2005 Timothy Daly

Portions Copyright (c) 1991-2002,

The Numerical ALgorithms Group Ltd.

All rights reserved.

This book and the Axiom software is licensed as follows:

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are

met:

- Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
- Neither the name of The Numerical ALgorithms Group Ltd. nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Inclusion of names in the list of credits is based on historical information and is as accurate as possible. Inclusion of names does not in any way imply an endorsement but represents historical influence on Axiom development.

Michael Albaugh	Cyril Alberga	Roy Adler
Christian Aistleitner	Richard Anderson	George Andrews
Jerry Archibald	S.J. Atkins	Jeremy Avigad
Henry Baker	Martin Baker	Stephen Balzac
Yurij Baransky	David R. Barton	Thomas Baruchel
Gerald Baumgartner	Gilbert Baumslag	Michael Becker
Nelson H. F. Beebe	Jay Belanger	David Bindel
Fred Blair	Vladimir Bondarenko	Mark Botch
Raoul Bourquin	Alexandre Bouyer	Karen Braman
Wolfgang Brehm	Peter A. Broadbery	Martin Brock
Manuel Bronstein	Christopher Brown	Stephen Buchwald
Florian Bundschuh	Luanne Burns	William Burge
Ralph Byers	Quentin Carpent	Pierre Casteran
Robert Cavines	Pablo Cayuela	Bruce Char
Ondrej Certik	Tzu-Yi Chen	Bobby Cheng
Cheekai Chin	David V. Chudnovsky	Gregory V. Chudnovsky
Mark Clements	Roland Coeurjoly	James Cloos
Jia Zhao Cong	Josh Cohen	Christophe Conil
Don Coppersmith	George Corliss	Robert Corless
Gary Cornell	Meino Cramer	Karl Crary
Jeremy Du Croz	David Cyganski	Nathaniel Daly
Timothy Daly Sr.	Timothy Daly Jr.	James H. Davenport
David Day	James Demmel	Didier Deshommes
Michael Dewar	Inderjit Dhillon	Jack Dongarra
Jean Della Dora	Gabriel Dos Reis	Claire DiCrescendo
Sam Dooley	Nicolas James Doye	Zlatko Drmac
Lionel Ducos	Iain Duff	Lee Duhem
Martin Dunstan	Brian Dupee	Dominique Duval
Robert Edwards	Hans-Dieter Ehrich	Heow Eide-Goodman
Lars Erickson	Mark Fahey	Richard Fateman
Bertfried Fauser	Stuart Feldman	John Fletcher
Brian Ford	Albrecht Fortenbacher	George Frances
Constantine Frangos	Timothy Freeman	Korriinn Fu
Marc Gaetano	Rudiger Gebauer	Van de Geijn
Kathy Gerber	Patricia Gianni	Gustavo Goertkin
Samantha Goldrich	Holger Gollan	Teresa Gomez-Diaz
Laureano Gonzalez-Vega	Stephen Gortler	Johannes Grabmeier
Matt Grayson	Klaus Ebbe Grue	James Griesmer
Vladimir Grinberg	Oswald Gschnitzer	Ming Gu
Jocelyn Guidry	Gaetan Hache	Steve Hague
Satoshi Hamaguchi	Sven Hammarling	Mike Hansen
Richard Hanson	Richard Harke	Bill Hart
Vilya Harvey	Martin Hassner	Arthur S. Hathaway
Dan Hatton	Waldek Hebisch	Karl Hegbloom
Ralf Hemmecke	Henderson	Antoine Hersen
Nicholas J. Higham	Hoon Hong	Roger House
Gernot Hueber	Pietro Iglio	Alejandro Jakubi
Richard Jenks	Bo Kagstrom	William Kahan
Kyriakos Kalorkoti	Kai Kaminski	Grant Keady
Wilfrid Kendall	Tony Kennedy	David Kincaid
Keshav Kini	Ted Kosan	Paul Kosinski

Igor Kozachenko	Fred Krogh	Klaus Kusche
Bernhard Kutzler	Tim Lahey	Larry Lambe
Kaj Laurson	Charles Lawson	George L. Legendre
Franz Lehner	Frederic Lehubey	Michel Levaud
Howard Levy	J. Lewis	Ren-Cang Li
Rudiger Loos	Craig Lucas	Michael Lucks
Richard Luczak	Camm Maguire	Francois Maltey
William Martin	Osni Marques	Alasdair McAndrew
Bob McElrath	Michael McGettrick	Edi Meier
Ian Meikle	David Mentre	Jonathan Millen
Victor S. Miller	Gerard Milmeister	Mohammed Mobarak
H. Michael Moeller	Michael Monagan	Marc Moreno-Maza
Scott Morrison	Joel Moses	Mark Murray
William Naylor	Patrice Naudin	C. Andrew Neff
John Nelder	Godfrey Nolan	Arthur Norman
Jinzhong Niu	Michael O'Connor	Summat Oemrawsingh
Kostas Oikonomou	Humberto Ortiz-Zuazaga	Julian A. Padget
Bill Page	David Parnas	Susan Pelzel
Michel Petitot	Didier Pinchon	Ayal Pinkus
Frederick H. Pitts	Frank Pfenning	Jose Alfredo Portes
E. Quintana-Orti	Gregorio Quintana-Orti	Beresford Parlett
A. Petitot	Andre Platzer	Peter Poromaas
Claude Quitte	Arthur C. Ralfs	Norman Ramsey
Anatoly Raportirenko	Guilherme Reis	Huan Ren
Albert D. Rich	Michael Richardson	Jason Riedy
Renaud Rioboo	Jean Rivlin	Nicolas Robidoux
Simon Robinson	Raymond Rogers	Michael Rothstein
Martin Rubey	Jeff Rutter	Philip Santas
David Saunders	Alfred Scheerhorn	William Schelter
Gerhard Schneider	Martin Schoenert	Marshall Schor
Frithjof Schulze	Fritz Schwarz	Steven Segletes
V. Sima	Nick Simicich	William Sit
Elena Smirnova	Jacob Nyffeler Smith	Matthieu Sozeau
Ken Stanley	Jonathan Steinbach	Fabio Stumbo
Christine Sundaresan	Klaus Sutner	Robert Sutor
Moss E. Sweedler	Eugene Surowitz	Yong Kiam Tan
Max Tegmark	T. Doug Telford	James Thatcher
Laurent Thery	Balbir Thomas	Mike Thomas
Dylan Thurston	Francoise Tisseur	Steve Toleque
Raymond Toy	Barry Trager	Themos T. Tsikas
Gregory Vanuxem	Kresimir Veselic	Christof Voemel
Bernhard Wall	Stephen Watt	Andreas Weber
Jaap Weel	Juergen Weiss	M. Weller
Mark Wegman	James Wen	Thorsten Werther
Michael Wester	R. Clint Whaley	James T. Wheeler
John M. Wiley	Berhard Will	Clifton J. Williamson
Stephen Wilson	Shmuel Winograd	Robert Wisbauer
Sandra Wityak	Waldemar Wiwianka	Knut Wolf
Yanyang Xiao	Liu Xiaojun	Clifford Yapp
David Yun	Qian Yun	Vadim Zhytnikov
Richard Zippel	Evelyn Zoernack	Bruno Zuercher
Dan Zwillinger		

# Contents

<b>1</b>	<b>Overview</b>	<b>1</b>
<b>2</b>	<b>The axiom Command</b>	<b>3</b>
2.0.1	<a href="#">[-ht   -noht]</a> . . . . .	3
2.0.2	<a href="#">[-gr   -nogr]</a> . . . . .	3
2.0.3	<a href="#">[-clef   -noclef]</a> . . . . .	4
2.0.4	<a href="#">[-noiw   -iw]</a> . . . . .	4
2.0.5	<a href="#">[-ihere   -noihere]</a> . . . . .	5
2.0.6	<a href="#">[-nox]</a> . . . . .	5
2.0.7	<a href="#">[-go   -nogo]</a> . . . . .	6
2.0.8	<a href="#">[-ws wsname]</a> . . . . .	6
2.0.9	<a href="#">[-list]</a> . . . . .	6
2.0.10	<a href="#">[-grprog fname]</a> . . . . .	6
2.0.11	<a href="#">[-htprog fname]</a> . . . . .	6
2.0.12	<a href="#">[-clefprog fname]</a> . . . . .	7
2.0.13	<a href="#">[-sessionprog fname]</a> . . . . .	7
2.0.14	<a href="#">[-clientprog fname]</a> . . . . .	7
2.0.15	<a href="#">[-h]</a> . . . . .	7
<b>3</b>	<b>The sman program</b>	<b>15</b>
3.1	<a href="#">include files</a> . . . . .	15
3.1.1	<a href="#">include/sman.h</a> . . . . .	16
3.1.2	<a href="#">include/com.h</a> . . . . .	17
3.1.3	<a href="#">include/bsdsignal.h</a> . . . . .	19
3.1.4	<a href="#">include/bsdsignal.h1</a> . . . . .	19

3.1.5	<code>include/openpty.h1</code>	19
3.1.6	<code>include/sman.h1</code>	19
3.1.7	<code>include/session.h1</code>	20
3.2	<code>sman.c</code>	21
3.2.1	<code>includes</code>	21
3.2.2	<code>variables</code>	21
3.2.3	<code>process_arguments</code>	23
3.2.4	<code>should_I_clef</code>	25
3.2.5	<code>in_X</code>	25
3.2.6	<code>set_up_defaults</code>	26
3.2.7	<code>process_options</code>	26
3.2.8	<code>death_handler</code>	26
3.2.9	<code>sman_catch_signals</code>	27
3.2.10	<code>fix_env</code>	27
3.2.11	<code>init_term_io</code>	27
3.2.12	<code>strPrefix</code>	28
3.2.13	<code>check_spad_proc</code>	28
3.2.14	<code>clean_up_old_sockets</code>	29
3.2.15	<code>fork_you</code>	29
3.2.16	<code>exec_command_env</code>	30
3.2.17	<code>spawn_of_hell</code>	30
3.2.18	<code>start_the_spadclient</code>	31
3.2.19	<code>start_the_local_spadclient</code>	31
3.2.20	<code>start_the_session_manager</code>	32
3.2.21	<code>start_the_hypertext</code>	32
3.2.22	<code>start_the_graphics</code>	32
3.2.23	<code>fork_Axiom</code>	33
3.2.24	<code>start_the_Axiom</code>	34
3.2.25	<code>clean_up_sockets</code>	35
3.2.26	<code>read_from_spad_io</code>	35
3.2.27	<code>read_from_manager</code>	36
3.2.28	<code>manage_spad_io</code>	36
3.2.29	<code>init_spad_process_list</code>	37

3.2.30	<code>print_spad_process_list</code>	38
3.2.31	<code>find_child</code>	38
3.2.32	<code>kill_all_children</code>	38
3.2.33	<code>clean_up_terminal</code>	39
3.2.34	<code>monitor_children</code>	39
3.2.35	<code>main sman</code>	40
3.2.36	<code>sman.c</code>	41
<b>4</b>	<b>Support Routines</b>	<b>43</b>
4.1	Command Completion	43
<b>5</b>	<b>The viewman program</b>	<b>45</b>
<b>6</b>	<b>The hypertext program</b>	<b>47</b>
<b>7</b>	<b>The clef program</b>	<b>49</b>
<b>8</b>	<b>The session program</b>	<b>51</b>
8.1	<code>session</code>	51
8.1.1	<code>includes</code>	51
8.1.2	<code>variables</code>	51
8.1.3	<code>usr1_handler</code>	52
8.1.4	<code>usr2_handler</code>	52
8.1.5	<code>term_handler</code>	53
8.1.6	<code>pr</code>	53
8.1.7	<code>close_client</code>	53
8.1.8	<code>read_SpadServer_command</code>	55
8.1.9	<code>test_sock_for_process</code>	55
8.1.10	<code>read_menu_client_command</code>	56
8.1.11	<code>read_from_spad_io</code>	57
8.1.12	<code>kill_spad</code>	57
8.1.13	<code>accept_session_connection</code>	58
8.1.14	<code>read_from_session</code>	59
8.1.15	<code>manage_sessions</code>	60
8.1.16	<code>main sessionmanager</code>	61



8.1.17 session . . . . .	62
<b>9 The spadclient program</b>	<b>65</b>
9.1 spadclient . . . . .	65
<b>10 The Command Completion List</b>	<b>67</b>
<b>11 Research Topics</b>	<b>145</b>
11.1 Proofs . . . . .	145
11.2 Indefinites . . . . .	145
11.3 Provisos . . . . .	145
<b>12 Makefile</b>	<b>147</b>
<b>Bibliography</b>	<b>149</b>

## New Foreword

On October 1, 2001 Axiom was withdrawn from the market and ended life as a commercial product. On September 3, 2002 Axiom was released under the Modified BSD license, including this document. On August 27, 2003 Axiom was released as free and open source software available for download from the Free Software Foundation's website, Savannah.

Work on Axiom has had the generous support of the Center for Algorithms and Interactive Scientific Computation (CAISS) at City College of New York. Special thanks go to Dr. Gilbert Baumslag for his support of the long term goal.

The online version of this documentation is roughly 1000 pages. In order to make printed versions we've broken it up into three volumes. The first volume is tutorial in nature. The second volume is for programmers. The third volume is reference material. We've also added a fourth volume for developers. All of these changes represent an experiment in print-on-demand delivery of documentation. Time will tell whether the experiment succeeded.

Axiom has been in existence for over thirty years. It is estimated to contain about three hundred man-years of research and has, as of September 3, 2003, 143 people listed in the credits. All of these people have contributed directly or indirectly to making Axiom available. Axiom is being passed to the next generation. I'm looking forward to future milestones.

With that in mind I've introduced the theme of the "30 year horizon". We must invent the tools that support the Computational Mathematician working 30 years from now. How will research be done when every bit of mathematical knowledge is online and instantly available? What happens when we scale Axiom by a factor of 100, giving us 1.1 million domains? How can we integrate theory with code? How will we integrate theorems and proofs of the mathematics with space-time complexity proofs and running code? What visualization tools are needed? How do we support the conceptual structures and semantics of mathematics in effective ways? How do we support results from the sciences? How do we teach the next generation to be effective Computational Mathematicians?

The "30 year horizon" is much nearer than it appears.

Tim Daly  
CAISS, City College of New York  
November 10, 2003 ((iHy))

# Chapter 1

## Overview

The axiom system consists of a set of processes managed by the superman process. The superman process, called sman, is normally invoked from the axiom shell script in order to start a tree of subprocesses.

The **axiom** command is a shell script that collects the command line options for the **sman** process, sets some shell variables, and then invokes **sman**.

The **sman** process starts the following tree of processes:

```
--xterm---bash---sman-|-AXIOMsys
                        |-clef---spadclient
                        |-hypertex
                        |-session
                        |-sman
                        |-viewman
```



## Chapter 2

# The axiom Command

The `axiom` command starts everything for Axiom. The options for the `axiom` command are:

```
axiom
  [-ht      |-noht]      whether to use HyperDoc
  [-gr      |-nogr]      whether to use Graphics
  [-clef    |-noclef]    whether to use Clef
  [-noiw    |-iw]        start in interpreter in a separate window
  [-ihere   |-noihere]   start an interpreter in this window
  [-nox]                don't use X Windows
  [-go      |-nogo]      whether to start system
  [-ws wsname]           use named workspace
  [-list]               list workspaces only
  [-grprog fname]        use named program for Graphics
  [-htprog fname]        use named program for HyperDoc
  [-clefprog fname]      use named program for Clef
  [-sessionprog fname]   use named program for session
  [-clientprog fname]    use named program for spadclient
  [-h]                  show usage
```

In detail, the command options are:

### 2.0.1 [-ht | -noht]

```
[-ht      |-noht]      whether to use HyperDoc
```

Hyperdoc is the documentation tool for Axiom. The `-ht` option, enabled by default, will start this tool. See Jenks[Jenk92] Chapter 3 for further information on the `hyperdoc` subsystem.

### 2.0.2 [-gr | -nogr]

```
[-gr      |-nogr]      whether to use Graphics
```

The `graphics` subsystem is enabled using the `-gr` option, enabled by default. Graphics will appear as a result of a `draw` command, such as

```
draw(sin(x),x=0..1)
```

Note that attempting to use draw commands when the graphics is disabled will simply hang the interpreter waiting for a response. See Jenks[[Jenk92](#)] Chapter 7 for further information on the `graphics` subsystem.

### 2.0.3 [-clef | -noclef]

`[-clef | -noclef]      whether to use Clef`

The `clef` (Command Line Edit Facility) allows for command completion. The list of command completion strings is in the last chapter of this document. If `clef`, enabled by default, is running then you can type:

```
x:Dena<tab>
```

and this will automatically be expanded to:

```
x:DenavitHartenbergMatrix
```

The `clef` program also allows command line editing. The commands are special keyboard keys.

- HOME move to beginning of the line
- END move to the end of the line
- CTRL-END delete to end of the line
- TAB command completion (multiple tabs give new choices)
- UPARROW move back thru commands
- DOWNARROW move forward thru commands
- LEFTARROW move left on the line
- RIGHTARROW move right on the line
- INSERT toggle insert/overstrike

See Jenks[[Jenk92](#)] page 21 for further information on the `clef` command.

### 2.0.4 [-noiw | -iw]

`[-noiw | -iw]            start in interpreter in a separate window`

The `iw` option, disabled by default, will start a second interpreter in its own window with its own frame. The fact that the second interpreter is in its own frame can be seen using the `)frame` command. For instance, if you type

```
axiom -iw
```

there will be two interpreter windows available, one in the current window and one in a new window. In the current window if you type:

```
)frame names
```

you will see:

```
The names of the existing frames are:
```

```
frame0
frame1
initial
```

```
The current frame is the first one listed.
```

In the second window, if you type

```
)frame names
```

you will see:

```
The names of the existing frames are:
```

```
frame1
```

```
frame0
```

```
initial
```

```
The current frame is the first one listed.
```

Setting

```
x:=3
```

in the second window will set the variable  $x$  in the frame **frame1**. Switching to the first window and typing:

```
x
```

gives:

```
(1) x
```

```
Type: Variable x
```

since the first window is in **frame0** and the variable  $x$  is defined in **frame1**. But we can switch frames in the first window using

```
)frame next
```

and then

```
x
```

gives:

```
(2) 3
```

```
Type: PositiveInteger
```

and now the two windows share the same frame space. See Jenks[Jenk92] page 579 for further information on the **frame** command.

### 2.0.5 [-ihere | -noihere]

```
[-ihere | -noihere] start an interpreter in this window
```

This option determines whether Axiom will start in the current window. Using this option alone is not particularly useful and it is generally used in combination with the **-iw** option:

```
axiom -noihere -iw &
```

However, used alone, as in:

```
axiom -noihere &
```

it will start Axiom and show the Hyperdoc window. Graphics will also work from the Hyperdoc pages.

### 2.0.6 [-nox]

```
[-nox] don't use X Windows
```

allows Axiom to start the interpreter without Hyperdoc or the graphics subsystem. This is useful for starting Axiom in an emacs buffer.

### 2.0.7 [-go | -nogo]

`[-go | -nogo]`                      whether to start system

uses the `-go` option, enabled by default, controls whether the system starts from the command line. If the `-nogo` option is chosen the system prints the command line that would have been issued. This is useful for finding out what the command line options to `sman` will be. For instance:

```
axiom -nogo -iw
```

does not start Axiom but types out:

```
Would now start the processes.
```

```
exec ~/mnt/linux/bin/sman -iw -ws ~/mnt/linux/bin/AXIOMsys
```

### 2.0.8 [-ws wsname]

`[-ws wsname]`                      use named workspace

In the `-nogo` command above you can see that the default workspace name is

```
-ws ~/mnt/linux/bin/AXIOMsys
```

This option allows you to change that. This is useful for debugging new system builds. During build a debugging version of Axiom is created in the `obj/linux/bin` directory. The `debugsys` image uses interpreted lisp code rather than compiled code. This makes it possible to do deep debugging. To use this workspace you would incant:

```
cd youraxiombuild
export AXIOM='pwd'/mnt/linux
export PATH=$AXIOM/bin:$PATH
axiom -ws obj/linux/bin/debugsys
```

### 2.0.9 [-list]

`[-list]`                              list workspaces only

shows you the executable workspaces. Generally in a built system there is only one, called `$AXIOM/bin/AXIOMsys`.

### 2.0.10 [-grprog fname]

`[-grprog fname]`                      use named program for Graphics

allows you to specify which program to use for the graphics. By default this is `$AXIOM/lib/viewman`.

### 2.0.11 [-htprog fname]

`[-htprog fname]`                      use named program for Hyperdoc



allows you to specify which program to use for Hyperdoc. By default it is  
`$AXIOM/bin/hypertext -s`.

### 2.0.12 [-clefprog fname]

`[-clefprog fname]` use named program for Clef

allows you to specify which program to use for clef. By default it is  
`$AXIOM/bin/clef -f $AXIOM/lib/command.list -e`.

### 2.0.13 [-sessionprog fname]

`[-sessionprog fname]` use named program for session

allows you to specify the session manager program. By default it is  
`$AXIOM/lib/session`.

### 2.0.14 [-clientprog fname]

`[-clientprog fname]` use named program for spadclient

allows you to specify the spadclient program. By default it is  
`$AXIOM/lib/spadclient`.

### 2.0.15 [-h]

`[-h]` show usage

— axiomcmd —

`#!/bin/sh`

—————

The `MALLOCTYPE` shell variable is an IBM AIX shell variable that controls buckets based extensions in the default memory allocator which may enhance performance. AIX uses a new memory management routine that does not zero `malloc` memory and does not round up to the nearest power of 2, unlike most non-AIX systems. This can cause failures so we protect against that here. See the AIX Performance Tuning Guide[\[Haya05\]](#) for details.

— axiomcmd —

`MALLOCTYPE=3.1`  
`export MALLOCTYPE`

—————

— axiomcmd —

`HOST='hostname'`  
`export HOST`

---

There are 4 basic utilities used by this script. The `ciao` script for immediate exit:

— **axiomcmd** —

```
ciao() {
echo "Goodbye."
exit 1
}
```

---

The `needsubopt` script which is used to issue an error message when one of the command line options requires an option:

— **axiomcmd** —

```
needsubopt () {
echo "The $1 option requires an argument."
ciao
}
```

---

The `showuse` script which gives basic command line help:

— **axiomcmd** —

```
showuse() {
echo "axiom"
echo "  [-ht    |-noht]      whether to use HyperDoc"
echo "  [-gr    |-nogr]      whether to use Graphics"
echo "  [-clef  |-noclef]     whether to use Clef"
echo "  [-noiw  |-iw]        start in interpreter in a separate window"
echo "  [-ihere |-noihere]    start an interpreter in this window"
echo "  [-nox]                don't use X Windows"
echo "  [-go    |-nogo]       whether to start system"
echo "  [-ws wsname]          use named workspace"
echo "  [-list]               list workspaces only"
echo "  [-grprog fname]       use named program for Graphics"
echo "  [-htprog fname]       use named program for HyperDoc"
echo "  [-clefprog fname]     use named program for Clef"
echo "  [-sessionprog fname]  use named program for session"
echo "  [-clientprog fname]   use named program for spadclient"
echo "  [-h]                  show usage"
}
```

---

List the various workspaces if asked.

— **axiomcmd** —

```
listwspace()
{
    echo "$1"
    ls -l $2 | grep "sys$"
    echo ""
}
```

---

Step 1. Ensure the environment is set.

Just process “-h”. If it exists in the command line then we print out the simple command line help menu.

```

— axiomcmd —
if [ "$*" = "-h" ] ; then
    showuse
fi

```

---

We assume that Axiom is installed in the standard place on a linux system. We will modify this assumption as we process the environment and command line. The term **spad** is an historical shortened version of the name **scratchpad**, the original name of the **Axiom** system.

```

— axiomcmd —
SPADDEFAULT=/usr/local/axiom/mnt/linux

```

---

If the **\$AXIOM** shell variable is set then we use it.

If not, then if the **\$SPAD** shell variable is set then we use it.

If not, then we try to use the default value above.

If not, we simply fail.

```

— axiomcmd —
if [ "$SPAD" = "" ] ; then
    if [ "$AXIOM" = "" ] ; then
        SPAD=$SPADDEFAULT
        echo "AXIOM variable is not set"
        echo "assuming AXIOM = $SPAD"
        AXIOM=$SPAD
        export AXIOM
    else
        SPAD=$AXIOM
    fi
    export SPAD
else
    if [ "$AXIOM" = "" ] ; then
        echo "AXIOM variable is not set"
        echo "but SPAD = $SPAD"
        echo "Using AXIOM = $SPAD"
        AXIOM=$SPAD
        export AXIOM
    else
        if [ ! "$SPAD" = "$AXIOM" ] ; then
            echo "ignoring SPAD variable"
            SPAD=$AXIOM
        fi
    fi
fi
fi

```

---

If we get here then all attempts to find axiom have failed so we complain and exit.

```

— axiomcmd —
if [ ! -d "$SPAD" ] ; then
  echo "The directory for Axiom, $SPAD, does not exist."
  ciao
fi

```

Step 2. Process command line arguments.

Name the workspace directories

```

— axiomcmd —
rootwsdir=$SPAD/bin

```

We set up the defaults for command-line arguments. We don't want just a list by default

```

— axiomcmd —
list=no

```

We default to actually executing the workspace.

```

— axiomcmd —
go=yes

```

We default to the AXIOMsys workspace.

```

— axiomcmd —
wsname=AXIOMsys

```

And all other options are unset.

```

— axiomcmd —
otheropts=""

```

For each option on the command line do

```

— axiomcmd —
while [ "$*" != "" ] ; do

```

```

— axiomcmd —
case $1 in

```

If the user specified list anywhere then we give the workspace list and exit.

```
— axiomcmd —
- list) list=yes
      go=no;;
—
```

If the user specified go or nogo we handle that case

```
— axiomcmd —
- go) go=yes ;;
- nogo) go=no ;;
—
```

The workspace option requires an argument which follows immediately. If the argument is missing we complain and exit.

```
— axiomcmd —
- ws)
if [ "$2" = "" ] ; then needsubopt "$1" ; fi
shift
wsname="$1"
;;
—
```

We can specify the various subprograms to use.

```
— axiomcmd —
- grprog|htprog|clefprog|sessionprog|clientprog)
if [ "$2" = "" ] ; then needsubopt "$1" ; fi
otheropts="$otheropts $1 $2"
shift
;;
—
```

These options were not explained earlier and are only for developer use.

```
— axiomcmd —
- paste|-rm|-rv)
if [ "$2" = "" ] ; then needsubopt "$1" ; fi
otheropts="$otheropts $1 $2"
shift
;;
—
```

We handle the various [-option | -nooption] cases

```
— axiomcmd —
- clef|-noclef|-gr|-nogr|-ht|-noht|-iw|-noiw)
otheropts="$otheropts $1"
;;
- ihere|-noihere|-nox)
otheropts="$otheropts $1"
;;
—
```

The user wanted help so we will not execute.

— **axiomcmd** —

```
-h)
go=no
;;
```

—————

The user is confused. Complain and exit.

— **axiomcmd** —

```
*) echo "Unknown option: $1"
echo "To use a specific workspace use, e.g.: spad -ws $1"
ciao
;;
esac
```

—————

Move to the next option and loop.

— **axiomcmd** —

```
shift
done
```

—————

Step 3. Handle options that require special case handling.

The user just wanted to know what workspaces are available.

— **axiomcmd** —

```
if [ $list = yes ] ; then
  listwspace "$AXIOM workspaces in \ $AXIOM/bin = $rootwsdir: " $rootwsdir
fi
```

—————

Try to ensure a suitable workspace on this host.

— **axiomcmd** —

```
if [ 'expr $wsname : '.*/*.*' = 0 ] ; then
  serverws=$rootwsdir/$wsname
else
  serverws=$wsname
fi
```

—————

If we can't find the executable then we complain and exit.

— **axiomcmd** —

```
if [ ! -x $serverws ] ; then
  echo "Cannot find the executable $serverws"
showuse
ciao
fi
```

—————

The user just wanted to see what would happen so we output the command line and exit.

— **axiomcmd** —

```
if [ $go = no ] ; then
echo "Would now start the processes."
echo exec $SPAD/bin/sman $otheropts -ws $serverws
exit 0
fi
```

—————

All of the options have been processed so we start **sman**

— **axiomcmd** —

```
exec $SPAD/bin/sman $otheropts -ws $serverws
```

—————





## Chapter 3

# The sman program

### 3.1 include files

```
— include/sockio-c.h1 —  
  
/* from bookvol6 chunk include/sockio-c.h1 */  
extern int get_int(Sock * );  
extern char * get_string(Sock * );  
extern double get_float(Sock * );  
extern Sock * connect_to_local_server(char * , int , int );  
extern int sread(Sock * , char * , int , char * );  
extern double plus_infinity(void );  
extern double minus_infinity(void );  
extern double NANQ(void );  
extern void sigpipe_handler(int );  
extern int wait_for_client_read(Sock * , char * , int , char * );  
extern int wait_for_client_write(Sock * , char * , int , char * );  
extern int swrite(Sock * , char * , int , char * );  
extern int sselect(int , fd_set * , fd_set * , fd_set * , void * );  
extern int fill_buf(Sock * , char * , int , char * );  
extern int sock_get_int(int );  
extern int get_ints(Sock * , int * , int );  
extern int sock_get_ints(int , int * , int );  
extern int send_int(Sock * , int );  
extern int sock_send_int(int , int );  
extern int send_ints(Sock * , int * , int );  
extern int sock_send_ints(int , int * , int );  
extern int send_string(Sock * , char * );  
extern int send_string_len(Sock * , char * , int );  
extern int sock_send_string(int , char * );  
extern int sock_send_string_len(int , char * , int );  
extern int send_strings(Sock * , char * * , int );  
extern int sock_send_strings(int , char * * , int );  
extern char * sock_get_string(int );  
extern char * get_string_buf(Sock * , char * , int );  
extern char * sock_get_string_buf(int , char * , int );
```

```

extern int get_strings(Sock * , char * * , int );
extern int sock_get_strings(int , char * * , int );
extern int send_float(Sock * , double );
extern int sock_send_float(int , double );
extern int send_sfloats(Sock * , float * , int );
extern int sock_send_sfloats(int , float * , int );
extern int send_floats(Sock * , double * , int );
extern int sock_send_floats(int , double * , int );
extern double sock_get_float(int );
extern int get_sfloats(Sock * , float * , int );
extern int sock_get_sfloats(int , float * , int );
extern int get_floats(Sock * , double * , int );
extern int sock_get_floats(int , double * , int );
extern int wait_for_client_kill(Sock * , int );
extern int sock_get_remote_fd(int );
extern int send_signal(Sock * , int );
extern int sock_send_signal(int , int );
extern int send_wakeup(Sock * );
extern int sock_send_wakeup(int );
extern Sock * connect_to_local_server_new(char * , int , int );
extern void remote_stdio(Sock * );
extern void init_purpose_table(void );
extern int make_server_number(void );
extern void close_socket(int , char * );
extern int make_server_name(char * , char * );
extern int open_server(char * );
extern int accept_connection(Sock * );
extern void get_socket_type(Sock * );
extern int sock_accept_connection(int );
extern void redirect_stdio(Sock * );
extern void init_socks(void );
extern int server_switch(void );
extern void flush_stdout(void );
extern void print_line(char * );

```

---

### 3.1.1 include/sman.h

The `spad_proc` structure holds information about the process id of a child process, what to do when it dies, and the shell command line necessary to restart the process. There is a linked list of these structures which maintains the process list for axiom.

— **include/sman.h** —

```

/* from bookvol6 chunk include/sman.h */
/* Process control definitions. Used by fork_you and spawn_of_hell */

/* When a process dies it kills off everything else */
#define Die 1
/* When a process dies, do nothing */
#define NadaDelShitsky 2
/* When a process dies start it up again */
#define DoItAgain 3
/* When hypertext dies, clean its socket */

```

```
#define CleanHypertextSocket 4

typedef struct spad_proc {
    int proc_id; /* process id of child */
    int death_action; /* one of the above constants */
    char *command; /* sh command line to restart the process */
    struct spad_proc *next;
} SpadProcess;
```

---

### 3.1.2 include/com.h

— include/com.h —

```
/* from bookvol6 chunk include/com.h */
#ifndef _COM_H_
#define _COM_H_

#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#if defined(RIOSplatform)
#include <sys/select.h>
#endif

typedef struct {
    int socket;          /* socket number returned by "socket" call */
    int type;            /* socket type (AF_UNIX or AF_INET) */
    int purpose;         /* can be SessionManager, GraphicsServer, etc. */
    int pid;             /* process ID of connected socket */
    int frame;           /* spad interpreter frame (for interpreter windows) */
    int remote_fd;       /* file descriptor of remote socket */
    union {
        struct sockaddr u_addr;
        struct sockaddr_in i_addr;
    } addr;
    char *host_name;     /* name of foreign host if type == AF_INET */
} Sock;

#define MaxClients      150

/* possible socket types (purpose) */

#define SessionManager  1
#define ViewportServer  2
#define MenuServer      3
#define SessionIO       4
#define BalloonServer   5
#define InterpWindow    6
#define KillSpad        7
#define DebugWindow     8
```

```

#define Forker          9
#define AV              10 /*Simon's algebraic viewer */

#define Acknowledge     255

/* Timeout value for connection to remote socket */

#define Forever 0

/* Socket name for local AXIOM server and session manager */

#define SpadServer      "/tmp/.d"
#define SessionServer   "/tmp/.s"
#define SessionIOName   "/tmp/.i"
#define MenuServerName  "/tmp/.h"
#define ForkServerName  "/tmp/.f"

#define MASK_SIZE      (NBBY*sizeof(fd_set))

/* table of dedicated socket types */

extern Sock *purpose_table[];
extern Sock server[];
extern Sock clients[];
extern fd_set socket_mask;
extern fd_set server_mask;

/* Commands sent over the AXIOM session manager or menu socket */

#define CreateFrame      1
#define SwitchFrames     2
#define EndOfOutput      3
#define CallInterp       4
#define EndSession       5
#define LispCommand      6
#define SpadCommand      7
#define SendXEventToHyperTeX 8
#define QuietSpadCommand 9
#define CloseClient     10
#define QueryClients     11
#define QuerySpad        12
#define NonSmanSession   13
#define KillLispSystem    14

#define CreateFrameAnswer 50

/* Commands from AXIOM menu server to interpreter windows */

#define ReceiveInputLine 100
#define TestLine         101

#endif

```

### 3.1.3 include/bsdsignal.h

---

```

— include/bsdsignal.h —
/* from bookvol6 chunk include/bsdsignal.h */
#ifndef _BSDSIGNAL_H_
#define _BSDSIGNAL_H_

#define RestartSystemCalls 1
#define DontRestartSystemCalls 0

typedef void (* SignalHandlerFunc)(int);

#endif      /* _BSDSIGNAL */

```

---

### 3.1.4 include/bsdsignal.h1

---

```

— include/bsdsignal.h1 —
/* from bookvol6 chunk include/bsdsignal.h1 */
extern SignalHandlerFunc bsdSignal(int , SignalHandlerFunc , int );

```

---

### 3.1.5 include/openpty.h1

---

```

— include/openpty.h1 —
/* from bookvol6 chunk include/openpty.h1 */
extern void makeNextPtyNames(char * , char * );
extern int ptyopen(int * , int * , char * , char * );

```

---

### 3.1.6 include/sman.h1

---

```

— include/sman.h1 —
/* from bookvol6 chunk include/sman.h1 */
extern int main(int argc , char * argv[] , char * envp[]);
#ifdef _SMAN_C
static void process_arguments(int argc , char * * argv);
static int should_I_clef(void);
static int in_X(void);
static void set_up_defaults(void);
static void process_options(int argc , char * * argv);

```

```

static void death_handler(int sig);
static void sman_catch_signals(void);
static void fix_env(char * * envp , int spadnum);
static void init_term_io(void);
static char * strPrefix(char * prefix , char * s);
static void check_spad_proc(char * file , char * prefix);
static void clean_up_old_sockets(void);
static SpadProcess * fork_you(int death_action);
static void exec_command_env(char * command , char * * env);
static SpadProcess * spawn_of_hell(char * command , int death_action);
static void start_the_spadclient(void);
static void start_the_local_spadclient(void);
static void start_the_session_manager(void);
static void start_the_hypertext(void);
static void start_the_graphics(void);
static void fork_Axiom(void);
static void start_the_Axiom(char * * envp);
static void clean_up_sockets(void);
static void clean_hypertext_socket(void);
static void read_from_spad_io(int ptcNum);
static void read_from_manager(int ptcNum);
static void manage_spad_io(int ptcNum);
static void init_spad_process_list(void);
static SpadProcess * find_child(int proc_id);
static void kill_all_children(void);
static void clean_up_terminal(void);
static void monitor_children(void);
#endif

```

---

### 3.1.7 include/session.h1

```

— include/session.h1 —

/* from bookvol6 chunk include/session.h1 */
extern int main(void);
#ifdef _SESSION_C
static void usr1_handler(int sig);
static void usr2_handler(int sig);
static void term_handler(int sig);
static void close_client(int frame);
static void read_SpadServer_command(void);
static int test_sock_for_process(Sock * sock);
static void read_menu_client_command(void);
static void read_from_spad_io(void);
static void kill_spad(void);
static int accept_session_connection(Sock * server_sock);
static void read_from_session(Sock * sock);
static void manage_sessions(void);
#endif

```

---

```

— include/spadclient.h1 —

/* from bookvol6 chunk include/spadclient.h1 */
extern int main(void);
#ifdef _SPADCLIENT_C
static void inter_handler(int sig);
#endif

```

---

## 3.2 sman.c

### 3.2.1 includes

```

— sman.includes —

#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#include <stdio.h>
#include <pwd.h>
#include <fcntl.h>
#include <termios.h>
#include <errno.h>
#include <sys/time.h>
#include <sys/wait.h>
#include <signal.h>

#if defined(SUN40S5platform) || defined(HP10platform)
#include <sys/stropts.h>
#endif

\getchunk{include/com.h}
\getchunk{include/bsdsignal.h}
\getchunk{include/sman.h}
\getchunk{include/bsdsignal.h1}
\getchunk{include/sockio-c.h1}
\getchunk{include/openpty.h1}
\getchunk{include/sman.h1}

```

---

### 3.2.2 variables

```

— sman.variables —

char *ws_path; /* location of the AXIOM executable */
int start_clef; /* start clef under spad */
int start_graphics; /* start the viewman */
int start_ht; /* start hypertex */

```

```

int start_spadclient; /* Start the client spad buffer */
int start_local_spadclient; /* Start the client spad buffer */
int use_X; /* Use the X windows environment */
int server_num; /* AXIOM server number */

```

We add a debug flag so we can print information about what sman is trying to do. This change is pervasive as it touches nearly every routine.

— sman.variables —

```

int tpd=0; /* to-print-debug information */

/*****
/* definitions of programs which sman can start */
*****/

\getchunk{the viewman command line}
\getchunk{the hypertext command line}
\getchunk{the clef command line}
\getchunk{the session manager command line}
\getchunk{the spadclient command line}
char *PasteFile = NULL;
char *MakeRecordFile = NULL;
char *VerifyRecordFile = NULL;

SpadProcess *spad_process_list = NULL;
/*****
/* sman defaults file name */
*****/

#define SpadDefaultFile "spadprof.input"

char ClefCommandLine[256];

#define BufSize 4096 /* size of communication buffer */
char big_bad_buf[BufSize]; /* big I/O buffer */

Sock *session_io = NULL; /* socket connecting to session manager */

/*****
/* Some characters used and externally defined in edible.h */
*****/

unsigned char _INTR, _QUIT, _ERASE, _KILL, _EOF, _EOL, _RES1, _RES2;

/*****
/* Stuff for opening pseudo-terminal */
*****/

int ptsNum, ptcNum;
char ptsPath[20], ptcPath[20];

char **new_envp; /* new environment for AXIOM */
int child_pid; /* child's process id */

```



```

struct termios oldbuf;          /* the original settings */
struct termios childbuf;       /* terminal structure for user i/o */

int death_signal = 0;

```

---

### 3.2.3 process\_arguments

— sman.processarguments —

```

static void
process_arguments(int argc, char ** argv)
{
    int arg;
    if (tpd == 1) fprintf(stderr, "sman:process_arguments entered\n");
    for (arg = 1; arg < argc; arg++) {
        if (strcmp(argv[arg], "-debug") == 0)
            tpd = 1;
        else if (strcmp(argv[arg], "-noclef") == 0)
            start_clef = 0;
        else if (strcmp(argv[arg], "-clef") == 0)
            start_clef = 1;
        else if (strcmp(argv[arg], "-gr") == 0)
            start_graphics = 1;
        else if (strcmp(argv[arg], "-nogr") == 0)
            start_graphics = 0;
        else if (strcmp(argv[arg], "-ht") == 0)
            start_ht = 1;
        else if (strcmp(argv[arg], "-noht") == 0)
            start_ht = 0;
        else if (strcmp(argv[arg], "-iw") == 0)
            start_spadclient = 1;
        else if (strcmp(argv[arg], "-ihere") == 0)
            start_local_spadclient = 1;
        else if (strcmp(argv[arg], "-noihere") == 0)
            start_local_spadclient = 0;
        else if (strcmp(argv[arg], "-noiw") == 0)
            start_spadclient = 0;
        else if (strcmp(argv[arg], "-ws") == 0)
            ws_path = argv[++arg];
        else if (strcmp(argv[arg], "-comp") == 0)
            ws_path = "$AXIOM/etc/images/comp";
        else if (strcmp(argv[arg], "-nox") == 0)
        {
            use_X = 0;
            start_local_spadclient = 1;
            start_spadclient = 0;
            start_ht = 0;
            start_graphics = 0;
        }
        else if (strcmp(argv[arg], "-grprog") == 0)
    }
}

```

```

    GraphicsProgram = argv[++arg];
else if (strcmp(argv[arg], "-htprog") == 0)
    HypertextProgram = argv[++arg];
else if (strcmp(argv[arg], "-clefprog") == 0) {
    strcpy(ClefCommandLine, argv[++arg]);
ClefProgram =
    strcat(ClefCommandLine, " -f $AXIOM/lib/command.list -e ");
}
else if (strcmp(argv[arg], "-sessionprog") == 0)
    SessionManagerProgram = argv[++arg];
else if (strcmp(argv[arg], "-clientprog") == 0)
    SpadClientProgram = argv[++arg];
else if (strcmp(argv[arg], "-rm") == 0)
    MakeRecordFile = argv[++arg];
else if (strcmp(argv[arg], "-rv") == 0)
    VerifyRecordFile = argv[++arg];
else if (strcmp(argv[arg], "-paste") == 0)
    PasteFile = argv[++arg];
else {
    fprintf(stderr, "Usage: sman <-clef|-noclef> <-gr|-nogr> <-ht|-noht>");
    fprintf(stderr, " <-iw|-noiw> <-nox> <-comp>");
    fprintf(stderr, " <-ws spad_workspace> <-grprog path> <-htprog path>");
    fprintf(stderr, " <-clefprog path> <-sessionprog path>");
    fprintf(stderr, " <-clientprog path>\n");
    exit(-1);
}
}
if (tpd == 1)
{ fprintf(stderr, " sman ");
  if (start_clef == 0)
    fprintf(stderr, "-noclef ");
  else
    fprintf(stderr, "-clef ");
  if (start_graphics == 0)
    fprintf(stderr, "-nogr ");
  else
    fprintf(stderr, "-gr ");
  if (start_ht == 0)
    fprintf(stderr, "-noht ");
  else
    fprintf(stderr, "-ht ");
  if (start_spadclient == 0)
    fprintf(stderr, "-noiw ");
  else
    fprintf(stderr, "-iw ");
  if (start_local_spadclient == 0)
    fprintf(stderr, "-noihere ");
  else
    fprintf(stderr, "-ihere ");
  if (start_local_spadclient == 0)
    fprintf(stderr, "-noihere ");
  else
    fprintf(stderr, "-ihere ");
  if (use_X == 0)

```

```

    fprintf(stderr, "-nox ");
    fprintf(stderr, "-ws ");
    fprintf(stderr, "'%s' ", ws_path);
    fprintf(stderr, "-grprog ");
    fprintf(stderr, "'%s' ", GraphicsProgram);
    fprintf(stderr, "-htprog ");
    fprintf(stderr, "'%s' ", HypertextProgram);
    fprintf(stderr, "-clefprog ");
    fprintf(stderr, "'%s' ", ClefCommandLine);
    fprintf(stderr, "-sessionprog ");
    fprintf(stderr, "'%s' ", SessionManagerProgram);
    fprintf(stderr, "-clientprog ");
    fprintf(stderr, "'%s' ", SpadClientProgram);
    fprintf(stderr, "-rm ");
    fprintf(stderr, "'%s' ", MakeRecordFile);
    fprintf(stderr, "-rv ");
    fprintf(stderr, "'%s' ", VerifyRecordFile);
    fprintf(stderr, "-paste ");
    fprintf(stderr, "'%s' ", PasteFile);
    fprintf(stderr, "\n");
}
if (tpd == 1) fprintf(stderr, "sman:process_arguments exit\n");
}

```

---

### 3.2.4 should\_I\_clef

— sman.shouldIclef —

```

static int
should_I_clef(void)
{
    return(1);
}

```

---

### 3.2.5 in\_X

— sman.inX —

```

static int
in_X(void)
{
    if (getenv("DISPLAY")) return 1;
    return 0;
}

```

---

### 3.2.6 set\_up\_defaults

These are the default values for sman. A '1' value means that sman will try to start the given process, a '0' value means not starting the process.

```

— sman.setupdefaults —

static void
set_up_defaults(void)
{
    if (tpd == 1) fprintf(stderr,"sman:set_up_defaults entered\n");
    start_clef = should_I_clef();
    start_graphics = 1;
    start_ht = 1;
    start_spadclient = 0;
    start_local_spadclient = 1;
    use_X = isatty(0) && in_X();
    ws_path = "$AXIOM/bin/AXIOMsys";
    if (tpd == 1) fprintf(stderr,"sman:set_up_defaults exit\n");
}

```

---

### 3.2.7 process\_options

```

— sman.processoptions —

static void
process_options(int argc, char **argv)
{
    if (tpd == 1) fprintf(stderr,"sman:process_options entered\n");
    set_up_defaults();
    process_arguments(argc, argv);
    if (tpd == 1) fprintf(stderr,"sman:process_options exit\n");
}

```

---

### 3.2.8 death\_handler

```

— sman.deathhandler —

static void
death_handler(int sig)
{
    death_signal = 1;
}

```

---

### 3.2.9 sman\_catch\_signals

— sman.smancatchsignals —

```
static void
sman_catch_signals(void)
{
    /* Set up the signal handlers for sman */
    bsdSignal(SIGINT,  SIG_IGN, RestartSystemCalls);
    bsdSignal(SIGTERM, death_handler, RestartSystemCalls);
    bsdSignal(SIGQUIT, death_handler, RestartSystemCalls);
    bsdSignal(SIGHUP,  death_handler, RestartSystemCalls);
    bsdSignal(SIGILL,  death_handler, RestartSystemCalls);
    bsdSignal(SIGTRAP, death_handler, RestartSystemCalls);
    bsdSignal(SIGIOT,  death_handler, RestartSystemCalls);
    bsdSignal(SIGBUS,  death_handler, RestartSystemCalls);
    bsdSignal(SIGSEGV, death_handler, RestartSystemCalls);
    bsdSignal(SIGUSR1, death_handler, RestartSystemCalls);
}
```

—————

### 3.2.10 fix\_env

insert SPADSERVER and SPADNUM variables into the environemnt

— sman.fixenv —

```
static void
fix_env(char **envp, int spadnum)
{
    int len, i;
    char *sn;
    for(len = 0; envp[len] != NULL; len++);
    new_envp = (char **) malloc((len + 3) * sizeof(char *));
    new_envp[0] = "SPADSERVER=TRUE";
    sn = (char *) malloc(20 * sizeof(char));
    sprintf(sn, "SPADNUM=%d", spadnum);
    new_envp[1] = sn;
    for(i=0; i<=len; i++)
        new_envp[i+2] = envp[i];
}
```

—————

### 3.2.11 init\_term\_io

— sman.inittermio —

```
static void
```

```

init_term_io(void)
{
    if(!isatty(0)) return;
    if( tcgetattr(0, &oldbuf) == -1) {
        perror("getting termios");
        return ; /* exit(-1); */
    }
    if( tcgetattr(0, &childbuf) == -1) {
        perror("getting termios");
        return ; /* exit(-1); */
    }
    _INTR = oldbuf.c_cc[VINTR];
    _QUIT = oldbuf.c_cc[VQUIT];
    _ERASE = oldbuf.c_cc[VERASE];
    _KILL = oldbuf.c_cc[VKILL];
    _EOF = oldbuf.c_cc[VEOF];
    _EOL = oldbuf.c_cc[VEOL];
}

```

---

### 3.2.12 strPrefix

— sman.strPrefix —

```

static char *
strPrefix(char *prefix, char * s)
{
    while (*prefix != '\0' && *prefix == *s) {
        prefix++;
        s++;
    }
    if (*prefix == '\0') return s;
    return NULL;
}

```

---

### 3.2.13 check\_spad\_proc

— sman.checkspadproc —

```

static void
check_spad_proc(char *file, char *prefix)
{
    char *num;
    int pid;
    if ((num = strPrefix(prefix, file))) {
        pid = atoi(num);
        if (pid > 2) {

```

```

        kill(pid, 0);
        if (kill(pid, 0) == -1 && errno == ESRCH) {
unlink(file);
        }
    }
}
}

```

---

### 3.2.14 clean\_up\_old\_sockets

— sman.cleanupoldsockets —

```

static void
clean_up_old_sockets(void)
{
    char com[512], tmp_file[128];
    FILE *file;
    int len;
    sprintf(tmp_file, "/tmp/socks.%d", server_num);
    sprintf(com, "ls /tmp/.d* /tmp/.s* /tmp/.i* /tmp/.h* 2> %s > %s",
tmp_file, tmp_file);
    system(com);
    file = fopen(tmp_file, "r");
    if (file == NULL) {
        fprintf(stderr, "Can't open socket listing file\n");
        return;
    }
    while(fgets(com, 512, file) != NULL) {
        len = strlen(com);
        if (len) com[len-1] = '\0';
        else break;
        check_spad_proc(com, "/tmp/.d");
        check_spad_proc(com, "/tmp/.s");
        check_spad_proc(com, "/tmp/.i");
        check_spad_proc(com, "/tmp/.h");
    }
    fclose(file);
    unlink(tmp_file);
}

```

---

### 3.2.15 fork\_you

— sman.forkyou —

```

static SpadProcess *
fork_you(int death_action)

```

```

{
    /* fork a new process, giving it a default death action */
    /* return NULL in child, SpadProcess in parent          */
    int child_pid = fork();
    SpadProcess *proc;
    if (!child_pid) return NULL;
    proc = (SpadProcess *) malloc(sizeof(SpadProcess));
    proc->proc_id = child_pid;
    proc->death_action = death_action;
    proc->command = NULL;
    proc->next = spad_process_list;
    spad_process_list = proc;
    return proc;
}

```

---

### 3.2.16 exec\_command\_env

Note that the next-to-last argument of `execle` must be an explicit NULL pointer. The previous naked 0 value was not correct.

— sman.execcommandenv —

```

static void
exec_command_env(char *command, char ** env)
{
    char new_command[512];
    sprintf(new_command, "exec %s", command);
    execle("/bin/sh", "/bin/sh", "-c", new_command, (char *)0, env);
}

```

---

### 3.2.17 spawn\_of\_hell

— sman.spawnofhell —

```

static SpadProcess *
spawn_of_hell(char *command, int death_action)
{
    SpadProcess *proc = fork_you(death_action);
    if (proc != NULL) {
        proc->command = command;
        return proc;
    }
    exec_command_env(command, new_envp);
    return NULL;
}

```

---



### 3.2.18 start\_the\_spadclient

run a AXIOM client in the main process

— sman.startthespadclient —

```
static void
start_the_spadclient(void)
{
    char command[256];
    if (start_clef)
#ifdef RIOSplatform
        sprintf(command,
            "aixterm -sb -sl 500 -name axiomclient -n AXIOM -T AXIOM -e %s %s",
            ClefProgram, SpadClientProgram);
    #else
        sprintf(command,
            "xterm -sb -sl 500 -name axiomclient -n AXIOM -T AXIOM -e %s %s",
            ClefProgram, SpadClientProgram);
    #endif
    else
#ifdef RIOSplatform
        sprintf(command,
            "aixterm -sb -sl 500 -name axiomclient -n AXIOM -T AXIOM -e %s",
            SpadClientProgram);
    #else
        sprintf(command,
            "xterm -sb -sl 500 -name axiomclient -n AXIOM -T AXIOM -e %s",
            SpadClientProgram);
    #endif
    if (tpd == 1)
        fprintf(stderr, "sman:start_the_spadclient: %s\n", command);
    spawn_of_hell(command, NadaDelShitsky);
}
```

—————

### 3.2.19 start\_the\_local\_spadclient

— sman.startthelocalspadclient —

```
static void
start_the_local_spadclient(void)
{
    char command[256];
    if (start_clef)
        sprintf(command, "%s %s", ClefProgram, SpadClientProgram);
    else
        sprintf(command, "%s", SpadClientProgram);
    if (tpd == 1)
        fprintf(stderr, "sman:start_the_local_spadclient: %s\n", command);
    spawn_of_hell(command, NadaDelShitsky);
}
```

---

### 3.2.20 start\_the\_session\_manager

— sman.startthesessionmanager —

```
static void
start_the_session_manager(void)
{
    spawn_of_hell(SessionManagerProgram, Die);
}
```

---

### 3.2.21 start\_the\_hypertext

— sman.startthehypertext —

```
static void
start_the_hypertext(void)
{
    char prog[512];

    if (PasteFile){
        sprintf(prog, "%s -k -ip %s", HypertextProgram, PasteFile);
        spawn_of_hell(prog, NadaDelShitsky);
    }
    else if (MakeRecordFile){
        sprintf(prog, "%s -k -rm %s", HypertextProgram, MakeRecordFile );
        spawn_of_hell(prog, NadaDelShitsky);
    }
    else if (VerifyRecordFile){
        sprintf(prog, "%s -k -rv %s", HypertextProgram, VerifyRecordFile);
        spawn_of_hell(prog, NadaDelShitsky);
    }
    /* If we restart hyperdoc from the axiom command prompt */
    else spawn_of_hell(HypertextProgram, CleanHypertextSocket);
}
```

---

### 3.2.22 start\_the\_graphics

— sman.startthegraphics —

```
static void
start_the_graphics(void)
```

```

{
    spawn_of_hell(GraphicsProgram, DoItAgain);
}

```

---

### 3.2.23 fork\_Axiom

— sman.forkAxiom —

```

/* Start the AXIOM session in a separate process, */
/* using a pseudo-terminal to catch all input and output */
static void
fork_Axiom(void)
{
    char augmented_ws_path[256]; /* will append directory path */
    char *tmp_pointer;
    SpadProcess *proc;

    proc = fork_you(Die);
    child_pid = (proc == NULL ? 0 : proc->proc_id);
    switch(child_pid) {
    case -1 :
        fprintf(stderr, "Can't create a new process \n");
        exit(0);
    case 0:
        /* Dissasociate from my parents group so all my child processes */
        /* look at my terminal as the controlling terminal for the */
        /* group */
        /* group */

        if(setuid(0) < 0) {
            perror("Dissassociating from parents group");
            exit(-1);
        }

        close(ptsNum);
        /* Now reopen the server side, so that pg, su, etc. work properly */

        if ((ptsNum = open(ptsPath, O_RDWR)) < 0 ) {
            perror("fork_Axiom: Failed to reopen server");
            exit(-1);
        }
    }
    #if defined(SUN40S5platform) || defined(HP10platform)
        ioctl(ptsNum, I_PUSH, "ptem");
        ioctl(ptsNum, I_PUSH, "ldterm");
    #endif

    /* since I am the child, I can close ptc, and dup pts for all its */
    /* standard descriptors */

    if( (dup2(ptsNum, 0) == -1) ||
        (dup2(ptsNum, 1) == -1) ||

```

```

        (dup2(ptsNum, 2) == -1) ) {
            perror("trying to dupe the child");
            exit(-1);
        }
        close(ptyNum);
        close(ptsNum);

        /* I also have to turn off echoing, since I am echoing all the */
        /* input myself */

        childbuf.c_lflag &= ~ECHO;
        if( tcsetattr(0, TCSAFLUSH, &childbuf) == -1) {
            perror("setting the term buffer");
            exit(-1);
        }
        strcpy(augmented_ws_path, ws_path);          /* write the name */
        strcat(augmented_ws_path, " ");              /* space */
        strcat(augmented_ws_path, ws_path);          /* name again */
        tmp_pointer = (char *)
            strchr(augmented_ws_path, '/');          /*pointer to last / */
        *(++tmp_pointer) = '\0';
        exec_command_env(augmented_ws_path, new_envp);

        /*    fprintf(stderr, "Cannot execute the %s system.\n", ws_path); */

        exit(0);
    }
}

```

### 3.2.24 start\_the\_Axiom

— sman.starttheAxiom —

```

static void
start_the_Axiom(char **envp)
{
    server_num = make_server_number();
    clean_up_old_sockets();
    if (server_num == -1) {
        fprintf(stderr, "could not get an AXIOM server number\n");
        exit(-1);
    }
    if (ptyopen(&ptyNum, &ptsNum, ptyPath, ptsPath) == -1) {
        perror("start_the_Axiom: ptyopen failed");
        exit(-1);
    }
    fix_env(envp, server_num);
    fork_Axiom();
    close(ptsNum);
}

```

```
}

```

---

### 3.2.25 clean\_up\_sockets

In order to be able to restart hyperdoc from the axiom command prompt we need to remove the socket for this server.

— sman.cleanupsockets —

```
static void
clean_hypertext_socket(void)
{
    char name[256];
    sprintf(name, "%s%d", MenuServerName, server_num);
    unlink(name);
}

static void
clean_up_sockets(void)
{
    char name[256];
    sprintf(name, "%s%d", SpadServer, server_num);
    unlink(name);
    sprintf(name, "%s%d", SessionServer, server_num);
    unlink(name);
    sprintf(name, "%s%d", SessionIOName, server_num);
    unlink(name);
    clean_hypertext_socket();
}
```

---

### 3.2.26 read\_from\_spad\_io

— sman.readfromspadio —

```
static void
read_from_spad_io(int ptcNum)
{
    int ret_code = 0, i=0;
    static int mes_len =0;
    ret_code = read(ptcNum, big_bad_buf, BufSize);
    if (ret_code == -1) {
        clean_up_sockets();
        exit(-1);
    }
    if (session_io == NULL) {
        if (ret_code < mes_len)
            mes_len -= ret_code;
        else {
```

```

        if (mes_len > 0) {
i = mes_len;
mes_len = 0;
        }
        else
i = 0;
        ret_code = write(1, big_bad_buf+i, ret_code-i);
    }
}
else
    ret_code = swrite(session_io, big_bad_buf, ret_code,
        "writing to session man");
if (ret_code == -1) {
    perror("writing output to session manager");
    clean_up_sockets();
    exit(-1);
}
}

```

---

### 3.2.27 read\_from\_manager

— sman.readfrommanager —

```

static void
read_from_manager(int ptcNum)
{
    int ret_code;
    ret_code = sread(session_io, big_bad_buf, BufSize, "reading session io");
    if (ret_code == -1) {
        return;
    }
    ret_code = write(ptcNum, big_bad_buf, ret_code);
    if (ret_code == -1) {
        return;
    }
}

```

---

### 3.2.28 manage\_spad\_io

— sman.managespadio —

```

static void
manage_spad_io(int ptcNum)
{
    int ret_code, i, p;
    fd_set rd;

```

```

while (1) {
    rd = socket_mask;
    FD_SET(putcNum, &rd);
    if (session_io != NULL)
        FD_SET(session_io->socket, &rd);
    ret_code = sselect(FD_SETSIZE, &rd, 0, 0, NULL);
    if (ret_code == -1) {
        perror("Session manager select");
        clean_up_sockets();
        exit(-1);
    }
    if (FD_ISSET(putcNum, &rd)) {
        read_from_spad_io(putcNum);
    }
    for(i=0; i<2; i++) {
        if (server[i].socket > 0 && FD_ISSET(server[i].socket, &rd)) {
p = accept_connection(server+i);
switch(p) {
case SessionIO:
    session_io = purpose_table[SessionIO];
    /* printf("connected session manager\n\r");*/
    printf("\n");
    break;
default:
    printf("sman: Unkown connection request type: %d\n", p);
    break;
}
        }
    }
    if (session_io != NULL && FD_ISSET(session_io->socket, &rd)) {
        read_from_manager(putcNum);
    }
}
}

```

---

### 3.2.29 init\_spad\_process\_list

— sman.initspadprocesslist —

```

static void
init_spad_process_list(void)
{
    spad_process_list = NULL;
}

```

---

### 3.2.30 print\_spad\_process\_list

— sman.printspadprocesslist —

```
#if 0
static void
print_spad_process_list()
{
    SpadProcess *proc;
    for(proc = spad_process_list; proc != NULL; proc = proc->next)
        fprintf(stderr, "proc_id = %d, death_action = %d\n", proc->proc_id,
            proc->death_action);
}
#endif
```

---

### 3.2.31 find\_child

— sman.findchild —

```
static SpadProcess *
find_child(int proc_id)
{
    SpadProcess *proc;
    for(proc = spad_process_list; proc != NULL; proc = proc->next)
        if (proc->proc_id == proc_id) return proc;
    return NULL;
}
```

---

### 3.2.32 kill\_all\_children

— sman.killallchildren —

```
static void
kill_all_children(void)
{
    char name[256];
    SpadProcess *proc;

    for(proc = spad_process_list; proc != NULL; proc = proc->next) {
        kill(proc->proc_id, SIGTERM);
    }
    sprintf(name, "/tmp/hyper%d.input", server_num);
    unlink(name);
}
```



### 3.2.33 clean\_up\_terminal

— sman.cleantupterminal —

```
static void
clean_up_terminal(void)
{
    tcsetattr(0, TCSAFLUSH, &oldbuf);
}
```

### 3.2.34 monitor\_children

— sman.monitorchildren —

```
static void
monitor_children(void)
{
    int dead_baby, stat;
    SpadProcess *proc;
    while (1) {
        stat = 0;
        dead_baby = wait(&stat);
        /* Check the value of dead_baby, since wait may have returned
           a pid but subsequently we have received a signal.  Yeuch!
           In order to restart hyperdoc from the axiom command prompt
           we no longer call clean_up_terminal */
        if (dead_baby == -1 && death_signal) {
            kill_all_children();
            clean_up_sockets();
            sleep(2);
            exit(0);
        }
        if (dead_baby == -1) {
            fprintf(stderr, "sman: wait returned -1\n");
            continue;
        }
        proc = find_child(dead_baby);
        if (proc == NULL) {
            /*      fprintf(stderr, "sman: %d is not known to be a child process\n",
               dead_baby);
            */
            continue;
        }
        switch(proc->death_action) {
            /* In order to restart hyperdoc from the axiom command prompt
```

```

        we no longer call clean_up_terminal. Instead we've added a
        case to just clean up the socket. */
    case Die:
        kill_all_children();
        clean_up_sockets();
        sleep(2);
        exit(0);
    case NadaDelShitsky:
        break;
    case DoItAgain:
        spawn_of_hell(proc->command, DoItAgain);
        break;
    case CleanHypertextSocket:
        clean_hypertext_socket();
        break;
}
}
}

```

### 3.2.35 main sman

The main procedure should return an int. We change the return value here and in src/include/sman.h1.

```

    — sman.result —

return(0);

    — sman.main —

int
main(int argc, char *argv[], char *envp[])
{
    if (tpd == 1) fprintf(stderr, "sman:main entered\n");
    bsdSignal(SIGINT, SIG_IGN, RestartSystemCalls);
    process_options(argc, argv);

    init_term_io();
    init_spad_process_list();
    start_the_Axiom(envp);
    if (open_server(SessionIName) == -2) {
        fprintf(stderr, "Fatal error opening I/O socket\n");
        clean_up_sockets();
        exit(-1);
    }
    start_the_session_manager();
    if (start_spadclient) start_the_spadclient();
    if (start_local_spadclient) start_the_local_spadclient();
    if (start_ht) start_the_hypertext();
    if (start_graphics) start_the_graphics();
}

```

```

sleep(1);

if (fork_you(Die) != NULL) {
    sman_catch_signals();
    monitor_children();
    exit(0);
}
manage_spad_io(putcNum);
if (tpd == 1) fprintf(stderr,"sman:main exit\n");
\getchunk{sman.result}
}

```

### 3.2.36 sman.c

— sman.c —

```

#define _SMAN_C

\getchunk{sman.includes}
\getchunk{sman.variables}
\getchunk{sman.processarguments}
\getchunk{sman.shouldIclef}
\getchunk{sman.inX}
\getchunk{sman.setupdefaults}
\getchunk{sman.processoptions}
\getchunk{sman.deathhandler}
\getchunk{sman.smancatchsignals}
\getchunk{sman.fixenv}
\getchunk{sman.inittermio}
\getchunk{sman.strPrefix}
\getchunk{sman.checkspadproc}
\getchunk{sman.cleanupoldsockets}
\getchunk{sman.forkyou}
\getchunk{sman.execcommandenv}
\getchunk{sman.spawnofhell}
\getchunk{sman.startthespadclient}
\getchunk{sman.startthelocalspadclient}
\getchunk{sman.startthesessionmanager}
\getchunk{sman.startthehypertex}
\getchunk{sman.startthegraphics}
\getchunk{sman.forkAxiom}
\getchunk{sman.starttheAxiom}
\getchunk{sman.cleanupsockets}
\getchunk{sman.readfromspadio}
\getchunk{sman.readfrommanager}
\getchunk{sman.managespadio}
\getchunk{sman.initspadprocesslist}
\getchunk{sman.printspadprocesslist}
\getchunk{sman.findchild}
\getchunk{sman.killallchildren}

```

```
\getchunk{sman.cleanupterminal}  
\getchunk{sman.monitorchildren}  
\getchunk{sman.main}
```

---

## Chapter 4

# Support Routines

### 4.1 Command Completion

Hyperdoc has the ability to do command completion. The known commands are listed, one entry per line, in a file called `command.list`.



## Chapter 5

# The viewman program

```
— the viewman command line —  
char *GraphicsProgram = "$AXIOM/lib/viewman";  
—————→
```





## Chapter 6

# The hypertext program

— the hypertext command line —  
char \*HypertextProgram = "\$AXIOM/bin/hypertext -s";  
—————→



## Chapter 7

# The clef program

— the clef command line —

```
char *ClefProgram = "$AXIOM/bin/clef -f $AXIOM/lib/command.list -e ";
```

—————→



## Chapter 8

# The session program

— the session manager command line —

```
char *SessionManagerProgram = "$AXIOM/lib/session";
```

—————

### 8.1 session

#### 8.1.1 includes

— ses.includes —

```
#include <stdlib.h>
#include <sys/time.h>
#include <stdio.h>
#include <string.h>
#include <signal.h>
#ifdef SGIplatform
#include <bstring.h>
#endif
\getchunk{include/com.h}
\getchunk{include/bsdsignal.h}
\getchunk{include/sockio-c.h1}
\getchunk{include/bsdsignal.h1}
\getchunk{include/session.h1}
```

—————

#### 8.1.2 variables

— ses.variables —

```

#define BufSize 4096 /* size of communication buffer */

typedef struct sock_list {      /* linked list of Sock */
    Sock Socket;
    struct sock_list *next;
} Sock_List;

Sock *spad_io = (Sock *) 0;    /* to_server socket for SessionIO */
Sock *spad_server = (Sock *) 0; /* to_server socket for SpadServer */
Sock *menu_client = (Sock *) 0; /* to_client socket for MenuServerName */
Sock *active_session = (Sock *) 0; /* pointer to currently active session */

Sock_List *plSock = (Sock_List *) 0;

char big_bad_buf[BufSize]; /* big I/O buffer */
int num_active_clients = 0; /* number of InterpWindows attached */
int reading_output = 0;
fd_set session_socket_mask;

```

---

### 8.1.3 usr1\_handler

```

— ses.usr1handler —

static void
usr1_handler(int sig)
{
    return;
}

```

---

### 8.1.4 usr2\_handler

SIGUSR2 is generated by spadclients. We interpret it as an interrupt for the Lisp.

```

— ses.usr2handler —

static void
usr2_handler(int sig)
{
    send_signal(spad_server, SIGINT);
    return;
}

```

---

### 8.1.5 term\_handler

```

— ses.termhandler —

static void
term_handler(int sig)
{
    exit(1);
}

```

---

### 8.1.6 pr

```

— ses.pr —

static void
pr()
{
    Sock_List *pSock;

    fprintf(stderr, "The socket list:\n");
    for(pSock=plSock; pSock!=(Sock_List *)0; pSock=pSock->next){
        fprintf(stderr, "(%d,%d,%d)\t",
            pSock->Socket.pid, 2<<(pSock->Socket.socket), pSock->Socket.frame);
    }
    fprintf(stderr, "\n");
}

```

---

### 8.1.7 close\_client

```

— ses.closeclient —

static void
close_client(int frame)
{
    Sock_List *pSock, *locSock;
    int socket_fd;

    /* we will check for frame equality,
       kill with send_signal,
       notify HyperTex so that it updates its list (if it's a spadbuf),
       repair the list,
       unset the active_session,
       update num_active_clients
    */
}

```

```

/* first check head */
#ifdef DEBUG
fprintf(stderr,"close_client(%d)\n",frame);
#endif

if ( (plSock) && (plSock->Socket.frame == frame) ){
    socket_fd = plSock->Socket.socket;
    send_signal((Sock *)plSock, SIGTERM);
    if ( menu_client != (Sock *) 0){
        send_int(menu_client,CloseClient);
        send_int(menu_client,(*plSock).Socket.pid);
    }
#ifdef DEBUG
fprintf(stderr,"trying to clear %u\n",socket_fd);
#endif
    FD_CLR(socket_fd,&session_socket_mask);
    locSock = plSock;
    if ((*plSock).next == (Sock_List *) 0)
        {plSock = (Sock_List *) 0;}
    else
        {plSock = plSock->next;}
    active_session = (Sock *) 0;
    num_active_clients--;
    free(locSock);
}

/* now check the rest */

else {
    for (pSock=plSock; pSock->next != (Sock_List *) 0 ; pSock=pSock->next)
        if (pSock->next->Socket.frame == frame){
            socket_fd = pSock->next->Socket.socket;
            send_signal((Sock *)pSock->next, SIGTERM);
            if ( menu_client != (Sock *) 0){
                send_int(menu_client,CloseClient);
                send_int(menu_client,(*plSock).Socket.pid);
            }
#ifdef DEBUG
fprintf(stderr,"trying to clear %u\n",socket_fd);
#endif
            FD_CLR(socket_fd,&session_socket_mask);
            locSock = pSock->next;
            if ( pSock->next->next == (Sock_List *) 0 )
                { pSock->next= (Sock_List *) 0;}
            else
                { pSock->next = pSock->next->next;}
            num_active_clients--;
            active_session = (Sock *) 0;
            free(locSock);
            break;
        }
}
#ifdef DEBUG
pr();

```



```
#endif
}
```

---

### 8.1.8 read\_SpadServer\_command

— ses.readSpadServercommand —

```
static void
read_SpadServer_command(void)
{
    int cmd, frame, num;
    cmd = get_int(spad_server);
    switch (cmd) {
    case EndOfOutput:
        if (menu_client != (Sock *) 0) send_signal(menu_client, SIGUSR2);
        if (reading_output != 0) reading_output = 0;
        break;
    case QueryClients:
        /* don't count MenuServer */
        num = num_active_clients;
        send_int(spad_server, num);
        break;
    case CloseClient:
        frame = get_int(spad_server);
        if (frame != -1) close_client(frame);
        break;
    case SendXEventToHyperTeX:
        break;
    default:
        fprintf(stderr, "session : unknown command from SpadServer %d\n", cmd);
        break;
    }
}
```

---

### 8.1.9 test\_sock\_for\_process

— ses.testsockforprocess —

```
static int
test_sock_for_process(Sock *sock)
{
    if (sock == (Sock *)0 ) return -1;
    return kill(sock->pid, 0);
}
```

---

## 8.1.10 read\_menu\_client\_command

— ses.readmenuclientcommand —

```

static void
read_menu_client_command(void)
{
    int cmd, frame, i, socket_fd;
    Sock_List *pSock;

    /* save it for possible clearing */
    socket_fd = menu_client->socket;

    if (test_sock_for_process(menu_client) == -1) {
        FD_CLR(socket_fd, &session_socket_mask);
        menu_client = (Sock *) 0;
        reading_output = 0;
        return;
    }
    cmd = get_int(menu_client);
    switch(cmd) {
    case -1: /* socket closed */
        FD_CLR(socket_fd, &session_socket_mask);
        menu_client = (Sock *) 0;
        reading_output = 0;
        break;
    case SwitchFrames:
#ifdef DEBUG
        fprintf(stderr, "menu:SwitchFrames\n");
#endif
        frame = get_int(menu_client);
        send_int(spada_server, SwitchFrames);
        send_int(spada_server, frame);
        for(i=0, pSock=plSock; pSock != (Sock_List *) 0 ; i++, pSock=pSock->next)
            if ((pSock->Socket.frame == frame)) {
                active_session = (Sock *)pSock;
                reading_output = 1;
                break;
            }
        if (i == num_active_clients) {
            /* fprintf(stderr, "Couldn't find socket for frame %d\n", frame); */
        }
        break;
    case QuerySpad:
#ifdef DEBUG
        fprintf(stderr, "menu:QuerySpad\n");
#endif
        send_int(menu_client, reading_output);
        break;
    default:
        fprintf(stderr, "session : unknown command from MenuServer: %d\n", cmd);
        menu_client = (Sock *) 0;
        break;
    }
}

```

```

    }
}

```

---

### 8.1.11 read\_from\_spad\_io

```

— ses.readfromspadio —

static void
read_from_spad_io(void)
{
    int ret_code;
    ret_code = sread(spad_io, big_bad_buf, BufSize, "session: stdout socket");
    if (ret_code == -1) return;
    if (active_session != (Sock *) 0) {
        ret_code = swrite(active_session, big_bad_buf, ret_code,
                          NULL);
    }
}

```

---

### 8.1.12 kill\_spad

```

— ses.killspad —

static void
kill_spad(void)
{
    int i;
    Sock_List *pSock;

    send_signal(spad_server, SIGTERM);
    for (pSock=plSock,i=0;
         (i<num_active_clients) && (pSock != (Sock_List *) 0);
         i++,pSock=pSock->next) {
        if ((pSock->Socket).socket != 0)
            send_signal((Sock *)pSock, SIGTERM);
    }
    if (menu_client != (Sock *) 0) send_signal(menu_client, SIGTERM);
    exit(0);
}

```

---

## 8.1.13 accept\_session\_connection

— ses.acceptsessionconnection —

```

static int
accept_session_connection(Sock *server_sock)
{
    int sock_fd, ret_code;
    Sock_List *pls;

    /* Could be three things : KillSpad MenuServer InterpWindow */

    pls = (Sock_List *) malloc(sizeof (Sock_List));
    sock_fd = accept(server_sock->socket, 0, 0);
    if (sock_fd == -1) {
        perror("session : accepting connection");
        return -1;
    }
    (pls->Socket).socket = sock_fd;
    get_socket_type((Sock *)pls);

    switch((pls->Socket).purpose) {
    case KillSpad:
        kill_spad();
        return KillSpad;
        free(pls);
    case MenuServer:
#ifdef DEBUG
        fprintf(stderr,"session: accepted MenuServer , fd = %d\n",sock_fd);
#endif
        menu_client = &(pls->Socket);
        FD_SET(menu_client->socket, &session_socket_mask);
        return MenuServer;
    case InterpWindow:
#ifdef DEBUG
        fprintf(stderr,"session: accepted InterpWindow , fd = %d\n",sock_fd);
#endif

        /* new Sock is put at the head of the list */
        if (plSock == (Sock_List *)0 ) {
            plSock = pls;
            plSock->next = (Sock_List *)0 ;
        }
        else{
            pls->next = plSock;
            plSock = pls;
        }

        /* we need to maintain session_socket_mask here
           since we roll our own accept */

        FD_SET(plSock->Socket.socket, &session_socket_mask);
        send_int(spad_server, CreateFrame);

```

```

{
    int command = get_int(spad_server);
    /* XXX hack -- the whole protocol looks broken, we just
       try to detect losage */
    if (command != CreateFrameAnswer) {
        fprintf(stderr, "session: non-fatal, got out of sync "
                      "with Spad server\n (lost race)\n");
        /* exit(1); */
    }
}

plSock->Socket.frame = get_int(spad_server);
active_session = (Sock *)plSock;
get_string_buf(spad_server, big_bad_buf, BufSize);
ret_code = swrite((Sock *)plSock, big_bad_buf, strlen(big_bad_buf)+1,
"session: writing to InterpWindow");
if (ret_code == -1)
return -1;
num_active_clients++;
#ifdef DEBUG
pr();
#endif
return plSock->Socket.purpose;
}
return (-1);
}

```

---

#### 8.1.14 read\_from\_session

— ses.readfromsession —

```

static void
read_from_session(Sock *sock)
{
    int ret_code;
    if (sock != active_session) {
        send_int(spad_server, SwitchFrames);
        send_int(spad_server, sock->frame);
    }
    active_session = sock;
    ret_code = sread(sock, big_bad_buf, BufSize,
"session: reading InterpWindow");
    if (ret_code == -1) {
        active_session = (Sock *) 0;
        reading_output = 0;
        return;
    }
    ret_code = swrite(spad_io, big_bad_buf, ret_code,
"session: writing SessionIO");
    if (ret_code == -1) {
        active_session = (Sock *)0 ;
    }
}

```

```

    reading_output = 0;
    return;
}
reading_output = 1;
}

```

—————

### 8.1.15 manage\_sessions

— ses.managesessions —

```

static void
manage_sessions(void)
{
    int ret_code;
    fd_set rd, wr, ex;
    Sock_List *pSock;

    reading_output = 0;
    while (1) {
        FD_ZERO(&rd);
        FD_ZERO(&wr);
        FD_ZERO(&ex);

        /* Allow server socket and all connections if not waiting for output
           socket_mask is maintained by libspad.a */
#ifdef DEBUG
        fprintf(stderr, "session_socket_mask=%u ", *((long *)session_socket_mask.fds_bits));
#endif
        rd = session_socket_mask;
        if (!reading_output) {
            rd = session_socket_mask;
        }

        /* Allow the active_session if set */
        if (active_session) FD_SET(active_session->socket, &rd);
#ifdef DEBUG
        fprintf(stderr, "[rd=%u ", *((long *)rd.fds_bits));
#endif
        ret_code = sselect(FD_SETSIZE, &rd, &wr, &ex, NULL);
        if (ret_code == -1) {
            break;
        }
#ifdef DEBUG
        fprintf(stderr, "rd=%u]\n", *((long *)rd.fds_bits));
#endif

        if ((menu_client != (Sock *) 0) && FD_ISSET(menu_client->socket, &rd)) {
            /* MenuServer wants to talk */
            read_menu_client_command(); }
    }
}

```

```

if (FD_ISSET(spad_io->socket, &rd)) {
    /* Lisp has output */
    read_from_spad_io(); }

if (FD_ISSET(server[1].socket, &rd)) {
    /* Someone wants to connect to our server socket */
    accept_session_connection(server+1); }

for(pSock=plSock; pSock != (Sock_List *) 0 ; pSock=pSock->next) {
    if ((active_session == (Sock *)pSock || !reading_output) &&
        (pSock->Socket).socket>0 && FD_ISSET(pSock->Socket.socket, &rd)) {
/* An InterpWindow */
read_from_session((Sock *)pSock); }
    }

if (FD_ISSET(spad_server->socket, &rd)) {
    /* The Lisp socket */
    read_SpadServer_command(); }
}
}

```

---

### 8.1.16 main sessionmanager

```

— ses.main —

int
main(void)
{
#ifdef DEBUG2
    /* delay for attaching with debugger before interesting things happen */
    sleep(30);
#endif

    /* spad_server connects to Lisp server socket
       read_SpadServer_command handles requests */
    spad_server = connect_to_local_server(SpadServer, SessionManager, Forever);
    if (spad_server == (Sock *) 0) {
        fprintf(stderr, "session: Cannot connect to AXIOM server!\n");
        exit(0);
    }
    else {
#ifdef DEBUG
        fprintf(stderr, "session: connected SpadServer , fd = %d\n",
            spad_server->socket);

```

```

#endif
    FD_SET(spada_server->socket, &session_socket_mask);
}

/* spada_io connects to SessionIOName server socket
   this is Lisp std IO read_from_spada_io handles requests */
spada_io = connect_to_local_server(SessionIOName, SessionIO, Forever);
if (spada_io == (Sock *) 0) {
    fprintf(stderr, "session: Cannot connect to AXIOM IO!\n");
    exit(0);
}
else {
#ifdef DEBUG
    fprintf(stderr, "session: connected SessionIOName , fd = %d\n",
        spada_io->socket);
#endif
    FD_SET(spada_io->socket, &session_socket_mask);
}
bsdSignal(SIGUSR2, usr2_handler, DontRestartSystemCalls);
bsdSignal(SIGUSR1, usr1_handler, RestartSystemCalls);
bsdSignal(SIGINT, SIG_IGN, RestartSystemCalls);
bsdSignal(SIGTERM, term_handler, RestartSystemCalls);

/* open_server opens the server socket so that we can accept connections
   we expect connections from spadbuf/spadclient(purpose:InterpWindow)
   and hypertex (MenuServer) */

if (open_server(SessionServer) == -2) {
    fprintf(stderr, "session: Cannot make server socket!\n");
    exit(-1);
}
else {
#ifdef DEBUG
    fprintf(stderr, "session: opened SessionServer , fd = %d\n",
        server[1].socket);
#endif
    FD_SET(server[1].socket, &session_socket_mask);
}
manage_sessions();
return(0);
}

```

### 8.1.17 session

— session.c —

```

/* #define DEBUG */
#define _SESSION_C

```



```
\getchunk{ses.includes}  
\getchunk{ses.variables}  
\getchunk{ses.usr1handler}  
\getchunk{ses.usr2handler}  
\getchunk{ses.termhandler}  
\getchunk{ses.pr}  
\getchunk{ses.closeclient}  
\getchunk{ses.readSpadServercommand}  
\getchunk{ses.testsockforprocess}  
\getchunk{ses.readmenuclientcommand}  
\getchunk{ses.readfromspadio}  
\getchunk{ses.killspad}  
\getchunk{ses.acceptsessionconnection}  
\getchunk{ses.readfromsession}  
\getchunk{ses.managesessions}  
\getchunk{ses.main}
```

---



## Chapter 9

# The spadclient program

— the spadclient command line —

```
char *SpadClientProgram = "$AXIOM/lib/spadclient";
```

—————

### 9.1 spadclient

— spadclient.c —

```
#define _SPADCLIENT_C

#include <stdio.h>
#include <signal.h>

\getchunk{include/com.h}
\getchunk{include/bsdsignal.h}
\getchunk{include/bsdsignal.h1}
\getchunk{include/sockio-c.h1}
\getchunk{include/spadclient.h1}

Sock *sock;

static void
inter_handler(int sig)
{
    send_signal(sock, SIGUSR2);
    fflush(stderr);
}

int
main(void)
{
```

```
sock = connect_to_local_server(SessionServer, InterpWindow, Forever);  
bsdSignal(SIGINT, inter_handler, RestartSystemCalls);  
remote_stdio(sock);  
return(0);  
}
```

---

## Chapter 10

# The Command Completion List

— command.list —

```
-  
/  
/\n^  
^=  
~  
~=  
*  
**  
\/  
#  
+  
<  
<=  
=  
>  
>=  
0  
1  
abelianGroup  
abs  
absolutelyIrreducible?  
accuracyIF  
acos  
acosh  
acoshIfCan  
acosIfCan  
acot  
acoth  
acothIfCan  
acotIfCan  
acsc  
acsch  
acschIfCan
```

acscIfCan  
aCubic  
adaptive  
adaptive?  
adaptive3D?  
addBadValue  
addChild!  
addData!  
addField!  
addiag  
addMatch  
addMatchRestricted  
addmod  
addPoint  
addPoint2  
addPointLast  
adjoint  
airyAi  
airyBi  
Aleph  
algDsolve  
algebraic?  
algebraicCoefficients?  
algebraicDecompose  
algebraicOf  
algebraicSort  
algebraicVariables  
algint  
algintegrate  
algSplitSimple  
aLinear  
allRootsOf  
alphabetic  
alphabetic?  
alphanumeric  
alphanumeric?  
alternating  
alternatingGroup  
alternative?  
An  
AND  
And  
and  
anfactor  
antiAssociative?  
antiCommutative?  
antiCommutator  
anticoord  
antisymmetric?  
antisymmetricTensors  
any  
any?  
append  
appendPoint

apply  
applyQuote  
applyRules  
approximants  
approximate  
approxNthRoot  
approxSqrt  
aQuadratic  
aQuartic  
areEquivalent?  
arg1  
arg2  
argscript  
argument  
argumentList!  
argumentListOf  
arity  
aromberg  
arrayStack  
asec  
asech  
asechIfCan  
asecIfCan  
asimpson  
asin  
asinh  
asinhIfCan  
asinIfCan  
aspFilename  
assert  
assign  
assoc  
associatedEquations  
associatedSystem  
associates?  
associative?  
associator  
associatorDependence  
atan  
atanh  
atanhIfCan  
atanIfCan  
atom?  
atoms  
atrapezoidal  
att2Result  
augment  
autoReduced?  
axes  
axesColorDefault  
Bisolve  
back  
backOldPos  
badNum

badValues  
bag  
balancedBinaryTree  
balancedFactorisation  
bandedHessian  
bandedJacobian  
base  
baseRDE  
baseRDEsys  
BasicMethod  
basicSet  
basis  
basisOfCenter  
basisOfCentroid  
basisOfCommutingElements  
basisOfLeftAnnihilator  
basisOfLeftNucleus  
basisOfLeftNucloid  
basisOfMiddleNucleus  
basisOfNucleus  
basisOfRightAnnihilator  
basisOfRightNucleus  
basisOfRightNucloid  
bat  
bat1  
beauzamyBound  
belong?  
bernoulli  
bernoulliB  
bessell  
besselJ  
besselK  
bessely  
Beta  
bezoutDiscriminant  
bezoutMatrix  
bezoutResultant  
bfEntry  
bfKeys  
binary  
binaryFunction  
binarySearchTree  
binaryTournament  
binaryTree  
binomial  
binomThmExpt  
bipolar  
bipolarCylindrical  
biRank  
birth  
bit?  
bitCoef  
bitLength  
bits



bitTruth  
bivariate?  
bivariatePolynomials  
bivariateSLPEBR  
blankSeparate  
block  
blue  
bombieriNorm  
bool  
bool?  
bottom!  
boundOfCauchy  
box  
brace  
bracket  
branchIfCan  
branchPoint?  
branchPointAtInfinity?  
bright  
brillhartIrreducible?  
brillhartTrials  
bringDown  
bsolve  
btwFact  
bubbleSort!  
build  
BumInSepFFE  
bumprow  
bumptab  
bumptab1  
BY  
c02aff  
c02agf  
c05adf  
c05nbf  
c05pbf  
c06eaf  
c06ebf  
c06ecf  
c06ekf  
c06fpf  
c06fqf  
c06frf  
c06fuf  
c06gbf  
c06gcf  
c06gqf  
c06gsf  
cache  
cAcos  
cAcosh  
cAcot  
cAcoth  
cAcsc

cAcsch  
calcRanges  
call  
cap  
car  
cardinality  
cartesian  
cAsec  
cAsech  
cAsin  
cAsinh  
cAtan  
cAtanh  
cCos  
cCosh  
cCot  
cCoth  
cCsc  
cCsch  
cdr  
ceiling  
center  
central?  
certainlySubVariety?  
cExp  
cfirst  
chainSubResultants  
changeBase  
changeMeasure  
changeName  
changeNameToObjf  
changeThreshold  
changeVar  
changeWeightLevel  
char  
character?  
characteristic  
characteristicPolynomial  
characteristicSerie  
characteristicSet  
charClass  
charpol  
charthRoot  
chebyshevT  
chebyshevU  
check  
checkCxResult  
checkForZero  
checkMxCDF  
checkMxDF  
checkPrecision  
checkResult  
checkRur  
child

child?  
children  
chineseRemainder  
chiSquare  
chiSquare1  
choosemon  
chvar  
Ci  
className  
clearCache  
clearDenominator  
clearFortranOutputStack  
clearTable!  
clearTheFTable  
clearTheIFTable  
clearTheSymbolTable  
clikeUniv  
clip  
clipBoolean  
clipParametric  
clipPointsDefault  
clipSurface  
clipWithRanges  
cLog  
close  
close!  
closeComponent  
closed?  
closedCurve  
closedCurve?  
cn  
code  
coef  
coefChoose  
coefficient  
coefficients  
coerce  
coerceImages  
coerceListOfPairs  
coerceP  
coercePreimagesImages  
coHeight  
coleman  
collect  
collectQuasiMonic  
collectUnder  
collectUpper  
color  
colorDef  
colorFunction  
column  
combineFeatureCompatibility  
commaSeparate  
comment

common  
commonDenominator  
commutative?  
commutativeEquality  
commutator  
comp  
compactFraction  
companionBlocks  
comparison  
compBound  
compdegd  
compile  
compiledFunction  
complement  
complementaryBasis  
complete  
completeEchelonBasis  
completeEval  
completeHensel  
completeHermite  
completeSmith  
complex  
complex?  
complexEigenvalues  
complexEigenvectors  
complexElementary  
complexExpand  
complexForm  
complexIntegrate  
complexLimit  
complexNormalize  
complexNumeric  
complexNumericIfCan  
complexRoots  
complexSolve  
complexZeros  
component  
components  
compose  
composite  
composites  
computeBasis  
computeCycleEntry  
computeCycleLength  
computeInt  
computePowers  
concat  
concat!  
cond  
condition  
conditionP  
conditions  
conditionsForIdempotents  
conical

conjHerm  
conjug  
conjugate  
conjugates  
connect  
connect?  
cons  
consnewpol  
const  
constant  
constant?  
constantCoefficientRicDE  
constantIfCan  
constantKernel  
constantLeft  
constantOperator  
constantOpIfCan  
constantRight  
constantToUnaryFunction  
constDsolve  
construct  
contains?  
content  
continue  
continuedFraction  
contract  
contractSolve  
controlPanel  
convergents  
convert  
coord  
coordinate  
coordinates  
copies  
copy  
copy!  
copyInto!  
corrPoly  
cos  
cos2sec  
cosh  
cosh2sech  
coshIfCan  
cosIfCan  
cosSinInfo  
cot  
cot2tan  
cot2trig  
coth  
coth2tanh  
coth2trigh  
cothIfCan  
cotIfCan  
count

countable?  
countRealRoots  
countRealRootsMultiple  
cPower  
cRationalPower  
create  
create3Space  
createGenericMatrix  
createIrreduciblePoly  
createLowComplexityNormalBasis  
createLowComplexityTable  
createMultiplicationMatrix  
createMultiplicationTable  
createNormalElement  
createNormalPoly  
createNormalPrimitivePoly  
createPrimitiveElement  
createPrimitiveNormalPoly  
createPrimitivePoly  
createRandomElement  
createThreeSpace  
createZechTable  
credPol  
crest  
critB  
critBonD  
critM  
critMonD1  
critMTonD1  
critpOrder  
critT  
cross  
crushedSet  
csc  
csc2sin  
csch  
csch2sinh  
cschIfCan  
cscIfCan  
cSec  
cSech  
cSin  
cSinh  
csubst  
cTan  
cTanh  
cubic  
cup  
currentSubProgram  
curry  
curryLeft  
curryRight  
curve  
curve?

curveColor  
curveColorPalette  
cycle  
cycleElt  
cycleEntry  
cycleLength  
cyclePartition  
cycleRagits  
cycles  
cycleSplit!  
cycleTail  
cyclic  
cyclic?  
cyclicCopy  
cyclicEntries  
cyclicEqual?  
cyclicGroup  
cyclicParents  
cyclicSubmodule  
cyclotomic  
cyclotomicDecomposition  
cyclotomicFactorization  
cylindrical  
D  
d01ajf  
d01akf  
d01alf  
d01amf  
d01anf  
d01apf  
d01aqf  
d01asf  
d01bbf  
d01fcf  
d01gaf  
d01gbf  
d02bbf  
d02bhf  
d02cjf  
d02ejf  
d02gaf  
d02gbf  
d02kef  
d02raf  
d03edf  
d03eef  
d03faf  
dAndcExp  
dark  
datalist  
ddFact  
debug  
debug3D  
dec

decimal  
declare  
declare!  
decompose  
decomposeFunc  
decrease  
decreasePrecision  
deepCopy  
deepestInitial  
deepestTail  
deepExpand  
defineProperty  
definingEquations  
definingInequation  
definingPolynomial  
degree  
degreePartition  
degreeSubResultant  
degreeSubResultantEuclidean  
delay  
delete  
delete!  
deleteProperty!  
deleteRoutine!  
delta  
denom  
denominator  
denominators  
denomLODE  
denomRicDE  
depth  
dequeue  
dequeue!  
deref  
deriv  
derivationCoordinates  
derivative  
destruct  
determinant  
df2ef  
df2fi  
df2mf  
df2st  
dflist  
dfRange  
diag  
diagonal  
diagonal?  
diagonalMatrix  
diagonalProduct  
diagonals  
dictionary  
diff  
difference



differentialVariables  
differentiate  
digamma  
digit  
digit?  
digits  
dihedral  
dihedralGroup  
dilog  
dim  
dimension  
dimensionOfIrreducibleRepresentation  
dimensions  
dimensionsOf  
diophantineSystem  
dioSolve  
direction  
directory  
directProduct  
directSum  
discreteLog  
discriminant  
discriminantEuclidean  
display  
dispose!  
distance  
distdfact  
distFact  
distribute  
div  
divergence  
divide  
divideExponents  
divideIfCan  
divideIfCan!  
divisor  
divisorCascade  
divisors  
dmp2rfi  
dmpToHdmp  
dmpToP  
dn  
dom  
domainOf  
dominantTerm  
dot  
double  
double?  
doubleComplex?  
doubleDisc  
doubleRank  
doubleResultant  
doublyTransitive?  
draw

drawComplex  
drawComplexVectorField  
drawCurves  
drawStyle  
drawToScale  
droot  
duplicates  
duplicates?  
e  
e01baf  
e01bef  
e01bff  
e01bgf  
e01bhf  
e01daf  
e01saf  
e01sbf  
e01sef  
e01sff  
e02adf  
e02aef  
e02agf  
e02ahf  
e02ajf  
e02akf  
e02baf  
e02bbf  
e02bcf  
e02bdf  
e02bef  
e02daf  
e02dcf  
e02ddf  
e02def  
e02dff  
e02gaf  
e02zaf  
e04dgf  
e04fdf  
e04gcf  
e04jaf  
e04mbf  
e04naf  
e04ucf  
e04ycf  
edf2df  
edf2ef  
edf2efi  
edf2fi  
ef2edf  
Ei  
eigenMatrix  
eigenvalues  
eigenvector

eigenvectors  
eisensteinIrreducible?  
elColumn2!  
elem?  
element?  
elementary  
elements  
elliptic  
elliptic?  
ellipticCylindrical  
elRow1!  
elRow2!  
elt  
empty  
empty?  
endOfFile?  
endSubProgram  
enqueue!  
enterInCache  
enterPointData  
entries  
entry  
entry?  
enumerate  
epilogue  
EQ  
eq  
eq?  
equality  
equation  
erf  
error  
errorInfo  
errorKind  
escape  
euclideanGroebner  
euclideanNormalForm  
euclideanSize  
euler  
eulerE  
eulerPhi  
eval  
evaluate  
evaluateInverse  
even?  
evenInfiniteProduct  
evenlambert  
every?  
exactQuotient  
exactQuotient!  
exists?  
exp  
exp1  
expand

expandLog  
expandPower  
expandTrigProducts  
expenseOfEvaluation  
expenseOfEvaluationIF  
expextendedint  
expIfCan  
expint  
expintegrate  
expintfldpoly  
explicitEntries?  
explicitlyEmpty?  
explicitlyFinite?  
explimitedint  
explogs2trigs  
exponent  
exponential  
exponential1  
exponentialOrder  
exponents  
expPot  
expr  
expressIdealMember  
exprHasAlgebraicWeight  
exprHasLogarithmicWeights  
exprHasWeightCosWXorSinWX  
exprToGenUPS  
exprToUPS  
exprToXXP  
expt  
exptMod  
exQuo  
exquo  
extend  
extendedEuclidean  
extendedint  
extendedIntegrate  
extendedResultant  
extendedSubResultantGcd  
extendIfCan  
extension  
extensionDegree  
exteriorDifferential  
external?  
externalList  
extract!  
extractBottom!  
extractClosed  
extractIfCan  
extractIndex  
extractPoint  
extractProperty  
extractSplittingLeaf  
extractTop!

eyeDistance  
F  
f01brf  
f01bsf  
f01maf  
f01mcf  
f01qcf  
f01qdf  
f01qef  
f01rcf  
f01rdf  
f01ref  
f02aaf  
f02abf  
f02adf  
f02aef  
f02aff  
f02agf  
f02ajf  
f02akf  
f02awf  
f02axf  
f02bbf  
f02bjf  
f02fjf  
f02wef  
f02xef  
f04adf  
f04arf  
f04asf  
f04atf  
f04axf  
f04faf  
f04jgf  
f04maf  
f04mbf  
f04mcf  
f04qaf  
f07adf  
f07aef  
f07fdf  
f07fef  
f2df  
F2FG  
f2st  
factor  
factor1  
factorAndSplit  
factorByRecursion  
factorFraction  
factorGroebnerBasis  
factorial  
factorials  
factorList

factorOfDegree  
factorPolynomial  
factors  
factorset  
factorSFBRLcUnit  
factorsOfCyclicGroupSize  
factorsOfDegree  
factorSquareFree  
factorSquareFreeByRecursion  
factorSquareFreePolynomial  
failed  
failed?  
false  
ffactor  
FG2F  
fglmIfCan  
fi2df  
fibonacci  
field  
fields  
figureUnits  
filename  
fill!  
fillPascalTriangle  
filterUntil  
filterWhile  
find  
findCycle  
finite?  
finiteBasis  
finiteBound  
fintegrate  
first  
firstDenom  
firstNumer  
firstSubsetGray  
firstUncouplingMatrix  
fixedDivisor  
fixedPoint  
fixedPointExquo  
fixedPoints  
fixPredicate  
flagFactor  
flatten  
flexible?  
flexibleArray  
float  
float?  
floatlist  
floatlist?  
floor  
fmecg  
forLoop  
FormatArabic

FormatRoman  
 formula  
 fortran  
 fortranCarriageReturn  
 fortranCharacter  
 fortranCompilerName  
 fortranComplex  
 fortranDouble  
 fortranDoubleComplex  
 fortranInteger  
 fortranLinkerArgs  
 fortranLiteral  
 fortranLiteralLine  
 fortranLogical  
 fortranReal  
 fortranTypeOf  
 fprindINFO  
 fracPart  
 fractionFreeGauss!  
 fractionPart  
 fractRadix  
 fractRagits  
 freeOf?  
 Frobenius  
 frobenius  
 front  
 froot  
 first  
 fTable  
 fullDisplay  
 fullPartialFraction  
 function  
 functionIsContinuousAtEndPoints  
 functionIsFracPolynomial?  
 functionIsOscillatory  
 Gamma  
 gbasis  
 gcd  
 gcdcofact  
 gcdcofactprim  
 gcdPolynomial  
 gcdprim  
 gcdPrimitive  
 gderiv  
 GE  
 generalInfiniteProduct  
 generalizedContinuumHypothesisAssumed  
 generalizedContinuumHypothesisAssumed?  
 generalizedEigenvector  
 generalizedEigenvectors  
 generalizedInverse  
 generalLambert  
 generalPosition  
 generalSqFr

generalTwoFactor  
generate  
generateIrredPoly  
generator  
generators  
generic  
generic?  
genericLeftDiscriminant  
genericLeftMinimalPolynomial  
genericLeftNorm  
genericLeftTrace  
genericLeftTraceForm  
genericPosition  
genericRightDiscriminant  
genericRightMinimalPolynomial  
genericRightNorm  
genericRightTrace  
genericRightTraceForm  
genus  
geometric  
getBadValues  
getButtonValue  
getCode  
getCurve  
getDatabase  
getExplanations  
getGoodPrime  
getGraph  
gethi  
getlo  
getMatch  
getMeasure  
getMultiplicationMatrix  
getMultiplicationTable  
getOrder  
getPickedPoints  
getRef  
getStream  
getVariableOrder  
getZechTable  
GF2FG  
goodnessOfFit  
goodPoint  
GospersMethod  
goto  
gradient  
graeffe  
gramschmidt  
graphCurves  
graphImage  
graphs  
graphState  
graphStates  
green



groebgen  
groebner  
groebner?  
groebnerFactorize  
groebnerIdeal  
groebSolve  
ground  
ground?  
GT  
halfExtendedResultant1  
halfExtendedResultant2  
halfExtendedSubResultantGcd1  
halfExtendedSubResultantGcd2  
harmonic  
has?  
hash  
hasHi  
hasIn  
hasPredicate?  
hasSolution?  
hasTopPredicate?  
Hausdorff  
hclf  
hconcat  
hcrf  
hdmpToDmp  
hdmpToP  
head  
headReduce  
headReduced?  
headRemainder  
heap  
heapSort  
height  
henselFact  
HenselLift  
hermite  
hermiteH  
HermiteIntegrate  
hessian  
hex  
hexDigit  
hexDigit?  
hi  
high  
highCommonTerms  
hitherPlane  
hMonic  
HMS  
homogeneous?  
horizConcat  
hspace  
htrigs  
hue

hyperelliptic  
hypergeometricOF1  
iCompose  
id  
ideal  
idealiser  
idealiserMatrix  
idealSimplify  
identification  
identity  
identityMatrix  
identitySquareMatrix  
iExquo  
iflist2Result  
iFTable  
ignore?  
iiabs  
iiacos  
iiacosh  
iiacot  
iiacoth  
iiacsc  
iiacsch  
iiasec  
iiasech  
iiasin  
iiasinh  
iiatan  
iiatanh  
iibinom  
iicos  
iicosh  
iicot  
iicoth  
iicsc  
iicsch  
iidprod  
iidsum  
iiexp  
iifact  
iiGamma  
iilog  
iiperm  
iipow  
iisec  
iisech  
iisin  
iisinh  
iisqrt2  
iisqrt3  
iitan  
iitanh  
imag  
imagE

```

imagI
imagi
imaginary
imagJ
imagj
imagK
imagk
implies
in?
inc
incr
increase
increasePrecision
increment
incrementBy
incrementKthElement
index
index?
indices
indiceSubResultant
indiceSubResultantEuclidean
indicialEquation
indicialEquationAtInfinity
indicialEquations
inf
infieldint
infieldIntegrate
infinite?
infiniteProduct
infinity
infinityNorm
infix
infix?
infLex?
infRittWu?
inGroundField?
inHallBasis?
init
initial
initializeGroupForWordProblem
initiallyReduce
initiallyReduced?
initials
initTable!
innerEigenvectors
innerint
innerSolve
innerSolve1
input
inR?
inRadical?
inrootof
insert
insert!

```

insertBottom!  
insertionSort!  
insertMatch  
insertRoot!  
insertTop!  
inspect  
int  
int?  
intChoose  
intcompBasis  
integer  
integer?  
integerBound  
integerIfCan  
integers  
integral  
integral?  
integralAtInfinity?  
integralBasis  
integralBasisAtInfinity  
integralCoordinates  
integralDerivationMatrix  
integralLastSubResultant  
integralMatrix  
integralMatrixAtInfinity  
integralRepresents  
integrate  
intensity  
intermediateResultsIF  
internal?  
internalAugment  
internalDecompose  
internalInfRittWu?  
internalIntegrate  
internalIntegrate0  
internalLastSubResultant  
internalSubPolSet?  
internalSubQuasiComponent?  
internalZeroSetSplit  
interpolate  
interpret  
interpretString  
interReduce  
intersect  
interval  
intlist  
intlist?  
intPatternMatch  
inv  
inverse  
inverseColeman  
inverseIntegralMatrix  
inverseIntegralMatrixAtInfinity  
inverseLaplace

invertible?  
invertibleElseSplit?  
invertibleSet  
invertIfCan  
invmod  
invmultisect  
invWrite  
iomode  
ipow  
iprint  
iroot  
irreducible?  
irreducibleFactor  
irreducibleFactors  
irreducibleRepresentation  
Is  
is?  
isAbsolutelyIrreducible?  
isExpt  
isList  
isMult  
isobaric?  
isOp  
isPlus  
isPower  
isQuotient  
isTimes  
iter  
iteratedInitials  
jacobi  
jacobian  
jacobiIdentity?  
janko2  
jordanAdmissible?  
jordanAlgebra?  
karatsuba  
karatsubaDivide  
karatsubaOnce  
kernel  
kernels  
key  
key?  
keys  
kmax  
knownInfBasis  
kovacic  
kroneckerDelta  
KrullNumber  
ksec  
label  
lagrange  
LagrangeInterpolation  
laguerre  
laguerreL

lambda  
lambert  
laplace  
laplacian  
largest  
last  
lastSubResultant  
lastSubResultantElseSplit  
lastSubResultantEuclidean  
latex  
laurent  
laurentIfCan  
laurentRep  
Lazard  
Lazard2  
LazardQuotient  
LazardQuotient2  
lazy?  
lazyEvaluate  
lazyGintegrate  
lazyIntegrate  
lazyIrreducibleFactors  
lazyPquo  
lazyPrem  
lazyPremWithDefault  
lazyPseudoDivide  
lazyPseudoQuotient  
lazyPseudoRemainder  
lazyResidueClass  
lazyVariations  
lcm  
ldf2lst  
ldf2vmf  
LE  
leader  
leadingBasisTerm  
leadingCoefficient  
leadingCoefficientRicDE  
leadingExponent  
leadingIdeal  
leadingIndex  
leadingMonomial  
leadingSupport  
leadingTerm  
leaf?  
leastAffineMultiple  
leastMonomial  
leastPower  
leaves  
left  
leftAlternative?  
leftCharacteristicPolynomial  
leftDiscriminant  
leftDivide

leftExactQuotient  
leftExtendedGcd  
leftFactor  
leftFactorIfCan  
leftGcd  
leftLcm  
leftMinimalPolynomial  
leftMult  
leftNorm  
leftOne  
leftPower  
leftQuotient  
leftRank  
leftRankPolynomial  
leftRecip  
leftRegularRepresentation  
leftRemainder  
leftScalarTimes!  
leftTrace  
leftTraceMatrix  
leftTrim  
leftUnit  
leftUnits  
leftZero  
legendre  
legendreP  
lend!  
length  
lepol  
less?  
level  
leviCivitaSymbol  
lex  
lexGroebner  
lexico  
lexTriangular  
lfextendedint  
lfextlimint  
lfinfieldint  
lfintegrate  
lflimitedint  
lfunc  
lhs  
li  
library  
lieAdmissible?  
lieAlgebra?  
LiePoly  
LiePolyIfCan  
lift  
lifting  
lifting1  
light  
lighting

limit  
limitedint  
limitedIntegrate  
limitPlus  
linear  
linear?  
linearAssociatedExp  
linearAssociatedLog  
linearAssociatedOrder  
linearDependence  
linearDependenceOverZ  
linearlyDependent?  
linearlyDependentOverZ?  
linearMatrix  
linearPart  
linearPolynomials  
linears  
lineColorDefault  
linGenPos  
linkToFortran  
linSolve  
lintgcd  
list  
list?  
listBranches  
listConjugateBases  
listexp  
listLoops  
listOfLists  
listOfMonoms  
listOfTerms  
listRepresentation  
lists  
listYoungTableaus  
l1lip  
l1lp  
llprop  
lo  
localAbs  
localIntegralBasis  
localReal?  
localUnquote  
LOD02FUN  
log  
log10  
log2  
logGamma  
logical?  
logIfCan  
logpart  
lookup  
loopPoints  
low  
lowerCase



lowerCase!  
lowerCase?  
lowerPolynomial  
LowTriBddDenomInv  
lp  
lprop  
lquo  
lSpaceBasis  
lstart!  
LT  
lyndon  
lyndon?  
LyndonBasis  
LyndonCoordinates  
lyndonIfCan  
LyndonWordsList  
LyndonWordsList1  
magnitude  
mainCharacterization  
mainCoefficients  
mainContent  
mainDefiningPolynomial  
mainForm  
mainKernel  
mainMonomial  
mainMonomials  
mainPrimitivePart  
mainSquareFreePart  
mainValue  
mainVariable  
mainVariable?  
mainVariables  
make  
makeCos  
makeCrit  
makeEq  
makeFloatFunction  
makeFR  
makeGraphImage  
makeMulti  
makeObject  
makeop  
makeprod  
makeRecord  
makeResult  
makeSceneGraph  
makeSeries  
makeSin  
makeSketch  
makeSUP  
makeTerm  
makeUnit  
makeVariable  
makeViewport2D

makeViewport3D  
makeYoungTableau  
makingStats?  
mantissa  
map  
map!  
mapBivariate  
mapCoef  
mapdiv  
mapDown!  
mapExpon  
mapExponents  
mapGen  
mapMatrixIfCan  
mapmult  
mapSolve  
mapUnivariate  
mapUnivariateIfCan  
mapUp!  
mask  
mat  
match  
match?  
mathieu11  
mathieu12  
mathieu22  
mathieu23  
mathieu24  
matrix  
matrixConcat3D  
matrixDimensions  
matrixGcd  
max  
maxColIndex  
maxdeg  
maximumExponent  
maxIndex  
maxint  
maxPoints  
maxPoints3D  
maxrank  
maxrow  
maxRowIndex  
mdeg  
measure  
measure2Result  
meatAxe  
medialSet  
member?  
members  
merge  
merge!  
mergeDifference  
mergeFactors

mesh  
mesh?  
meshFun2Var  
meshPar1Var  
meshPar2Var  
message  
messagePrint  
middle  
midpoint  
midpoints  
mightHaveRoots  
min  
minColIndex  
mindeg  
mindegTerm  
minGbasis  
minimalPolynomial  
minimize  
minimumDegree  
minimumExponent  
minIndex  
minordet  
minPoints  
minPoints3D  
minPol  
minPoly  
minrank  
minRowIndex  
minset  
minus!  
minusInfinity  
mirror  
mix  
mkAnswer  
mkcomm  
mkIntegral  
mkPrim  
modifyPoint  
modifyPointData  
modTree  
modularFactor  
modularGcd  
modularGcdPrimitive  
module  
moduleSum  
moduloP  
modulus  
moebius  
moebiusMu  
monic?  
monicCompleteDecompose  
monicDecomposeIfCan  
monicDivide  
monicLeftDivide

monicModulo  
monicRightDivide  
monicRightFactorIfCan  
monom  
monomial  
monomial?  
monomialIntegrate  
monomialIntPoly  
monomials  
monomRDE  
monomRDEsys  
more?  
moreAlgebraic?  
morphism  
move  
movedPoints  
mpsode  
mr  
mulmod  
multiEuclidean  
multiEuclideanTree  
multinomial  
multiple  
multiple?  
multiplyCoefficients  
multiplyExponents  
multisect  
multiset  
multivariate  
multMonom  
musserTrials  
mvar  
myDegree  
nagCosInt  
nagDAiryAi  
nagDAiryBi  
nagDFT  
nagEigenvalues  
nagEigenvectors  
nagEllipticIntegralRC  
nagEllipticIntegralRD  
nagEllipticIntegralRF  
nagEllipticIntegralRJ  
nagErf  
nagErfC  
nagExpInt  
nagFresnelC  
nagFresnelS  
nagHankelH1  
nagHankelH2  
nagHermitianDFT  
nagHermitianInverseDFT  
nagIncompleteGammaP  
nagIncompleteGammaQ

nagInverseDFT  
nagKelvinBei  
nagKelvinBer  
nagKelvinKei  
nagKelvinKer  
nagMin  
nagPolygonIntegrate  
nagScaledDAiryAi  
nagScaledDAiryBi  
nagScaledHankelH1  
nagScaledHankelH2  
nagSinInt  
name  
nand  
nary?  
ncols  
negative?  
neglist  
new  
newLine  
newReduc  
newSubProgram  
newTypeLists  
next  
nextColeman  
nextIrreduciblePoly  
nextItem  
nextLatticePermutation  
nextNormalPoly  
nextNormalPrimitivePoly  
nextPartition  
nextPrime  
nextPrimitiveNormalPoly  
nextPrimitivePoly  
nextsoursResultant2  
nextSublist  
nextsubResultant2  
nextSubsetGray  
nil  
nilFactor  
nlde  
node  
node?  
nodeOf?  
nodes  
noKaratsuba  
noLinearFactor?  
noncommutativeJordanAlgebra?  
nonLinearPart  
nonQsign  
nonSingularModel  
nor  
norm  
normal

normal?  
normal01  
normalDenom  
normalDeriv  
normalElement  
normalForm  
normalise  
normalize  
normalizeAtInfinity  
normalized?  
normalizedAssociate  
normalizedDivide  
normalizeIfCan  
normDeriv2  
normFactors  
normInvertible?  
NOT  
Not  
not  
notelem  
npcoef  
nrows  
nsqfree  
nthCoef  
nthExpon  
nthExponent  
nthFactor  
nthFlag  
nthFractionalTerm  
nthr  
nthRoot  
nthRootIfCan  
Nul  
null  
null?  
nullary  
nullary?  
nullity  
nullSpace  
number?  
numberOfChildren  
numberOfComponents  
numberOfComposites  
numberOfComputedEntries  
numberOfCycles  
numberOfDivisors  
numberOfFactors  
numberOfFractionalTerms  
numberOfHues  
numberOfImproperPartitions  
numberOfIrreduciblePoly  
numberOfMonomials  
numberOfNormalPoly  
numberOfOperations

numberOfPrimitivePoly  
numberOfVariables  
numer  
numerator  
numerators  
numeric  
numericalIntegration  
numericalOptimization  
numericIfCan  
numFunEvals  
numFunEvals3D  
obj  
objectOf  
objects  
oblateSpheroidal  
ocf2ocdf  
octon  
odd?  
oddInfiniteProduct  
oddintegers  
oddlambert  
ode  
ode1  
ode2  
ODESolve  
OMbindTCP  
OMclose  
OMcloseConn  
OMconnectTCP  
OMconnInDevice  
OMconnOutDevice  
OMencodingBinary  
OMencodingSGML  
OMencodingUnknown  
OMencodingXML  
omError  
OMgetApp  
OMgetAtp  
OMgetAttr  
OMgetBind  
OMgetBVar  
OMgetEndApp  
OMgetEndAtp  
OMgetEndAttr  
OMgetEndBind  
OMgetEndBVar  
OMgetEndError  
OMgetEndObject  
OMgetError  
OMgetFloat  
OMgetInteger  
OMgetObject  
OMgetString  
OMgetSymbol

OMgetType  
OMgetVariable  
OMlistCDs  
OMlistSymbols  
OMmakeConn  
OMopenFile  
OMopenString  
OMParseError?  
OMputApp  
OMputAtp  
OMputAttr  
OMputBind  
OMputBVar  
OMputEndApp  
OMputEndAtp  
OMputEndAttr  
OMputEndBind  
OMputEndBVar  
OMputEndError  
OMputEndObject  
OMputError  
OMputFloat  
OMputInteger  
OMputObject  
OMputString  
OMputSymbol  
OMputVariable  
OMread  
OMReadError?  
OMreadFile  
OMreadStr  
OMreceive  
OMsend  
OMserve  
OMsetEncoding  
OMsupportsCD?  
OMsupportsSymbol?  
OMunhandledSymbol  
OMUnknownCD?  
OMUnknownSymbol?  
OMwrite  
one?  
oneDimensionalArray  
op  
open  
open?  
operation  
operator  
operators  
opeval  
optAttributes  
optimize  
option  
option?



optional  
optional?  
options  
optpair  
OR  
Or  
or  
orbit  
orbits  
ord  
order  
orthonormalBasis  
outerProduct  
outlineRender  
output  
outputArgs  
outputAsFortran  
outputAsScript  
outputAsTex  
outputFixed  
outputFloating  
outputForm  
outputGeneral  
outputList  
outputMeasure  
outputSpacing  
over  
overbar  
overlabel  
overlap  
overset?  
pack!  
packageCall  
packHS  
pade  
padece  
padiicallyExpand  
padiicFraction  
pair?  
palgextint  
palgextint0  
palginfieldint  
palgint  
palgint0  
palgintegrate  
palglimint  
palglimint0  
palgLODE  
palgLODE0  
palgRDE  
palgRDE0  
parabolic  
parabolicCylindrical  
paraboloidal

parametersOf  
parametric?  
ParCond  
ParCondList  
paren  
parent  
partialDenominators  
partialFraction  
partialNumerators  
partialQuotients  
particularSolution  
partition  
partitions  
parts  
pascalTriangle  
pastel  
pattern  
patternMatch  
patternMatchTimes  
patternVariable  
pdct  
PDESolve  
pdf2df  
pdf2ef  
perfectNthPower?  
perfectNthRoot  
perfectSqrt  
perfectSquare?  
permanent  
permutation  
permutationGroup  
permutationRepresentation  
permutations  
perspective  
phiCoord  
pHS  
physicalLength  
physicalLength!  
pi  
pile  
plenaryPower  
pleskenSplit  
plot  
plotPolar  
plus  
plus!  
plusInfinity  
pmComplexintegrate  
pmintegrate  
po  
point  
point?  
pointColor  
pointColorDefault

pointColorPalette  
pointData  
pointlist  
pointlist?  
pointLists  
pointPlot  
points  
pointSizeDefault  
poisson  
pol  
polar  
polarCoordinates  
polCase  
pole?  
PollardSmallFactor  
polygamma  
polygon  
polygon?  
polynomial  
polynomialZeros  
polyPart  
polyRDE  
polyred  
polyRicDE  
pomopo!  
pop!  
popFortranOutputStack  
position  
position!  
positive?  
positiveRemainder  
positiveSolve  
possiblyInfinite?  
possiblyNewVariety?  
postfix  
pow  
power  
power!  
powerAssociative?  
powern  
powers  
powerSum  
powmod  
pquo  
pr2dmp  
precision  
predicate  
predicates  
prefix  
prefix?  
prefixRagits  
prem  
prepareDecompose  
prepareSubResAlgo

preprocess  
presub  
presuper  
previous  
prevPrime  
primaryDecomp  
prime  
prime?  
primeFactor  
primeFrobenius  
primes  
primextendedint  
primextintfrac  
primintegrate  
primintfldpoly  
primitive?  
primitiveElement  
primitiveMonomials  
primitivePart  
primitivePart!  
primlimintfrac  
primlimitedint  
primPartElseUnitCanonical  
primPartElseUnitCanonical!  
prinb  
principal?  
principalIdeal  
prindINFO  
prinpolINFO  
prinshINFO  
print  
printCode  
printHeader  
printInfo  
printInfo!  
printingInfo?  
printStatement  
printStats!  
printTypes  
probablyZeroDim?  
problemPoints  
processTemplate  
prod  
product  
prolateSpheroidal  
prologue  
properties  
property  
pseudoDivide  
pseudoQuotient  
pseudoRemainder  
psolve  
ptFunc  
pToDmp

pToHdmp  
ptree  
puiseux  
pureLex  
purelyAlgebraic?  
purelyAlgebraicLeadingMonomial?  
purelyTranscendental?  
push!  
pushdown  
pushdterm  
pushFortranOutputStack  
pushucoef  
pushuconst  
pushup  
put!  
putColorInfo  
putGraph  
qelt  
qfactor  
qinterval  
qPot  
qqq  
qroot  
qsetelt!  
quadratic  
quadratic?  
quadraticForm  
quadraticNorm  
quartic  
quasiAlgebraicSet  
quasiComponent  
quasiMonic?  
quasiMonicPolynomials  
quasiRegular  
quasiRegular?  
quatern  
queue  
quickSort  
quickWrite  
quo  
quoByVar  
quote  
quoted?  
quotedOperators  
quotient  
quotientByP  
radical  
radicalEigenvalues  
radicalEigenvector  
radicalEigenvectors  
radicalOfLeftTraceForm  
radicalRoots  
radicalSimplify  
radicalSolve

radix  
radPoly  
raisePolynomial  
ramified?  
ramifiedAtInfinity?  
ran  
randnum  
random  
randomLC  
randomR  
range  
rangeIsFinite  
rangePascalTriangle  
ranges  
rank  
rarrow  
ratDenom  
ratDsolve  
rational  
rational?  
rationalApproximation  
rationalFunction  
rationalIfCan  
rationalPoint?  
rationalPoints  
rationalPower  
ratpart  
ratPoly  
ravel  
rCoord  
rdHack1  
rdregime  
read  
read!  
readable?  
readIfCan!  
readLine!  
readLineIfCan!  
real  
real?  
realEigenvalues  
realEigenvectors  
realElementary  
realRoots  
realSolve  
realZeros  
recip  
reciprocalPolynomial  
recolor  
recoverAfterFail  
rectangularMatrix  
recur  
red  
redmat

redPo  
redPol  
redpps  
reduce  
reduceBasisAtInfinity  
reduceByQuasiMonic  
reduced?  
reducedContinuedFraction  
reducedDiscriminant  
reducedForm  
reducedQPowers  
reducedSystem  
reduceLODE  
ReduceOrder  
reduction  
reductum  
ref  
refine  
regime  
region  
regularRepresentation  
reindex  
relationsIdeal  
relativeApprox  
relerror  
rem  
remainder  
RemainderList  
remove  
remove!  
removeConstantTerm  
removeCoshSq  
removeCosSq  
removeDuplicates  
removeDuplicates!  
removeIrreducibleRedundantFactors  
removeRedundantFactors  
removeRedundantFactorsInContents  
removeRedundantFactorsInPols  
removeRoughlyRedundantFactorsInContents  
removeRoughlyRedundantFactorsInPol  
removeRoughlyRedundantFactorsInPols  
removeSinhSq  
removeSinSq  
removeSquaresIfCan  
removeSuperfluousCases  
removeSuperfluousQuasiComponents  
removeZero  
removeZeroes  
rename  
rename!  
render  
renderToFile!  
reopen!

reorder  
repeating  
repeating?  
repeatUntilLoop  
replace  
replaceKthElement  
representationType  
represents  
repSq  
reseed  
reset  
reset!  
resetAttributeButtons  
resetBadValues  
resetNew  
resetVariableOrder  
reshape  
resize  
rest  
restorePrecision  
result  
resultant  
resultantEuclidean  
resultantEuclideanNaif  
resultantNaif  
resultantRedit  
resultantReditEuclidean  
retract  
retractable?  
retractIfCan  
returns  
returnType!  
returnTypeOf  
reverse  
reverse!  
reverseLex  
revert  
rewriteIdealWithHeadRemainder  
rewriteIdealWithQuasiMonicGenerators  
rewriteIdealWithRemainder  
rewriteSetByReducingWithParticularGenerators  
rewriteSetWithReduction  
RF2UTS  
rhs  
ricDsolve  
ridHack1  
right  
rightAlternative?  
rightCharacteristicPolynomial  
rightDiscriminant  
rightDivide  
rightExactQuotient  
rightExtendedGcd  
rightFactorCandidate



rightFactorIfCan  
rightGcd  
rightLcm  
rightMinimalPolynomial  
rightMult  
rightNorm  
rightOne  
rightPower  
rightQuotient  
rightRank  
rightRankPolynomial  
rightRecip  
rightRegularRepresentation  
rightRemainder  
rightScalarTimes!  
rightTrace  
rightTraceMatrix  
rightTrim  
rightUnit  
rightUnits  
rightZero  
rischDE  
rischDEsys  
rischNormalize  
RittWuCompare  
rk4  
rk4a  
rk4f  
rk4qc  
roman  
romberg  
rombergo  
root  
root?  
rootBound  
rootKerSimp  
rootNormalize  
rootOf  
rootOfIrreduciblePoly  
rootPoly  
rootPower  
rootProduct  
rootRadius  
rootSimp  
rootsOf  
rootSplit  
rotate  
rotate!  
rotatex  
rotatey  
rotatez  
roughBase?  
roughBasicSet  
roughEqualIdeals?

roughSubIdeal?  
roughUnitIdeal?  
round  
routines  
row  
rowEch  
rowEchelon  
rowEchelonLocal  
rowEchLocal  
rquo  
rroot  
rspace  
rst  
rubiksGroup  
rule  
rules  
ruleset  
rur  
s01eaf  
s13aaf  
s13acf  
s13adf  
s14aaf  
s14abf  
s14baf  
s15adf  
s15aef  
s17acf  
s17adf  
s17aef  
s17aff  
s17agf  
s17ahf  
s17ajf  
s17akf  
s17dcf  
s17def  
s17dgf  
s17dhf  
s17dlf  
s18acf  
s18adf  
s18aef  
s18aff  
s18dcf  
s18def  
s19aaf  
s19abf  
s19acf  
s19adf  
s20acf  
s20adf  
s21baf  
s21bbf

s21bcf  
s21bdf  
safeCeiling  
safeFloor  
safetyMargin  
sample  
satisfy?  
saturate  
save  
say  
sayLength  
scalarMatrix  
scalarTypeOf  
scale  
scaleRoots  
scan  
ScanArabic  
ScanFloatIgnoreSpaces  
ScanFloatIgnoreSpacesIfCan  
scanOneDimSubspaces  
ScanRoman  
schema  
schwerpunkt  
screenResolution  
screenResolution3D  
script  
scripted?  
scripts  
sdf2lst  
se2rfi  
search  
sec  
sec2cos  
sech  
sech2cosh  
sechIfCan  
secIfCan  
second  
seed  
SEGMENT  
segment  
select  
select!  
selectAndPolynomials  
selectFiniteRoutines  
selectfirst  
selectIntegrationRoutines  
selectMultiDimensionalRoutines  
selectNonFiniteRoutines  
selectODEIVPRoutines  
selectOptimizationRoutines  
selectOrPolynomials  
selectPDERoutines  
selectPolynomials

selectsecond  
selectSumOfSquaresRoutines  
semicolonSeparate  
semiDegreeSubResultantEuclidean  
semiDiscriminantEuclidean  
semiIndiceSubResultantEuclidean  
semiLastSubResultantEuclidean  
semiResultantEuclidean1  
semiResultantEuclidean2  
semiResultantEuclideannaif  
semiResultantReduitEuclidean  
semiSubResultantGcdEuclidean1  
semiSubResultantGcdEuclidean2  
separant  
separate  
separateDegrees  
separateFactors  
sequences  
series  
seriesSolve  
seriesToOutputForm  
set  
setAdaptive  
setAdaptive3D  
setAttributeButtonStep  
setButtonValue  
setchildren!  
setClipValue  
setClosed  
setColumn!  
setCondition!  
setDifference  
setelt  
setelt!  
setEmpty!  
setEpilogue!  
setErrorBound  
setFieldInfo  
setfirst!  
setFormula!  
setImagSteps  
setIntersection  
setLabelValue  
setlast!  
setleaves!  
setleft!  
setLegalFortranSourceExtensions  
setMaxPoints  
setMaxPoints3D  
setMinPoints  
setMinPoints3D  
setnext!  
setOfMinN  
setOrder

setPoly  
setPosition  
setPredicates  
setprevious!  
setPrologue!  
setProperty  
setProperty  
setRealSteps  
setref  
setrest!  
setright!  
setRow!  
setScreenResolution  
setScreenResolution3D  
setStatus  
setStatus!  
setsubMatrix!  
setTex!  
setTopPredicate  
setUnion  
setValue!  
setvalue!  
setVariableOrder  
SFunction  
sh  
shade  
shallowCopy  
shallowExpand  
shanksDiscLogAlgorithm  
shellSort  
shift  
shiftLeft  
shiftRight  
shiftRoots  
show  
showAll?  
showAllElements  
showArrayValues  
showAttributes  
showClipRegion  
showFortranOutputStack  
showIntensityFunctions  
showRegion  
showScalarValues  
showTheFTable  
showTheIFTable  
showTheRoutinesTable  
showTheSymbolTable  
showTypeInOut  
shrinkable  
shuffle  
shufflein  
Si  
sign

signAround  
simpleBounds?  
simplify  
simplifyExp  
simplifyLog  
simplifyPower  
simpson  
simpsono  
sin  
sin?  
sin2csc  
sincos  
singleFactorBound  
singRicDE  
singular?  
singularAtInfinity?  
singularitiesOf  
sinh  
sinh2csch  
sinhcosh  
sinhIfCan  
sinIfCan  
size  
size?  
sizeLess?  
sizeMultiplication  
sizePascalTriangle  
skewSFunction  
slash  
slex  
smith  
sn  
sncndn  
socf2socdf  
solid  
solid?  
solve  
solve1  
solveid  
solveInField  
solveLinear  
solveLinearlyOverQ  
solveLinearPolynomialEquation  
solveLinearPolynomialEquationByFractions  
solveLinearPolynomialEquationByRecursion  
solveRetract  
someBasis  
sort  
sort!  
sortConstraints  
sorted?  
space  
sparsityIF  
specialTrigs

```

spherical
split
split!
splitConstant
splitDenominator
splitLinear
splitNodeOf!
splitSquarefree
sPol
sqfree
sqfrFactor
sqrt
square?
squareFree
squareFreeFactors
squareFreeLexTriangular
squareFreePart
squareFreePolynomial
squareFreePrim
squareMatrix
squareTop
stack
standardBasisOfCyclicSubmodule
start!
startPolynomial
startStats!
startTable!
startTableGcd!
startTableInvSet!
status
stFunc1
stFunc2
stFuncN
stiffnessAndStabilityFactor
stiffnessAndStabilityOfODEIF
stirling1
stirling2
stop
stop!
stopMusserTrials
stopTable!
stopTableGcd!
stopTableInvSet!
stoseIntegralLastSubResultant
stoseInternalLastSubResultant
stoseInvertible?
stoseInvertible?reg
stoseInvertibleSet
stoseInvertibleSetreg
stoseInvertibleSetsqfreg
stoseInvertible?sqfreg
stoseLastSubResultant
stosePrepareSubResAlgo
stoseSquareFreePart

```

string  
string?  
stripCommentsAndBlanks  
strongGenerators  
stronglyReduce  
stronglyReduced?  
structuralConstants  
sts2stst  
SturmHabicht  
SturmHabichtCoefficients  
SturmHabichtMultiple  
SturmHabichtSequence  
sturmSequence  
sturmVariationsOf  
style  
sub  
subCase?  
subHeight  
subMatrix  
submod  
subNode?  
subNodeOf?  
subPolSet?  
subQuasiComponent?  
subResultantChain  
subResultantGcd  
subResultantGcdEuclidean  
subResultantsChain  
subresultantSequence  
subresultantVector  
subscript  
subscriptedVariables  
subSet  
subset?  
subspace  
subst  
substitute  
substring?  
subtractIfCan  
subTriSet?  
suchThat  
suffix?  
sum  
summation  
sumOfDivisors  
sumOfKthPowerDivisors  
sumOfSquares  
sumSquares  
sup  
supDimElseRittWu?  
super  
superHeight  
superscript  
supersub



supRittWu?  
surface  
swap  
swap!  
swapColumns!  
swapRows!  
sylvesterMatrix  
sylvesterSequence  
symbol  
symbol?  
symbolIfCan  
symbolTable  
symbolTableOf  
symFunc  
symmetric?  
symmetricDifference  
symmetricGroup  
symmetricPower  
symmetricProduct  
symmetricRemainder  
symmetricSquare  
symmetricTensors  
systemCommand  
systemSizeIF  
t  
tab  
tab1  
table  
tableau  
tableForDiscreteLogarithm  
tablePow  
tail  
tan  
tan2cot  
tan2trig  
tanAn  
tanh  
tanh2coth  
tanh2trigh  
tanhIfCan  
tanIfCan  
tanintegrate  
tanNa  
tanQ  
tanSum  
taylor  
taylorIfCan  
taylorQuoByVar  
taylorRep  
tensorProduct  
terms  
test  
testDim  
testModulus

tex  
thetaCoord  
third  
timer  
times  
times!  
title  
top  
top!  
topFortranOutputStack  
topPredicate  
toroidal  
torsion?  
torsionIfCan  
toScale  
toseInvertible?  
toseInvertibleSet  
toseLastSubResultant  
toseSquareFreePart  
totalDegree  
totalDifferential  
totalfract  
totalGroebner  
totalLex  
totolex  
tower  
trace  
trace2PowMod  
traceMatrix  
tracePowMod  
trailingCoefficient  
tRange  
transcendenceDegree  
transcendent?  
transcendentalDecompose  
transform  
translate  
transpose  
trapezoidal  
trapezoidalO  
traverse  
tree  
triangSolve  
triangular?  
triangularSystems  
triangulate  
trigs  
trigs2explogs  
trim  
trivialIdeal?  
true  
trueEqual  
trunc  
truncate

tryFunctionalDecomposition  
tryFunctionalDecomposition?  
tube  
tubePlot  
tubePoints  
tubePointsDefault  
tubeRadius  
tubeRadiusDefault  
tValues  
twist  
twoFactor  
typeList  
typeLists  
unary?  
unaryFunction  
uncouplingMatrices  
unexpand  
uniform  
uniform01  
union  
uniqueID  
unit  
unit?  
unitCanonical  
unitNormal  
unitNormalize  
units  
unitsColorDefault  
unitVector  
univariate  
univariate?  
univariatePolynomial  
univariatePolynomials  
univariatePolynomialsGcds  
univariateSolve  
univcase  
universe  
unmakeSUP  
unparse  
unprotectedRemoveRedundantFactors  
unrankImproperPartitions0  
unrankImproperPartitions1  
unravel  
untab  
UnVectorise  
unvectorise  
UP2ifCan  
UP2UTS  
updatD  
update  
upDateBranches  
updateStatus!  
updatF  
upperCase

upperCase!  
upperCase?  
UpTriBddDenomInv  
useEisensteinCriterion  
useEisensteinCriterion?  
useNagFunctions  
userOrdered?  
useSingleFactorBound  
useSingleFactorBound?  
usingTable?  
UTS2UP  
validExponential  
value  
var1Steps  
var1StepsDefault  
var2Steps  
var2StepsDefault  
variable  
variables  
variationOfParameters  
vark  
varList  
varselect  
vconcat  
vector  
Vectorise  
vectorise  
vedf2vef  
vertConcat  
viewDefaults  
viewDeltaXDefault  
viewDeltaYDefault  
viewPhiDefault  
viewpoint  
viewport2D  
viewport3D  
viewPosDefault  
viewSizeDefault  
viewThetaDefault  
viewWriteAvailable  
viewWriteDefault  
viewZoomDefault  
virtualDegree  
void  
vput!  
vspace  
vstart!  
walkTree  
weakBiRank  
weierstrass  
weight  
weighted  
weights  
whatInfinity

```

whileLoop
wholePart
wholeRadix
wholeRagits
width
withPredicates
wordInGenerators
wordInStrongGenerators
wordsForStrongGenerators
wreath
writable?
write
write!
writeLine!
wronskianMatrix
wrregime
xCoord
xn
xor
xRange
Y
yCoord
yCoordinates
yellow
youngGroup
yRange
zag
zCoord
zero
zero?
zeroDim?
zeroDimensional?
zeroDimPrimary?
zeroDimPrime?
zeroMatrix
zeroOf
zeroSetSplit
zeroSetSplitIntoTriangularSystems
zerosOf
zeroSquareMatrix
zeroVector
zoom
zRange
AbelianGroup
AbelianMonoid
AbelianMonoidRing
AbelianSemiGroup
Aggregate
Algebra
AlgebraicallyClosedField
AlgebraicallyClosedFunctionSpace
ArcHyperbolicFunctionCategory
ArcTrigonometricFunctionCategory
AssociationListAggregate

```

AttributeRegistry  
BagAggregate  
BasicType  
BiModule  
BinaryRecursiveAggregate  
BinaryTreeCategory  
BitAggregate  
CachableSet  
CancellationAbelianMonoid  
CharacteristicNonZero  
CharacteristicZero  
CoercibleTo  
Collection  
CombinatorialFunctionCategory  
CombinatorialOpsCategory  
CommutativeRing  
ComplexCategory  
ConvertibleTo  
DequeueAggregate  
Dictionary  
DictionaryOperations  
DifferentialExtension  
DifferentialPolynomialCategory  
DifferentialRing  
DifferentialVariableCategory  
DirectProductCategory  
DivisionRing  
DoublyLinkedAggregate  
ElementaryFunctionCategory  
Eltable  
EltableAggregate  
EntireRing  
EuclideanDomain  
Evalable  
ExpressionSpace  
ExtensibleLinearAggregate  
ExtensionField  
Field  
FieldOfPrimeCharacteristic  
FileCategory  
FileNameCategory  
Finite  
FiniteAbelianMonoidRing  
FiniteAlgebraicExtensionField  
FiniteDivisorCategory  
FiniteFieldCategory  
FiniteLinearAggregate  
FiniteRankAlgebra  
FiniteRankNonAssociativeAlgebra  
FiniteSetAggregate  
FloatingPointSystem  
FortranFunctionCategory  
FortranMachineTypeCategory  
FortranMatrixCategory

FortranMatrixFunctionCategory  
FortranProgramCategory  
FortranVectorCategory  
FortranVectorFunctionCategory  
FramedAlgebra  
FramedNonAssociativeAlgebra  
FreeAbelianMonoidCategory  
FreeLieAlgebra  
FreeModuleCat  
FullyEvaluableOver  
FullyLinearlyExplicitRingOver  
FullyPatternMatchable  
FullyRetractableTo  
FunctionFieldCategory  
FunctionSpace  
GcdDomain  
GradedAlgebra  
GradedModule  
Group  
HomogeneousAggregate  
HyperbolicFunctionCategory  
IndexedAggregate  
IndexedDirectProductCategory  
InnerEvaluable  
IntegerNumberSystem  
IntegralDomain  
IntervalCategory  
IVLeafNodeCategory  
IVNodeCategory  
KeyedDictionary  
LazyStreamAggregate  
LeftAlgebra  
LeftModule  
LieAlgebra  
LinearAggregate  
LinearlyExplicitRingOver  
LinearOrdinaryDifferentialOperatorCategory  
LiouvillianFunctionCategory  
ListAggregate  
Logic  
MatrixCategory  
Module  
Monad  
MonadWithUnit  
MonogenicAlgebra  
MonogenicLinearOperator  
Monoid  
MultiDictionary  
MultisetAggregate  
MultivariateTaylorSeriesCategory  
NonAssociativeAlgebra  
NonAssociativeRing  
NonAssociativeRng  
NormalizedTriangularSetCategory

NumericalIntegrationCategory  
NumericalOptimizationCategory  
OctonionCategory  
OneDimensionalArrayAggregate  
OpenMath  
OrderedAbelianGroup  
OrderedAbelianMonoid  
OrderedAbelianMonoidSup  
OrderedAbelianSemiGroup  
OrderedCancellationAbelianMonoid  
OrderedFinite  
OrderedIntegralDomain  
OrderedMonoid  
OrderedMultisetAggregate  
OrderedRing  
OrderedSet  
OrdinaryDifferentialEquationsSolverCategory  
PAdicIntegerCategory  
PartialDifferentialEquationsSolverCategory  
PartialDifferentialRing  
PartialTranscendentalFunctions  
Patternable  
PatternMatchable  
PermutationCategory  
PlottablePlaneCurveCategory  
PlottableSpaceCurveCategory  
PointCategory  
PolynomialCategory  
PolynomialFactorizationExplicit  
PolynomialSetCategory  
PowerSeriesCategory  
PrimitiveFunctionCategory  
PrincipalIdealDomain  
PriorityQueueAggregate  
QuaternionCategory  
QueueAggregate  
QuotientFieldCategory  
RadicalCategory  
RealClosedField  
RealConstant  
RealNumberSystem  
RealRootCharacterizationCategory  
RectangularMatrixCategory  
RecursiveAggregate  
RecursivePolynomialCategory  
RegularTriangularSetCategory  
RetractableTo  
RightModule  
Ring  
Rng  
SegmentCategory  
SegmentExpansionCategory  
SemiGroup  
SetAggregate



SetCategory  
SExpressionCategory  
SpecialFunctionCategory  
SquareFreeNormalizedTriangularSetCategory  
SquareFreeRegularTriangularSetCategory  
SquareMatrixCategory  
StackAggregate  
StepThrough  
StreamAggregate  
StringAggregate  
StringCategory  
TableAggregate  
ThreeSpaceCategory  
TranscendentalFunctionCategory  
TriangularSetCategory  
TrigonometricFunctionCategory  
TwoDimensionalArrayCategory  
Type  
UnaryRecursiveAggregate  
UniqueFactorizationDomain  
UnivariateLaurentSeriesCategory  
UnivariateLaurentSeriesConstructorCategory  
UnivariatePolynomialCategory  
UnivariatePowerSeriesCategory  
UnivariatePuisseuxSeriesCategory  
UnivariatePuisseuxSeriesConstructorCategory  
UnivariateSkewPolynomialCategory  
UnivariateTaylorSeriesCategory  
VectorCategory  
VectorSpace  
XAlgebra  
XFreeAlgebra  
XPolynomialsCat  
AlgebraGivenByStructuralConstants  
AlgebraicFunctionField  
AlgebraicNumber  
AnonymousFunction  
AntiSymm  
Any  
ArrayStack  
Asp1  
Asp10  
Asp12  
Asp19  
Asp20  
Asp24  
Asp27  
Asp28  
Asp29  
Asp30  
Asp31  
Asp33  
Asp34  
Asp35

Asp4  
Asp41  
Asp42  
Asp49  
Asp50  
Asp55  
Asp6  
Asp7  
Asp73  
Asp74  
Asp77  
Asp78  
Asp8  
Asp80  
Asp9  
AssociatedJordanAlgebra  
AssociatedLieAlgebra  
AssociationList  
AttributeButtons  
Automorphism  
BalancedBinaryTree  
BalancedPAdicInteger  
BalancedPAdicRational  
BasicFunctions  
BasicOperator  
BinaryExpansion  
BinaryFile  
BinarySearchTree  
BinaryTournament  
BinaryTree  
Bits  
Boolean  
CardinalNumber  
CartesianTensor  
Character  
CharacterClass  
CliffordAlgebra  
Color  
Commutator  
Complex  
ContinuedFraction  
d01ajfAnnaType  
d01akfAnnaType  
d01alfAnnaType  
d01amfAnnaType  
d01anfAnnaType  
d01apfAnnaType  
d01aqfAnnaType  
d01asfAnnaType  
d01fcfAnnaType  
d01gbfAnnaType  
d01TransformFunctionType  
d02bbfAnnaType  
d02bhfAnnaType

d02cjfAnnaType  
d02ejfAnnaType  
d03eefAnnaType  
d03fafAnnaType  
Database  
DataList  
DecimalExpansion  
DenavitHartenbergMatrix  
Dequeue  
DeRhamComplex  
DifferentialSparseMultivariatePolynomial  
DirectProduct  
DirectProductMatrixModule  
DirectProductModule  
DistributedMultivariatePolynomial  
DoubleFloat  
DrawOption  
e04dgfAnnaType  
e04fdfAnnaType  
e04gcfAnnaType  
e04jafAnnaType  
e04mbfAnnaType  
e04nafAnnaType  
e04ucfAnnaType  
ElementaryFunctionsUnivariateLaurentSeries  
ElementaryFunctionsUnivariatePuisseuxSeries  
Enumeration  
EqTable  
Equation  
EuclideanModularRing  
Exit  
ExponentialExpansion  
ExponentialOfUnivariatePuisseuxSeries  
Expression  
ExtAlgBasis  
Factored  
File  
FileName  
FiniteDivisor  
FiniteField  
FiniteFieldCyclicGroup  
FiniteFieldCyclicGroupExtension  
FiniteFieldCyclicGroupExtensionByPolynomial  
FiniteFieldExtension  
FiniteFieldExtensionByPolynomial  
FiniteFieldNormalBasis  
FiniteFieldNormalBasisExtension  
FiniteFieldNormalBasisExtensionByPolynomial  
FlexibleArray  
Float  
FormalFraction  
FortranCode  
FortranExpression  
FortranProgram

FortranScalarType  
FortranTemplate  
FortranType  
FourierComponent  
FourierSeries  
Fraction  
FractionalIdeal  
FramedModule  
FreeAbelianGroup  
FreeAbelianMonoid  
FreeGroup  
FreeModule  
FreeModule1  
FreeMonoid  
FreeNilpotentLie  
FullPartialFractionExpansion  
FunctionCalled  
GeneralDistributedMultivariatePolynomial  
GeneralModulePolynomial  
GeneralPolynomialSet  
GeneralSparseTable  
GeneralTriangularSet  
GeneralUnivariatePowerSeries  
GenericNonAssociativeAlgebra  
GraphImage  
HashTable  
Heap  
HexadecimalExpansion  
HomogeneousDirectProduct  
HomogeneousDistributedMultivariatePolynomial  
HyperellipticFiniteDivisor  
IndexCard  
IndexedBits  
IndexedDirectProductAbelianGroup  
IndexedDirectProductAbelianMonoid  
IndexedDirectProductObject  
IndexedDirectProductOrderedAbelianMonoid  
IndexedDirectProductOrderedAbelianMonoidSup  
IndexedExponents  
IndexedFlexibleArray  
IndexedList  
IndexedMatrix  
IndexedOneDimensionalArray  
IndexedString  
IndexedTwoDimensionalArray  
IndexedVector  
InfiniteTuple  
InnerAlgebraicNumber  
InnerFiniteField  
InnerFreeAbelianMonoid  
InnerIndexedTwoDimensionalArray  
InnerPAdicInteger  
InnerPrimeField  
InnerSparseUnivariatePowerSeries

InnerTable  
InnerTaylorSeries  
InputForm  
Integer  
IntegerMod  
IntegrationFunctionsTable  
IntegrationResult  
Interval  
InventorDataSink  
InventorRenderPackage  
InventorViewPort  
IVBaseColor  
IVBasicNode  
IVCoordinate3  
IVCoordinate4  
IVFaceSet  
IVField  
IVGroup  
IVIndexedLineSet  
IVNodeConnection  
IVNodeObject  
IVPointSet  
IVQuadMesh  
IVSeparator  
IVSimpleInnerNode  
IVUtilities  
IVValue  
Kernel  
KeyedAccessFile  
LaurentPolynomial  
Library  
LieExponentials  
LiePolynomial  
LieSquareMatrix  
LinearOrdinaryDifferentialOperator  
LinearOrdinaryDifferentialOperator1  
LinearOrdinaryDifferentialOperator2  
List  
ListMonoidOps  
ListMultiDictionary  
LocalAlgebra  
Localize  
LyndonWord  
MachineComplex  
MachineFloat  
MachineInteger  
Magma  
MakeCachableSet  
Mapping  
Matrix  
ModMonic  
ModularField  
ModularRing  
ModuleMonomial

ModuleOperator  
MoebiusTransform  
MonoidRing  
Multiset  
MultivariatePolynomial  
NagDiscreteFourierTransformInterfacePackage  
NagEigenInterfacePackage  
NagOptimisationInterfacePackage  
NagQuadratureInterfacePackage  
NagResultChecks  
NagSpecialFunctionsInterfacePackage  
NewSparseMultivariatePolynomial  
NewSparseUnivariatePolynomial  
None  
NonNegativeInteger  
NumericalIntegrationProblem  
NumericalODEProblem  
NumericalOptimizationProblem  
NumericalPDEProblem  
Octonion  
ODEIntensityFunctionsTable  
OneDimensionalArray  
OnePointCompletion  
OpenMathConnection  
OpenMathDevice  
OpenMathEncoding  
OpenMathError  
OpenMathErrorKind  
Operator  
OppositeMonogenicLinearOperator  
OrderedCompletion  
OrderedDirectProduct  
OrderedFreeMonoid  
OrderedVariableList  
OrderlyDifferentialPolynomial  
OrderlyDifferentialVariable  
OrdinaryDifferentialRing  
OrdinaryWeightedPolynomials  
OrdSetInts  
OutputForm  
PackedHermitianSequence  
PAdicInteger  
PAdicRational  
PAdicRationalConstructor  
Palette  
ParametricPlaneCurve  
ParametricSpaceCurve  
ParametricSurface  
PartialFraction  
Partition  
Pattern  
PatternMatchListResult  
PatternMatchResult  
PendantTree

Permutation  
PermutationGroup  
Pi  
PlaneAlgebraicCurvePlot  
Plot  
Plot3D  
PoincareBirkhoffWittLyndonBasis  
Point  
Polynomial  
PolynomialIdeals  
PolynomialRing  
PositiveInteger  
PrimeField  
PrimitiveArray  
Product  
QuadraticForm  
QuasiAlgebraicSet  
Quaternion  
QueryEquation  
Queue  
RadicalFunctionField  
RadixExpansion  
RealClosure  
Record  
RectangularMatrix  
Reference  
RegularChain  
RegularTriangularSet  
RenderTools  
ResidueRing  
Result  
RewriteRule  
RightOpenIntervalRootCharacterization  
RomanNumeral  
RoutinesTable  
RuleCalled  
Ruleset  
ScriptFormulaFormat  
Segment  
SegmentBinding  
SequentialDifferentialPolynomial  
SequentialDifferentialVariable  
Set  
SetOfMIntegersInOneToN  
SExpression  
SExpressionOf  
SimpleAlgebraicExtension  
SimpleFortranProgram  
SingleInteger  
SingletonAsOrderedSet  
SparseMultivariatePolynomial  
SparseMultivariateTaylorSeries  
SparseTable  
SparseUnivariateLaurentSeries

SparseUnivariatePolynomial  
SparseUnivariatePuisseuxSeries  
SparseUnivariateSkewPolynomial  
SparseUnivariateTaylorSeries  
SplitHomogeneousDirectProduct  
SplittingNode  
SplittingTree  
SquareFreeRegularTriangularSet  
SquareMatrix  
Stack  
Stream  
String  
StringTable  
SubSpace  
SubSpaceComponentProperty  
SuchThat  
Switch  
Symbol  
SymbolTable  
SymmetricPolynomial  
Table  
Tableau  
TaylorSeries  
TexFormat  
TextFile  
TheSymbolTable  
ThreeDimensionalMatrix  
ThreeDimensionalViewport  
ThreeSpace  
Timer  
Tree  
TubePlot  
Tuple  
TwoDimensionalArray  
TwoDimensionalViewport  
Union  
UnivariateLaurentSeries  
UnivariateLaurentSeriesConstructor  
UnivariatePolynomial  
UnivariatePuisseuxSeries  
UnivariatePuisseuxSeriesConstructor  
UnivariatePuisseuxSeriesWithExponentialSingularity  
UnivariateSkewPolynomial  
UnivariateTaylorSeries  
UniversalSegment  
Variable  
Vector  
Void  
WeightedPolynomials  
WuWenTsunTriangularSet  
XDistributedPolynomial  
XPBWPolynomial  
XPolynomial  
XPolynomialRing



XRecursivePolynomial  
AlgebraicFunction  
AlgebraicHermiteIntegration  
AlgebraicIntegrate  
AlgebraicIntegration  
AlgebraicManipulations  
AlgebraicMultFact  
AlgebraPackage  
AlgFactor  
AnnaNumericalIntegrationPackage  
AnnaNumericalOptimizationPackage  
AnnaOrdinaryDifferentialEquationPackage  
AnnaPartialDifferentialEquationPackage  
AnyFunctions1  
ApplyRules  
ApplyUnivariateSkewPolynomial  
AssociatedEquations  
AttachPredicates  
BalancedFactorisation  
BasicOperatorFunctions1  
BezoutMatrix  
BoundIntegerRoots  
BrillhartTests  
CartesianTensorFunctions2  
ChangeOfVariable  
CharacteristicPolynomialInMonogenicalAlgebra  
CharacteristicPolynomialPackage  
ChineseRemainderToolsForIntegralBases  
CoerceVectorMatrixPackage  
CombinatorialFunction  
CommonDenominator  
CommonOperators  
CommuteUnivariatePolynomialCategory  
ComplexFactorization  
ComplexFunctions2  
ComplexIntegerSolveLinearPolynomialEquation  
ComplexPattern  
ComplexPatternMatch  
ComplexRootFindingPackage  
ComplexRootPackage  
ComplexTrigonometricManipulations  
ConstantLODE  
CoordinateSystems  
CRApackage  
CycleIndicators  
CyclicStreamTools  
CyclotomicPolynomialPackage  
d01AgentsPackage  
d01WeightsPackage  
d02AgentsPackage  
d03AgentsPackage  
DefiniteIntegrationTools  
DegreeReductionPackage  
DiophantineSolutionPackage

DirectProductFunctions2  
DiscreteLogarithmPackage  
DisplayPackage  
DistinctDegreeFactorize  
DoubleFloatSpecialFunctions  
DoubleResultantPackage  
DrawComplex  
DrawNumericHack  
DrawOptionFunctions0  
DrawOptionFunctions1  
e04AgentsPackage  
EigenPackage  
ElementaryFunction  
ElementaryFunctionDefiniteIntegration  
ElementaryFunctionLODESolver  
ElementaryFunctionODESolver  
ElementaryFunctionSign  
ElementaryFunctionStructurePackage  
ElementaryIntegration  
ElementaryRischDE  
ElementaryRischDESystem  
EllipticFunctionsUnivariateTaylorSeries  
EquationFunctions2  
ErrorFunctions  
EuclideanGroebnerBasisPackage  
EvaluateCycleIndicators  
ExpertSystemContinuityPackage  
ExpertSystemContinuityPackage1  
ExpertSystemToolsPackage  
ExpertSystemToolsPackage1  
ExpertSystemToolsPackage2  
ExpressionFunctions2  
ExpressionSpaceFunctions1  
ExpressionSpaceFunctions2  
ExpressionSpaceODESolver  
ExpressionToOpenMath  
ExpressionToUnivariatePowerSeries  
ExpressionTubePlot  
FactoredFunctions  
FactoredFunctions2  
FactoredFunctionUtilities  
FactoringUtilities  
FGLMIfCanPackage  
FindOrderFinite  
FiniteDivisorFunctions2  
FiniteFieldFunctions  
FiniteFieldHomomorphisms  
FiniteFieldPolynomialPackage  
FiniteFieldPolynomialPackage2  
FiniteFieldSolveLinearPolynomialEquation  
FiniteLinearAggregateFunctions2  
FiniteLinearAggregateSort  
FiniteSetAggregateFunctions2  
FloatingComplexPackage

FloatingRealPackage  
 FortranCodePackage1  
 FortranOutputStackPackage  
 FortranPackage  
 FractionalIdealFunctions2  
 FractionFunctions2  
 FramedNonAssociativeAlgebraFunctions2  
 FunctionalSpecialFunction  
 FunctionFieldCategoryFunctions2  
 FunctionFieldIntegralBasis  
 FunctionSpaceAssertions  
 FunctionSpaceAttachPredicates  
 FunctionSpaceComplexIntegration  
 FunctionSpaceFunctions2  
 FunctionSpaceIntegration  
 FunctionSpacePrimitiveElement  
 FunctionSpaceReduce  
 FunctionSpaceSum  
 FunctionSpaceToExponentialExpansion  
 FunctionSpaceToUnivariatePowerSeries  
 FunctionSpaceUnivariatePolynomialFactor  
 GaloisGroupFactorizationUtilities  
 GaloisGroupFactorizer  
 GaloisGroupPolynomialUtilities  
 GaloisGroupUtilities  
 GaussianFactorizationPackage  
 GeneralHenselPackage  
 GeneralizedMultivariateFactorize  
 GeneralPolynomialGcdPackage  
 GenerateUnivariatePowerSeries  
 GenExEuclid  
 GenUFactorize  
 GenusZeroIntegration  
 GosperSummationMethod  
 GraphicsDefaults  
 GrayCode  
 GroebnerFactorizationPackage  
 GroebnerInternalPackage  
 GroebnerPackage  
 GroebnerSolve  
 HallBasis  
 HeuGcd  
 IdealDecompositionPackage  
 IncrementingMaps  
 InfiniteProductCharacteristicZero  
 InfiniteProductFiniteField  
 InfiniteProductPrimeField  
 InfiniteTupleFunctions2  
 InfiniteTupleFunctions3  
 Infinity  
 InnerAlgFactor  
 InnerCommonDenominator  
 InnerMatrixLinearAlgebraFunctions  
 InnerMatrixQuotientFieldFunctions

InnerModularGcd  
InnerMultFact  
InnerNormalBasisFieldFunctions  
InnerNumericEigenPackage  
InnerNumericFloatSolvePackage  
InnerPolySign  
InnerPolySum  
InnerTrigonometricManipulations  
InputFormFunctions1  
IntegerBits  
IntegerCombinatoricFunctions  
IntegerFactorizationPackage  
IntegerLinearDependence  
IntegerNumberTheoryFunctions  
IntegerPrimesPackage  
IntegerRetractions  
IntegerRoots  
IntegerSolveLinearPolynomialEquation  
IntegralBasisPolynomialTools  
IntegralBasisTools  
IntegrationResultFunctions2  
IntegrationResultRFToFunction  
IntegrationResultToFunction  
IntegrationTools  
InternalPrintPackage  
InternalRationalUnivariateRepresentationPackage  
InverseLaplaceTransform  
IrredPolyOverFiniteField  
IrrRepSymNatPackage  
KernelFunctions2  
Kovacic  
LaplaceTransform  
LazardSetSolvingPackage  
LeadingCoefDetermination  
LexTriangularPackage  
LinearDependence  
LinearOrdinaryDifferentialOperatorFactorizer  
LinearOrdinaryDifferentialOperatorsOps  
LinearPolynomialEquationByFractions  
LinearSystemMatrixPackage  
LinearSystemMatrixPackage1  
LinearSystemPolynomialPackage  
LinGroebnerPackage  
LiouvillianFunction  
ListFunctions2  
ListFunctions3  
ListToMap  
MakeBinaryCompiledFunction  
MakeFloatCompiledFunction  
MakeFunction  
MakeRecord  
MakeUnaryCompiledFunction  
MappingPackage1  
MappingPackage2

MappingPackage3  
 MappingPackageInternalHacks1  
 MappingPackageInternalHacks2  
 MappingPackageInternalHacks3  
 MatrixCategoryFunctions2  
 MatrixCommonDenominator  
 MatrixLinearAlgebraFunctions  
 MergeThing  
 MeshCreationRoutinesForThreeDimensions  
 ModularDistinctDegreeFactorizer  
 ModularHermitianRowReduction  
 MonoidRingFunctions2  
 MonomialExtensionTools  
 MoreSystemCommands  
 MPolyCatFunctions2  
 MPolyCatFunctions3  
 MPolyCatPolyFactorizer  
 MPolyCatRationalFunctionFactorizer  
 MRationalFactorize  
 MultFiniteFactorize  
 MultipleMap  
 MultiVariableCalculusFunctions  
 MultivariateFactorize  
 MultivariateLifting  
 MultivariateSquareFree  
 NagEigenPackage  
 NagFittingPackage  
 NagIntegrationPackage  
 NagInterpolationPackage  
 NagLapack  
 NagLinearEquationSolvingPackage  
 NAGLinkSupportPackage  
 NagMatrixOperationsPackage  
 NagOptimisationPackage  
 NagOrdinaryDifferentialEquationsPackage  
 NagPartialDifferentialEquationsPackage  
 NagPolynomialRootsPackage  
 NagRootFindingPackage  
 NagSeriesSummationPackage  
 NagSpecialFunctionsPackage  
 NewSparseUnivariatePolynomialFunctions2  
 NonCommutativeOperatorDivision  
 NoneFunctions1  
 NonLinearFirstOrderODESolver  
 NonLinearSolvePackage  
 NormalizationPackage  
 NormInMonogenicAlgebra  
 NormRetractPackage  
 NPCoef  
 NumberFieldIntegralBasis  
 NumberFormats  
 NumberTheoreticPolynomialFunctions  
 Numeric  
 NumericalOrdinaryDifferentialEquations

NumericalQuadrature  
NumericComplexEigenPackage  
NumericContinuedFraction  
NumericRealEigenPackage  
NumericTubePlot  
OctonionCategoryFunctions2  
ODEIntegration  
ODETools  
OneDimensionalArrayFunctions2  
OnePointCompletionFunctions2  
OpenMathPackage  
OpenMathServerPackage  
OperationsQuery  
OrderedCompletionFunctions2  
OrderingFunctions  
OrthogonalPolynomialFunctions  
OutputPackage  
PadeApproximantPackage  
PadeApproximants  
PAdicWildFunctionFieldIntegralBasis  
ParadoxicalCombinatorsForStreams  
ParametricLinearEquations  
ParametricPlaneCurveFunctions2  
ParametricSpaceCurveFunctions2  
ParametricSurfaceFunctions2  
PartialFractionPackage  
PartitionsAndPermutations  
PatternFunctions1  
PatternFunctions2  
PatternMatch  
PatternMatchAssertions  
PatternMatchFunctionSpace  
PatternMatchIntegerNumberSystem  
PatternMatchIntegration  
PatternMatchKernel  
PatternMatchListAggregate  
PatternMatchPolynomialCategory  
PatternMatchPushDown  
PatternMatchQuotientFieldCategory  
PatternMatchResultFunctions2  
PatternMatchSymbol  
PatternMatchTools  
Permanent  
PermutationGroupExamples  
PiCoercions  
PlotFunctions1  
PlotTools  
PointFunctions2  
PointPackage  
PointsOfFiniteOrder  
PointsOfFiniteOrderRational  
PointsOfFiniteOrderTools  
PolToPol  
PolyGroebner

PolynomialAN2Expression  
PolynomialCategoryLifting  
PolynomialCategoryQuotientFunctions  
PolynomialComposition  
PolynomialDecomposition  
PolynomialFactorizationByRecursion  
PolynomialFactorizationByRecursionUnivariate  
PolynomialFunctions2  
PolynomialGcdPackage  
PolynomialInterpolation  
PolynomialInterpolationAlgorithms  
PolynomialNumberTheoryFunctions  
PolynomialRoots  
PolynomialSetUtilitiesPackage  
PolynomialSolveByFormulas  
PolynomialSquareFree  
PolynomialToUnivariatePolynomial  
PowerSeriesLimitPackage  
PrecomputedAssociatedEquations  
PrimitiveArrayFunctions2  
PrimitiveElement  
PrimitiveRatDE  
PrimitiveRatRicDE  
PrintPackage  
PseudoLinearNormalForm  
PseudoRemainderSequence  
PureAlgebraicIntegration  
PureAlgebraicLODE  
PushVariables  
QuasiAlgebraicSet2  
QuasiComponentPackage  
QuaternionCategoryFunctions2  
QuotientFieldCategoryFunctions2  
RadicalEigenPackage  
RadicalSolvePackage  
RadixUtilities  
RandomDistributions  
RandomFloatDistributions  
RandomIntegerDistributions  
RandomNumberSource  
RationalFactorize  
RationalFunction  
RationalFunctionDefiniteIntegration  
RationalFunctionFactor  
RationalFunctionFactorizer  
RationalFunctionIntegration  
RationalFunctionLimitPackage  
RationalFunctionSign  
RationalFunctionSum  
RationalIntegration  
RationalLODE  
RationalRetractions  
RationalRicDE  
RationalUnivariateRepresentationPackage

RealPolynomialUtilitiesPackage  
RealSolvePackage  
RealZeroPackage  
RealZeroPackageQ  
RectangularMatrixCategoryFunctions2  
ReducedDivisor  
ReduceLODE  
ReductionOfOrder  
RegularSetDecompositionPackage  
RegularTriangularSetGcdPackage  
RepeatedDoubling  
RepeatedSquaring  
RepresentationPackage1  
RepresentationPackage2  
ResolveLatticeCompletion  
RetractSolvePackage  
SAERationalFunctionAlgFactor  
ScriptFormulaFormat1  
SegmentBindingFunctions2  
SegmentFunctions2  
SimpleAlgebraicExtensionAlgFactor  
SimplifyAlgebraicNumberConvertPackage  
SmithNormalForm  
SortedCache  
SortPackage  
SparseUnivariatePolynomialFunctions2  
SpecialOutputPackage  
SquareFreeQuasiComponentPackage  
SquareFreeRegularSetDecompositionPackage  
SquareFreeRegularTriangularSetGcdPackage  
StorageEfficientMatrixOperations  
StreamFunctions1  
StreamFunctions2  
StreamFunctions3  
StreamInfiniteProduct  
StreamTaylorSeriesOperations  
StreamTranscendentalFunctions  
StreamTranscendentalFunctionsNonCommutative  
StructuralConstantsPackage  
SturmHabichtPackage  
SubResultantPackage  
SupFractionFactorizer  
SymmetricFunctions  
SymmetricGroupCombinatoricFunctions  
SystemODESolver  
SystemSolvePackage  
TableauxBumpers  
TabulatedComputationPackage  
TangentExpansions  
TemplateUtilities  
TexFormat1  
ToolsForSign  
TopLevelDrawFunctions  
TopLevelDrawFunctionsForAlgebraicCurves



TopLevelDrawFunctionsForCompiledFunctions  
TopLevelDrawFunctionsForPoints  
TopLevelThreeSpace  
TranscendentalHermiteIntegration  
TranscendentalIntegration  
TranscendentalManipulations  
TranscendentalRischDE  
TranscendentalRischDESystem  
TransSolvePackage  
TransSolvePackageService  
TriangularMatrixOperations  
TrigonometricManipulations  
TubePlotTools  
TwoDimensionalPlotClipping  
TwoFactorize  
UnivariateFactorize  
UnivariateLaurentSeriesFunctions2  
UnivariatePolynomialCategoryFunctions2  
UnivariatePolynomialCommonDenominator  
UnivariatePolynomialDecompositionPackage  
UnivariatePolynomialDivisionPackage  
UnivariatePolynomialFunctions2  
UnivariatePolynomialMultiplicationPackage  
UnivariatePolynomialSquareFree  
UnivariatePuisseuxSeriesFunctions2  
UnivariateSkewPolynomialCategoryOps  
UnivariateTaylorSeriesFunctions2  
UnivariateTaylorSeriesODESolver  
UniversalSegmentFunctions2  
UserDefinedPartialOrdering  
UserDefinedVariableOrdering  
UTSodetools  
VectorFunctions2  
ViewDefaultsPackage  
ViewportPackage  
WeierstrassPreparation  
WildFunctionFieldIntegralBasis  
XExponentialPackage  
ZeroDimensionalSolvePackage

---



# Chapter 11

## Research Topics

These are included here as ideas that may get expanded in more detail later.

### 11.1 Proofs

The goal would be to prove that Axiom's algorithms are correct.

For instance, show that the GCD algorithm is correct. This involves several levels of proof. At one level we need to prove that the GCD algorithm is mathematically correct and that it terminates. This can be picked up from the literature.

A second level of correctness involves proving that the implementation of the algorithm is correct. This involves using something like ACL2 [KMJ00] and proof of the common lisp implementation.

A third level is to show that the binary implementation conforms to the semantics of the common lisp implementation. This involves using something like Function Extraction (FX) [LMW79] to extract the machine-level behavior of the program and comparing it to the specification.

### 11.2 Indefinites

There are times when it would be convenient to write algorithms in terms of indefinite values. For instance, we would like to be able to declare that X and Y are matrices and compute X\*Y symbolically. We would like to be able to do the same with arbitrary integers, I and J. In general, for a given domain we would like to create domain elements that are not fully specified but have the computation proceed with these “indefinite” values.

### 11.3 Provisos

We would like to create “provisos” on statements such as:

$$\frac{1}{x} \text{ provided } x \neq 0$$

We would then like to rewrite this in terms of intervals to create three “continuations” where each continuation is a separate domain of computation (and could thus be computed in parallel). So for the above example we would generate:

$$\frac{1}{x} \text{ such that } x \in [-\infty, 0)$$

$$\frac{1}{x} \text{ such that } x \in (0, 0)$$

$$\frac{1}{x} \text{ such that } x \in (0, \infty]$$

When a new proviso is added, for instance, when we divide by  $y$  then there would be further subdivision of the computation, forming a tree:

$$\frac{1}{xy} \text{ such that } x \in [-\infty, 0) \text{ and } y \in [-\infty, 0)$$

$$\frac{1}{xy} \text{ such that } x \in (0, 0) \text{ and } y \in [-\infty, 0)$$

$$\frac{1}{xy} \text{ such that } x \in (0, \infty] \text{ and } y \in [-\infty, 0)$$

$$\frac{1}{xy} \text{ such that } x \in [-\infty, 0) \text{ and } y \in (0, 0)$$

$$\frac{1}{xy} \text{ such that } x \in (0, 0) \text{ and } y \in (0, 0)$$

$$\frac{1}{xy} \text{ such that } x \in (0, \infty] \text{ and } y \in (0, 0)$$

$$\frac{1}{xy} \text{ such that } x \in [-\infty, 0) \text{ and } y \in (0, \infty]$$

$$\frac{1}{xy} \text{ such that } x \in (0, 0) \text{ and } y \in (0, \infty]$$

$$\frac{1}{xy} \text{ such that } x \in (0, \infty] \text{ and } y \in (0, \infty]$$

Interesting questions arise, such as how to recover the function over the real line. Of course, the domain and range are not restricted to the real line in general but could, for instance, range over the complex plane.

Note that the provisos need not be an interval. They could be anything such as a polynomial or a property like “ $f(x)$  is entire”.

# Chapter 12

## Makefile

```
— * —

BOOK=${SPD}/books/bookvol6.pamphlet

# this is where to put the various commands
OUT= ${MNT}/${SYS}/bin
OUTLIB= ${MNT}/${SYS}/lib

# this is where we hid the libspad library
LIB= ${OBJ}/${SYS}/lib

# this is where the documentation ends up
LDFLAGS= -L${LIB} -lspad ${LDF}

all: announce ${OUTLIB}/session ${OUTLIB}/spadclient ${OUT}/sman \
      ${OUT}/axiom finish

announce:
@ echo =====
@ echo Making sman, session, spadclient, axiom bookvol6
@ echo =====

finish:
@ echo =====
@ echo Finished sman, session, spadclient, axiom bookvol6
@ echo =====

${OUTLIB}/session: ${LIB}/libspad.a
@ echo 1 making ${OUTLIB}/session from ${BOOK}
@ (cd ${LIB} ; \
    ${BOOKS}/tanglec ${BOOK} session.c >session.c ; \
    ${CC} ${CCF} -o ${OUTLIB}/session session.c libspad.a )

${OUTLIB}/spadclient: ${LIB}/libspad.a
@ echo 2 making ${OUTLIB}/spadclient from ${BOOK}
@ (cd ${LIB} ; \
```

```
    ${BOOKS}/tanglec ${BOOK} spadclient.c >spadclient.c ; \
    ${CC} ${CCF} -o ${OUTLIB}/spadclient spadclient.c libspad.a )

${OUT}/axiom: ${BOOK}
@ echo 3 making ${OUT}/axiom from ${BOOK}
@ (cd ${OUT} ; ${BOOKS}/tanglec ${BOOK} axiomcmd >axiom )
@ chmod +x ${OUT}/axiom

${OUT}/sman: ${LIB}/libspad.a
@ echo 4 making ${OUT}/sman from ${BOOK}
@ (cd ${LIB} ; \
    ${BOOKS}/tanglec ${BOOK} sman.c >sman.c ; \
    ${CC} ${CCF} -o ${OUT}/sman sman.c libspad.a )
```

---

# Bibliography

- [Haya05] K. Hayashi, J. Kangkook, O. Lascu, H. Pienaar, S. Schreitmueller, T. Tarquinio, and J. Thompson. *AIX 5L Practical Performance Tools and Tuning Guide*. IBM, 2005.
- Link:** <http://www.redbooks.ibm.com/redbooks/pdfs/sg246478.pdf>
- [Jenk92] Richard D. Jenks and Robert S. Sutor. *AXIOM: The Scientific Computation System*. Springer-Verlag, Berlin, Germany, 1992, 0-387-97855-0.

