

# axiom<sup>TM</sup>



## 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

Portions Copyright (c) 2005 Timothy Daly

The Blue Bayou image Copyright (c) 2004 Jocelyn Guidry

Portions Copyright (c) 2004 Martin Dunstan

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.

Cyril Alberga	Roy Adler	Richard Anderson
George Andrews	Henry Baker	Stephen Balzac
Yurij Baransky	David R. Barton	Gerald Baumgartner
Gilbert Baumslag	Fred Blair	Vladimir Bondarenko
Mark Botch	Alexandre Bouyer	Peter A. Broadbery
Martin Brock	Manuel Bronstein	Florian Bundschuh
William Burge	Quentin Carpent	Bob Caviness
Bruce Char	Cheekai Chin	David V. Chudnovsky
Gregory V. Chudnovsky	Josh Cohen	Christophe Conil
Don Coppersmith	George Corliss	Robert Corless
Gary Cornell	Meino Cramer	Claire Di Crescenzo
Timothy Daly Sr.	Timothy Daly Jr.	James H. Davenport
Jean Della Dora	Gabriel Dos Reis	Michael Dewar
Claire DiCrescendo	Sam Dooley	Lionel Ducos
Martin Dunstan	Brian Dupee	Dominique Duval
Robert Edwards	Heow Eide-Goodman	Lars Erickson
Richard Fateman	Bertfried Fauser	Stuart Feldman
Brian Ford	Albrecht Fortenbacher	George Frances
Constantine Frangos	Timothy Freeman	Korrinn Fu
Marc Gaetano	Rudiger Gebauer	Kathy Gerber
Patricia Gianni	Holger Gollan	Teresa Gomez-Diaz
Laureano Gonzalez-Vega	Stephen Gortler	Johannes Grabmeier
Matt Grayson	James Griesmer	Vladimir Grinberg
Oswald Gschnitzer	Jocelyn Guidry	Steve Hague
Vilya Harvey	Satoshi Hamaguchi	Martin Hassner
Ralf Hemmecke	Henderson	Antoine Hersen
Pietro Iglio	Richard Jenks	Kai Kaminski
Grant Keady	Tony Kennedy	Paul Kosinski
Klaus Kusche	Bernhard Kutzler	Larry Lambe
Frederic Lehouby	Michel Levaud	Howard Levy
Rudiger Loos	Michael Lucks	Richard Luczak
Camm Maguire	Bob McElrath	Michael McGettrick
Ian Meikle	David Mentre	Victor S. Miller
Gerard Milmeister	Mohammed Mobarak	H. Michael Moeller
Michael Monagan	Marc Moreno-Maza	Scott Morrison
Mark Murray	William Naylor	C. Andrew Neff
John Nelder	Godfrey Nolan	Arthur Norman
Jinzhong Niu	Michael O'Connor	Kostas Oikonomou
Julian A. Padget	Bill Page	Jaap Weel
Susan Pelzel	Michel Petitot	Didier Pinchon
Claude Quitte	Norman Ramsey	Michael Richardson
Renaud Rioboo	Jean Rivlin	Nicolas Robidoux
Simon Robinson	Michael Rothstein	Martin Rubey
Philip Santas	Alfred Scheerhorn	William Schelter
Gerhard Schneider	Martin Schoenert	Marshall Schor
Fritz Schwarz	Nick Simicich	William Sit
Elena Smirnova	Jonathan Steinbach	Christine Sundaresan
Robert Sutor	Moss E. Sweedler	Eugene Surowitz
James Thatcher	Baldir Thomas	Mike Thomas
Dylan Thurston	Barry Trager	Themos T. Tsikas
Gregory Vanuxem	Bernhard Wall	Stephen Watt
Juergen Weiss	M. Weller	Mark Wegman
James Wen	Thorsten Werther	Michael Wester
John M. Wiley	Berhard Will	Clifton J. Williamson
Stephen Wilson	Shmuel Winograd	Robert Wisbauer
Sandra Wityak	Waldemar Wiwianka	Knut Wolf

# Contents

<b>1</b>	<b>Overview</b>	<b>1</b>
<b>2</b>	<b>The axiom Command</b>	<b>3</b>
2.0.1	[-ht   -noht] . . . . .	3
2.0.2	[-gr   -nogr] . . . . .	4
2.0.3	[-clef   -noclef] . . . . .	4
2.0.4	[-nonag   -nag] . . . . .	5
2.0.5	[-noiw   -iw] . . . . .	5
2.0.6	[-ihere   -noihere] . . . . .	6
2.0.7	[-nox] . . . . .	6
2.0.8	[-go   -nogo] . . . . .	7
2.0.9	[-ws wsname] . . . . .	7
2.0.10	[-list] . . . . .	7
2.0.11	[-grprog fname] . . . . .	7
2.0.12	[-nagprog fname] . . . . .	8
2.0.13	[-htprog fname] . . . . .	8
2.0.14	[-clefprog fname] . . . . .	8
2.0.15	[-sessionprog fname] . . . . .	8
2.0.16	[-clientprog fname] . . . . .	8
2.0.17	[-h] . . . . .	8
<b>3</b>	<b>The sman program</b>	<b>17</b>
3.1	sman.h . . . . .	17
3.2	sman . . . . .	18
3.2.1	includes . . . . .	18
3.2.2	variables . . . . .	18
3.2.3	process_arguments . . . . .	20
3.2.4	should_I_clef . . . . .	23
3.2.5	in_X . . . . .	23
3.2.6	set_up_defaults . . . . .	23
3.2.7	process_options . . . . .	24
3.2.8	death_handler . . . . .	24
3.2.9	nagman_handler . . . . .	24
3.2.10	sman_catch_signals . . . . .	25

3.2.11	fix_env . . . . .	26
3.2.12	init_term_io . . . . .	26
3.2.13	strPrefix . . . . .	27
3.2.14	check_spad_proc . . . . .	27
3.2.15	clean_up_old_sockets . . . . .	28
3.2.16	fork_you . . . . .	28
3.2.17	exec_command_env . . . . .	29
3.2.18	spawn_of_hell . . . . .	29
3.2.19	start_the_spadclient . . . . .	30
3.2.20	start_the_local_spadclient . . . . .	30
3.2.21	start_the_nagman . . . . .	31
3.2.22	start_the_session_manager . . . . .	31
3.2.23	start_the_hypertext . . . . .	32
3.2.24	start_the_graphics . . . . .	32
3.2.25	fork_Axiom . . . . .	32
3.2.26	start_the_Axiom . . . . .	34
3.2.27	clean_up_sockets . . . . .	35
3.2.28	read_from_spad_io . . . . .	35
3.2.29	read_from_manager . . . . .	36
3.2.30	manage_spad_io . . . . .	37
3.2.31	init_spad_process_list . . . . .	38
3.2.32	print_spad_process_list . . . . .	38
3.2.33	find_child . . . . .	38
3.2.34	kill_all_children . . . . .	39
3.2.35	clean_up_terminal . . . . .	39
3.2.36	monitor_children . . . . .	39
3.2.37	main sman . . . . .	41
3.2.38	sman . . . . .	42
<b>4</b>	<b>Support Routines</b>	<b>45</b>
4.1	Command Completion . . . . .	45
<b>5</b>	<b>The viewman program</b>	<b>47</b>
<b>6</b>	<b>The nagman program</b>	<b>49</b>
6.1	nag.x . . . . .	49
6.2	nagman . . . . .	50
6.2.1	includes . . . . .	50
6.2.2	variables . . . . .	51
6.2.3	term . . . . .	52
6.2.4	size_of_file . . . . .	53
6.2.5	rpcloop . . . . .	53
6.2.6	catchSignals . . . . .	59
6.2.7	main nagman . . . . .	60
6.2.8	nagman . . . . .	61

<b>7</b>	<b>The hypertext program</b>	<b>63</b>
<b>8</b>	<b>The clef program</b>	<b>65</b>
<b>9</b>	<b>The session program</b>	<b>67</b>
9.1	session . . . . .	67
9.1.1	includes . . . . .	67
9.1.2	variables . . . . .	68
9.1.3	usr1_handler . . . . .	68
9.1.4	usr2_handler . . . . .	68
9.1.5	term_handler . . . . .	69
9.1.6	pr . . . . .	69
9.1.7	close_client . . . . .	70
9.1.8	read_SpadServer_command . . . . .	71
9.1.9	test_sock_for_process . . . . .	72
9.1.10	read_menu_client_command . . . . .	72
9.1.11	read_from_spad_io . . . . .	73
9.1.12	kill_spad . . . . .	74
9.1.13	accept_session_connection . . . . .	74
9.1.14	read_from_session . . . . .	76
9.1.15	manage_sessions . . . . .	77
9.1.16	main sessionmanager . . . . .	78
9.1.17	session . . . . .	80
<b>10</b>	<b>The spadclient program</b>	<b>81</b>
10.1	spadclient . . . . .	81
<b>11</b>	<b>The Command Completion List</b>	<b>83</b>
<b>12</b>	<b>Research Topics</b>	<b>167</b>
12.1	Proofs . . . . .	167
12.2	Indefinites . . . . .	167
12.3	Provisos . . . . .	168
<b>13</b>	<b>Makefile</b>	<b>169</b>
13.1	Environment variables . . . . .	169
13.2	The axiom command . . . . .	170
13.3	session . . . . .	170
13.4	nagman . . . . .	170
13.5	spadclient . . . . .	171
13.6	sman . . . . .	171

## 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
  [-nonag |-nag]     whether to use NAG
  [-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
  [-nagprog fname]   use named program for Nag
  [-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`<sup>[7]</sup> is the documentation tool for Axiom. The `-ht` option, enabled by default, will start this tool. See Jenks<sup>[1]</sup> Chapter 3 for further information on the `hyperdoc` subsystem.

### 2.0.2 [-gr | -nogr]

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

The `graphics`[8] 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[1] 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[1] page 21 for further information on the `clef` command.

## 2.0.4 [-nonag | -nag]

`[-nonag | -nag]`            whether to use NAG

The `nag` option, disabled by default, will attempt to start the `nagman` program in the `$AX-IOM/lib` subdirectory. Since the open source version does not include the NAG numeric libraries this option does not work.

## 2.0.5 [-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 names` 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[1] page 579 for further information on the **frame** command.

### 2.0.6 [-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.

### 2.0.7 [-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.

### 2.0.8 [-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
```

### 2.0.9 [-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
```

### 2.0.10 [-list]

`[-list]`                              list workspaces only

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

### 2.0.11 [-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`.

### 2.0.12 [-nagprog fname]

`[-nagprog fname]`      use named program for Nag

allows you to specify which program to use for the NAG library connection. By default this is

`$AXIOM/lib/nagman` but it is disabled by default.

### 2.0.13 [-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`.

### 2.0.14 [-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`.

### 2.0.15 [-sessionprog fname]

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

allows you to specify the session manager program. By default it is

`$AXIOM/lib/session`.

### 2.0.16 [-clientprog fname]

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

allows you to specify the spadclient program. By default it is

`$AXIOM/lib/spadclient`.

### 2.0.17 [-h]

`[-h]`                      show usage

```
#!/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[9] for details.

— **axiomcmd** —

```
MALLOCTYPE=3.1
export MALLOCTYPE
```

---

The `nagman` process needs to know the hostname

— **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 "  [-nonag  |-nag]       whether to use NAG"
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 "  [-nagprog fname]      use named program for Nag"
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
```

—————

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** —

```
-nagprog|-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 $1"
;;
    -ihere|-noihere|-nox|-nag|-nonag)
otheropts="$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 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.

— 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 hypertex 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;
```

—



## 3.2 sman

### 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

#include "com.h"
#include "bsdsignal.h"
#include "sman.h"

#include "bsdsignal.h1"
#include "sockio-c.h1"
#include "openpty.h1"
#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_nagman; /* start the nagman */
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 nagman 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 nagman_signal=0;
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], "-nag") == 0)
            start_nagman = 1;
        else if (strcmp(argv[arg], "-nonag") == 0)
            start_nagman = 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], "-nagprog") == 0)
            NagManagerProgram = 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> <-nag|-nonag> <-nox> <-comp>");
            fprintf(stderr, " <-ws spad_workspace> <-grprog path> <-htprog path>");
            fprintf(stderr, " <-clefprog path> <-sessionprog path> <-nagprog 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_nagman == 0)
    fprintf(stderr, "-nonag ");
else
    fprintf(stderr, "-nag ");
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, "-nagprog ");
fprintf(stderr, "%s' ", NagManagerProgram);
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.

We do not have replacement code for the nagman process nor do we have a copy of the nag fortran library to test the process. Until this changes we set start\_nagman = 0 in order to disable starting this process by default.

— 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_nagman = 0;
    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 nagman\_handler

— sman.nagmanhandler —

```
static void
nagman_handler(int sig)
{
    nagman_signal=1;
}
```

—————

### 3.2.10 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);
    /* don't restart wait call on SIGUSR1 */
    bsdSignal(SIGUSR1, nagman_handler,DontRestartSystemCalls);
    /* ONLY nagman should send this.
       If an error (such as C-c) interrupts a NAGLINK call, nagman
       gets a signal to clean up. We need to start another nagman
       almost immediately to process the next NAGLINK request.
       Since nagman takes a while to clean up, we treat it specially.
       nagman should send a signal (USR1) to sman.
       sman should respond by spawning a new nagman.

       so nagman is NOT a DoItAgain but a NadaDelShitsky.

       The USR1 mechanism does not work for HPUX 9 - use DoItAgain
       */
}
```

—————



### 3.2.11 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];
}
```

—————

### 3.2.12 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];
}
```

---

### 3.2.13 strPrefix

— sman.strPrefix —

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

---

### 3.2.14 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);
            }
        }
    }
}
```

---

### 3.2.15 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);
}
```

—————

### 3.2.16 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;
}

```

---

### 3.2.17 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);
    execl("/bin/sh", "/bin/sh", "-c", new_command, (char *)0, env);
}

```

---

### 3.2.18 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;
}

```

### 3.2.19 start\_the\_spadclient

run a AXIOM client in the main process

— sman.startthepadclient —

```
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);
}
```

### 3.2.20 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);
}

```

---

### 3.2.21 start\_the\_nagman

— sman.startthenagman —

```

static void
start_the_nagman(void)
{
#ifdef HP9platform
    spawn_of_hell(NagManagerProgram, DoItAgain);
#else
    spawn_of_hell(NagManagerProgram, NadaDelShitsky );
#endif
}

```

---

### 3.2.22 start\_the\_session\_manager

— sman.startthesessionmanager —

```

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

```

---

### 3.2.23 start\_the\_hypertex

— sman.startthehypertex —

```
static void
start_the_hypertex(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);
}
```

---

### 3.2.24 start\_the\_graphics

— sman.startthegraphics —

```
static void
start_the_graphics(void)
{
    spawn_of_hell(GraphicsProgram, DoItAgain);
}
```

---

### 3.2.25 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                                                         */

        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);
        }
#ifdef 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(ptcNum);
        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 *)
    strrchr(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);
}
}

```

### 3.2.26 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(&ptcNum, &ptsNum, ptcPath, ptsPath) == -1) {
        perror("start_the_Axiom: ptyopen failed");
        exit(-1);
    }
    fix_env(envp, server_num);
    fork_Axiom();
    close(ptsNum);
}

```

---

### 3.2.27 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();
}
```

---

### 3.2.28 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);
    }
}

```

---

### 3.2.29 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;
    }
}

```

---

## 3.2.30 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(ptcNum, &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(ptcNum, &rd)) {
            read_from_spad_io(ptcNum);
        }
        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(ptcNum);
        }
    }
}

```

---

### 3.2.31 `init_spad_process_list`

— `sman.initspadprocesslist` —

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

---

### 3.2.32 `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
```

---

### 3.2.33 `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;
}
```

---

### 3.2.34 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);
}
```

—————

### 3.2.35 clean\_up\_terminal

— sman.cleantupterminal —

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

—————

### 3.2.36 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);
    }
    /* Check the value of dead_baby, since wait may have returned
       a pid but subsequently we have received a signal.  Yeuch! */
    if (dead_baby == -1 && nagman_signal) {
        nagman_signal=0;
        spawn_of_hell(NagManagerProgram, NadaDelShitsky);
        continue;
    }

    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;
    }
}

```

```

    }
}

```

---

### 3.2.37 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(SessionIOName) == -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_nagman)         start_the_nagman();
    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}
}
```

### 3.2.38 sman

— sman —

```
#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.nagmanhandler}
\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.startthenagman}
\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 nagman program

— the nagman command line —

```
char *NagManagerProgram = "$AXIOM/lib/nagman";
```

—————

### 6.1 nag.x

— nag.nag.x —

```
/*
 * msg.x: Remote message printing protocol
 */
const MAXASP = 10;

/*
 * the nago structure is essentially a variable length string
 */

struct nago {
    opaque z <>;
};
struct nagerr {
    nago p;
    nago q;
};

struct host{
```



```

nago h <>;
};

struct nagst {

/* Okay, if you understand this bit you know the essentials of how the link
 * works. h <> is an array of nago, which is an array of fortran source
 * code, the length of the array being the no. of asps (0 for most routines).
 * y is the actual (XDR) input data for the routine. nm is the name of the
 * routine. id is a tag identifying the host/axiom session. Finally per is a
 * number telling whether or not to erase old fortran files on the remote
 * machine (persistence - the number per distinct fortran files will be
 * stored, any more than this and earlier ones will be deleted.
 */

    nago h <>;
    nago y;
    nago nm;
    nago id;
    int per;
};

program NAGPROG {
    version NAGVERS {
        nagerr CALLNAG(nagst) = 1;
        nago NAGMON(int)=2;
        void AXEND(nago)=3;
    } = 1;
/*
 * the following number is very important. It tells the
 * portmapper what number to register the nag daemon under.
 * There are rules about which number to pick - check SUN
 * technical info for more details
 */
} = 100088;

```

---

## 6.2 nagman

### 6.2.1 includes

— nag.includes —

```

#include <unistd.h>
#include <stdlib.h>

```

```

#include <stdio.h>
#include <string.h>
#include <errno.h>
#include <termios.h>
#include <signal.h>
#include <sys/time.h>
#include <sys/stat.h>
#include <sys/socket.h>
#include <sys/un.h>
#include <rpc/rpc.h>      /* always needed */
#include <fcntl.h>
#include <netinet/in.h>
#include <arpa/inet.h>
#include <netdb.h>
#include "nag.h" /* generated by rpcgen */
#include "com.h"
#include "bsdsignal.h"
#include "sockio-c.h1"
#include "bsdsignal.h1"
#include "nagman.h1"

```

---

### 6.2.2 variables

— nag.variables —

```

#ifdef ALPHAplatform
extern int getdomainname( char *, int );
#endif
#ifdef SUN4OS5platform
extern int getdomainname( char *, int );
extern int gethostname( char *, int );
#endif

nagerr * callnag_1(nagst *,CLIENT *);
nago * nagmon_1(int *,CLIENT *);
void * axend_1(nago *,CLIENT *);

#define DO 1
#define DONT 0

int hnum, vmax;
char *datafile, *resultsfile;

struct hostnode {
    char * name;

```

```

    struct hostnode *next;
} *hlist=NULL;

nagst nag4;
Sock *sock1;

```

---

### 6.2.3 term

this code runs when the user quits axiom. before nagman dies, it does an rpc call to nagd to tell it to get rid of files etc. The rpc call in question is axend.1 we also send a USR1 to sman to beget another nagman

— **nag.term** —

```

static void
term(int sig)
{
    CLIENT *cld;
    void *res;
    struct hostnode *pnode;

#ifdef HP9platform /* can't figure out a way to do this on HP/UX 9 */
    kill(atoi(getenv("SPADNUM")) , SIGUSR1);
#endif

    if(hnum!=0)
    {
        unlink(datafile);
        unlink(resultsfile);
    }

    for(pnode=hlist;pnode!=NULL;pnode=pnode->next)
    {
        cld=clnt_create(pnode->name,NAGPROG, NAGVERS, "tcp");
        if (cld == NULL)
goto NOHOST;

        res=axend_1(&(nag4.id),cld);
        NOHOST:
        clnt_destroy(cld);
    }
    exit(0);
}

```

---

### 6.2.4 size\_of\_file

— nag.sizeoffile —

```
static long
size_of_file(char *filename)
{
    struct stat buf_stat;

    stat(filename,&buf_stat);
    return (buf_stat.st_size);
}
```

—————

### 6.2.5 rpcloop

— nag.rpcloop —

```
static void
rpcloop(void)
{
    CLIENT *cl;
    int res,j,v=0,u,showMessage;
    long i;
    register struct hostent *alias1, *alias2;
    struct in_addr *addrnum;
    u_long junk;
    struct timeval tv;
    nagerr *result;
    char *Buf , *buf1;
    char *ffile[MAXASP];
    char routine[12], naghost[256];
    FILE *nfp1, *nfp2, *nfp3;
    struct hostnode *phost;
    int fd;

    for (;;)
    {
        if((Buf=get_string(sock1))==NULL) term(1); /* one string carries all */

        if(hnum!=0)
    {
```

```

/* call parameters */
free(nag4.nm.z.z_val); /* the routine name */
free(nag4.y.z.z_val); /* the XDR data */
for(i=0;i<v;i++)
{
    unlink(ffile[i]);
    free(ffile[i]); /* the asp filenames */
    free(nag4.h.h_val[i].z.z_val); /* the asps themselves*/
}
free(nag4.h.h_val); /* the asps array */
unlink(datafile);
unlink(resultsfile);
free(resultsfile);
free(datafile);
vmax= (v>vmax)? v : vmax;
}

    buf1=strtok(Buf, " ");
    if (buf1) strcpy(naghost,buf1);
    else printf("can't parse the naghost\n");
    /* INFO          printf("%s\n",naghost);*/

    buf1=strtok(NULL," ");
    if (buf1) strcpy(routine,buf1);
    else printf("can't parse the routine\n");
    /* INFO          printf("%s\n",routine);*/

    /* make copy of filenames because we will reuse Buf before deleting the files*/
    buf1=strtok(NULL," ");
    if (buf1) resultsfile=strdup(buf1);
    else printf("can't parse the resultsfile file\n");
    /* INFO          printf("%s\n",resultsfile);*/

    buf1=strtok(NULL," ");
    if (buf1) datafile=strdup(buf1);
    else printf("can't parse the datafile file\n");
    /* INFO          printf("%s\n",datafile);*/

    buf1=strtok(NULL," ");
    if (buf1) nag4.per=atoi(buf1);
    else printf("can't parse the persistence\n");
    /* INFO          printf("%d\n",nag4.per);*/

    buf1=strtok(NULL," ");
    if (buf1) {
if (!strcmp(buf1,"on")) showMessage=D0;
else showMessage=DONT;

```

```

    }
    else printf("can't parse the messages flag\n");
    /* INFO      printf("%s\n",buf1);*/

    v=0; /* asp counter */
    while( (buf1=strtok(NULL," ")) )
{
    ffile[v++]=strdup(buf1);
    /* INFO      printf("%s\n",ffile[v-1]);*/
}

    /* INFO      printf("number of asps seen %d\n",v);*/

    if(showMessage==D0) printf("nagman:acknowledging request for %s\n",routine);

    res=0; /* prepare result integer to be sent to Lisp */

    if((nfp3=fopen(resultsfile,"w"))==NULL)
{
    printf("can't open output file\n");
    goto END;
}

    /* nag4.h is the XDR array of asp text */
    nag4.h.h_len=v;
    nag4.h.h_val=(nago *)malloc((v)*sizeof(nago));

    /* get asp text in call argument */
    for(u=0;u<v;u++)
{
    /* this should be done by mmap */
    if((nfp1=fopen(ffile[u],"r"))==NULL)
    {
        fprintf(stderr,"can't open asp file %s\n",ffile[u]);
        fclose(nfp1);
        goto END;
    }
    fclose(nfp1);
    i=size_of_file(ffile[u]);

    /* allocs memory for the file */
    nag4.h.h_val[u].z.z_val= (char *)malloc((i+1)*sizeof(char));

    fd=open(ffile[u],O_RDONLY);
    read(fd,nag4.h.h_val[u].z.z_val,i);
    close(fd);
    /* make null-term. string */
    nag4.h.h_val[u].z.z_val[i]='\0';
    /* set the length */

```

```

    nag4.h.h_val[u].z.z_len=strlen(nag4.h.h_val[u].z.z_val);
}

    nag4.nm.z.z_val=strdup(routine);
    nag4.nm.z.z_len=strlen(routine);

    /* get XDR data in call argument */
    /* should be done by mmap */
    if((nfp2=fopen(datafile,"r"))==NULL)
{
    fprintf(stderr,"can't open data file\n");
    fclose(nfp2);
    goto END;
}

    fclose(nfp2);
    i=size_of_file(datafile);
    nag4.y.z.z_val=(char *)malloc(i*sizeof(char));

    fd=open(datafile,O_RDONLY);
    read(fd,nag4.y.z.z_val,i);
    close(fd);
    nag4.y.z.z_len=i;

    /*
     * Create client "handle" used for calling MESSAGEPROG on
     * the server designated on the command line. We tell
     * the RPC package to use the "tcp" protocol when
     * contacting the server.
     */

    /* update naghost by lookup */

    if ((junk = inet_addr(naghost))!=-1)
{
    addrnum=(struct in_addr *)junk;
    if((alias2=gethostbyaddr((char *)&addrnum,
        sizeof(addrnum),
        AF_INET))!=NULL)
        strcpy(naghost,alias2->h_name);
    else
        if((alias1=gethostbyname(naghost))!=NULL)
            strcpy(naghost,alias1->h_name);
}

    else
    if((alias1=gethostbyname(naghost))!=NULL)
        strcpy(naghost,alias1->h_name);

```

```

        cl = clnt_create(naghost, NAGPROG, NAGVERS, "tcp");
        if (cl == NULL)
    {
        /*
         * Couldn't establish connection with server.
         * Print error message and die.
         */
        clnt_pcreateerror(naghost);
        goto END;
    }

        else
    if (showMessage==D0)
        printf("nagman:connection successful to %s\n",naghost);

        /*
         * this number here sets the "timeout" for the rpc call. after this number
         * of seconds, the call will quit if no response is received
         */

        tv.tv_sec=1000000;
        tv.tv_usec=0;
        clnt_control(cl,CLSET_TIMEOUT,(char *)&tv);

        result = callnag_1(&nag4, cl);

        for(phost=hlist;phost!=NULL;phost=phost->next)
    {
        /*
         * hlist is the "hostlist" of sites that have been contacted by nagman.
         * here we check if this call is contacting a new site, and if so add it
         * to the hostlist
         */

        if(!strcmp(phost->name,naghost))
            goto SKIP;
    }

        if(hnum==0) {
        hlist=(struct hostnode *)malloc(sizeof(struct hostnode));
        hlist->name=strdup(naghost);
        hlist->next=NULL;
        }

        else {

```



```

phost=(struct hostnode *)malloc(sizeof(struct hostnode));
phost->name=strdup(naghost);
phost->next=hlist;
hlist=phost;
    }
    hnum++;

    SKIP:
        if (result == NULL)
    {
        /*
        * An error occurred while calling the server.
        * Print error message and die.
        */
        if (showMessage==D0)
            printf("nagman:no results (error) from %s\n",naghost);
        clnt_perror(cl,naghost);
        clnt_destroy(cl);
        goto END;
    }

    /*
    * (*result).p is the part of the result with the XDRed results in it
    * (numbers). (*result).q is the part with (text) error messages that
    * have come from the NAG library. If there is neither an XDR result,
    * nor a text error message from the library, then something is wrong
    * so we just print out the "no result or error returned" message.
    *
    */

    else if ((*result).p.z.z_len==0)
    {
        if((*result).q.z.z_len==0)
        {
            if (showMessage==D0)
                printf("nagman:empty result (error) from %s\n",naghost);
            clnt_destroy(cl);
            goto END;
        }
        else
        {
            if (showMessage==D0)
                printf("nagman:receiving results from %s\n\n",naghost);
            for(j=0;j<(*result).q.z.z_len;j++)
                printf("%c",(*result).q.z.z_val[j]);
            clnt_destroy(cl);
            goto END;
        }
    }
}

```

```

        else
if (showMessage==D0)
    printf("nagman:receiving results from %s\n\n",naghost);

        if (showMessage==D0)
fwrite(result->q.z.z_val,sizeof(char),result->q.z.z_len,stdout);

        /*INFO printf("\nRESULTS of length %d\n",(*result).p.z.z_len);*/

        fwrite(result->p.z.z_val,sizeof(char),result->p.z.z_len, nfp3);
        res=1;
        clnt_destroy(cl);

        /*
        * in case of any type of error, a goto END in the above code causes
        * nagman to skip here and return to AXIOM
        *
        */

    END:
        fclose(nfp3);
        /*
        * if everything has gone alright, send_int returns the integer res=1. If
        * not it returns res=0. This is detected by the boot code which acts
        * accordingly.
        */
        send_int(sock1,res);
        free(Buf);
    }

}

```

### 6.2.6 catchSignals

catchSignals sets up signal handling. If nagman gets a sigterm it does not die but goes back to rpcloop

— nag.catchSignals —

```

static void
catchSignals(void)
{
    bsdSignal(SIGTERM,term,RestartSystemCalls);
    bsdSignal(SIGSEGV,term,RestartSystemCalls);
}

```

### 6.2.7 main nagman

— nag.main —

```

void
main(int argc, char **argv)
{
    char this[256], *hname, *dname, *spadnum;
    int stat;

    catchSignals();
    stat=gethostname(this, 256);
    if (stat!=0) perror("gethostname");
    hname=strdup(this);

    stat=getdomainname(this, 256);
    if (stat!=0) perror("getdomainname");
    dname=strdup(this);
    spadnum=getenv("SPADNUM");
    if (spadnum==0) {
        fprintf(stderr, "nagman error: SPADNUM is not in the environment\n");
        exit(0);
    }

    /* some machines return a full name from hostname
       need to check hname has a . in it */

    if (strchr(hname, '.'))
        /* '.' found */
        sprintf(this, "%s_%i", hname, atoi(spadnum));
    else
        /* substring not found */
        sprintf(this, "%s.%s_%i", hname, dname, atoi(spadnum));

    /* this must contain the Internet address of the current host */
    nag4.id.z.z_val=strdup(this);
    nag4.id.z.z_len=strlen(nag4.id.z.z_val);
    hnum=0;
    vmax=0;
    /*
     * this line sets up a socket for communication with the lisp
     */

    sock1 = connect_to_local_server(SpadServer, DebugWindow, 120 /*seconds*/);

```

```
    if (!sock1) exit(0);

    rpcloop();
}
```

---

### 6.2.8 nagman

— nagman —

```
#define _NAGMAN_C
\getchunk{nag.includes}
\getchunk{nag.variables}
\getchunk{nag.term}
\getchunk{nag.sizeoffile}
\getchunk{nag.rpcloop}
\getchunk{nag.catchSignals}
\getchunk{nag.main}
```

---



## Chapter 7

# The hypertex program

— the hypertex command line —

```
char *HypertexProgram = "$AXIOM/bin/hypertex -s";
```

—————



## Chapter 8

# The clef program

— the clef command line —

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

—————





## Chapter 9

# The session program

— the session manager command line —

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

—————

### 9.1 session

#### 9.1.1 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
#include "com.h"
#include "bsdsignal.h"
#include "sockio-c.h1"
#include "bsdsignal.h1"
#include "session.h1"
```

—————

### 9.1.2 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;
```

—————

### 9.1.3 usr1\_handler

— ses.usr1handler —

```
static void
usr1_handler(int sig)
{
    return;
}
```

—————

### 9.1.4 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;
}
```

---

### 9.1.5 term\_handler

— ses.termhandler —

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

---

### 9.1.6 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");
}
```

---

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

    /* now check the rest */

    else {
        for (pSock=pSock; 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
}

```

### 9.1.8 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;
    }
}

```

---

### 9.1.9 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);
}

```

---

### 9.1.10 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;
}
}

```

### 9.1.11 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);
    }
}

```

---

### 9.1.12 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);
}

```

---

### 9.1.13 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(spada_server, CreateFrame);
        {
            int command = get_int(spada_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);
}

```

#### 9.1.14 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;
}

```

—————

### 9.1.15 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
#ifdef DEBUG
        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=p1Sock; 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(); }
}
}

```

### 9.1.16 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(spad_server->socket, &session_socket_mask);
}

/* spad_io connects to SessionIOName server socket
   this is Lisp std IO read_from_spad_io handles requests */
spad_io = connect_to_local_server(SessionIOName, SessionIO, Forever);
if (spad_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",
        spad_io->socket);
#endif
    FD_SET(spad_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);
}

```

---

### 9.1.17 session

— session —

```

/* #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 10

# The spadclient program

— the spadclient command line —

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

—————

### 10.1 spadclient

— spadclient —

```
#define _SPADCLIENT_C

#include <stdio.h>
#include <signal.h>
#include "com.h"
#include "bsdsignal.h"

#include "bsdsignal.h1"
#include "sockio-c.h1"
#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 11

# The Command Completion List

— command.list —

```
-  
/  
/\br/>^  
^=  
~  
~=br/>*br/>**br/>\/  
#br/>+br/><br/><=br/>=br/>>br/>>=br/>0br/>1br/>abelianGroupbr/>absbr/>absolutelyIrreducible?br/>accuracyIFbr/>acosbr/>acoshbr/>acoshIfCanbr/>acosIfCanbr/>acotbr/>acoth
```

acothIfCan  
acotIfCan  
acsc  
acsch  
acschIfCan  
acscIfCan  
aCubic  
adaptive  
adaptive?  
adaptive3D?  
addBadValue  
addChild!  
addData!  
addField!  
addiag  
addMatch  
addMatchRestricted  
addmod  
addPoint  
addPoint2  
addPointLast  
adjoin  
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  
besselI  
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  
coth2trig  
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  
cscIfCan  
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

```

frst
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  
lllip  
lllp  
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  
padeCF  
padiCallyExpand  
padiCFraction  
pair?  
palgextint  
palgextint0  
palginfieldint  
palgint  
palgint0  
palgintegrate  
palglimint  
palglimint0  
palgL0DE  
palgL0DE0  
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  
pushcoef  
pushconst  
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  
resultantReduit  
resultantReduitEuclidean



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  
s0leaf

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!  
setProperties  
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  
showTypeInOutput  
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  
sylvestersSequence  
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  
FullyEvalableOver  
FullyLinearlyExplicitRingOver  
FullyPatternMatchable  
FullyRetractableTo  
FunctionFieldCategory  
FunctionSpace  
GcdDomain  
GradedAlgebra



GradedModule  
Group  
HomogeneousAggregate  
HyperbolicFunctionCategory  
IndexedAggregate  
IndexedDirectProductCategory  
InnerEvalable  
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 12

# Research Topics

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

### 12.1 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.

### 12.2 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.

### 12.3 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 13

# Makefile

### 13.1 Environment variables

— make.environment —

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

# this is where we are compiling from
IN=    ${SRC}/sman

# this is the intermediate place
MID=    ${INT}/sman

# this is the intermediate place
MIDOBJ=    ${OBJ}/${SYS}/sman

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

# this is where the include files live
INC=    ${SRC}/include

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

# this is where the documentation ends up
DOC=    ${MNT}/${SYS}/doc
CFLAGS= ${CCF}
LDFLAGS= -L${LIB} -lspad ${LDF}

SMANOBJS= ${LIB}/libspad.a
```



## 13.2 The axiom command

— make.axiomcmd —

```

${OUT}/axiom: ${BOOK}
@echo 1 making ${OUT}/axiom from ${BOOK}
@ (cd ${OUT} ; \
    echo '(tangle "${BOOK}" "axiomcmd" "axiom")' | ${OBJ}/${SYS}/bin/lisp )
@chmod +x ${OUT}/axiom
@ cp ${OUT}/axiom ${MID}

```

## 13.3 session

— make.session —

```

${OUTLIB}/session: ${SMANOBJS} ${MIDOBJ}/session.o
@ echo 1 linking session
@ ${CC} -o ${OUTLIB}/session ${MIDOBJ}/session.o ${SMANOBJS}

${MID}/session.c: ${BOOK}
@ echo 2 making ${MID}/session.c from ${BOOK}
@ (cd ${MID} ; \
    echo '(tangle "${BOOK}" "session" "session.c")' | \
    ${OBJ}/${SYS}/bin/lisp )

${MIDOBJ}/session.o: ${MID}/session.c ${INC}/session.h1
@ echo 3 making ${MIDOBJ}/session.o from ${MID}/session.c
@ ( cd ${MIDOBJ} ; ${CC} -c ${CFLAGS} ${MID}/session.c -I${INC} )

```

## 13.4 nagman

Note that we do not build the nagman component as we do not have the necessary code (for instance, callnag).

— make.nagman —

```

${OUT}/nagman: ${SMANOBJS} ${MIDOBJ}/nagman.o
@ echo 5 linking nagman
@ ${CC} -o ${OUT}/nagman ${MIDOBJ}/nagman.o ${SMANOBJS}

${MID}/nagman.c: ${BOOK}
@ echo 6 making ${MID}/nagman.c from ${IN}/bookvol6.pamphlet
@ (cd ${MID} ; \
    echo '(tangle "${BOOK}" "nagman" "nagman.c")' | \
    ${OBJ}/${SYS}/bin/lisp )

${MIDOBJ}/nagman.o: ${MID}/nagman.c ${INC}/nagman.h1
@ echo 7 making ${MIDOBJ}/nagman.o from ${MID}/nagman.c
@ ( cd ${MIDOBJ} ; ${CC} -c ${CFLAGS} ${MID}/nagman.c -I${INC} )

```

—————

## 13.5 spadclient

— make.spadclient —

```

${OUTLIB}/spadclient: ${SMANOBJS} ${MIDOBJ}/spadclient.o
@ echo 9 linking spadclient
@ ${CC} -o ${OUTLIB}/spadclient ${MIDOBJ}/spadclient.o ${SMANOBJS}

${MID}/spadclient.c: ${BOOK}
@ echo 10 making ${MID}/spadclient.c from ${IN}/bookvol6.pamphlet
@ (cd ${MID} ; \
    echo '(tangle "${BOOK}" "spadclient" "spadclient.c")' | \
    ${OBJ}/${SYS}/bin/lisp )

${MIDOBJ}/spadclient.o: ${MID}/spadclient.c ${INC}/spadclient.h1
@ echo 11 making ${MIDOBJ}/spadclient.o from ${MID}/spadclient.c
@ ( cd ${MIDOBJ} ; ${CC} -c ${CFLAGS} ${MID}/spadclient.c -I${INC} )

```

—————

## 13.6 sman

— make.sman —

```

${OUT}/sman: ${SMANOBJS} ${MIDOBJ}/sman.o
@ echo 13 linking sman
@ ${CC} -o ${OUT}/sman ${MIDOBJ}/sman.o ${SMANOBJS}

${MID}/sman.h: ${BOOK}
@ echo 00 making ${MID}/sman.h from ${IN}/bookvol6.pamphlet
@ (cd ${MID} ; \
    echo '(tangle "${BOOK}" "sman.h" "sman.h")' | \
    ${OBJ}/${SYS}/bin/lisp )

${MID}/sman.c: ${MID}/sman.h ${BOOK}
@ echo 14 making ${MID}/sman.c from ${IN}/bookvol6.pamphlet
@ (cd ${MID} ; \
    echo '(tangle "${BOOK}" "sman" "sman.c")' | \
    ${OBJ}/${SYS}/bin/lisp )

${MIDOBJ}/sman.o: ${MID}/sman.c ${INC}/sman.h1
@ echo 15 making ${MIDOBJ}/sman.o from ${MID}/sman.c
@ ( cd ${MIDOBJ} ; ${CC} -I${INC} -I${MID} -c ${CFLAGS} ${MID}/sman.c )

_____

___ * ___

\getchunk{make.environment}
all: ${OUTLIB}/session ${OUTLIB}/spadclient ${OUT}/sman ${OUT}/axiom
@ echo 18 finished ${IN}

clean:
@echo 19 cleaning ${SRC}/sman

\getchunk{make.axiomcmd}
\getchunk{make.sman}
\getchunk{make.session}
\getchunk{make.spadclient}
\getchunk{make.nagman}
_____

```

# Bibliography

- [1] Jenks, R.J. and Sutor, R.S.  
“Axiom – The Scientific Computation System”  
Springer-Verlag New York (1992) ISBN 0-387-97855-0
- [2] Knuth, Donald E., “Literate Programming”  
Center for the Study of Language and Information ISBN 0-937073-81-4 Stanford CA  
(1992)
- [3] Page, William, “The Axiom Wiki Website”  
**<http://wiki.axiom-developer.org>**
- [4] Watt, Stephen, “Aldor”,  
**<http://www.aldor.org>**
- [5] Lamport, Leslie,  
“Latex – A Document Preparation System”, Addison-Wesley, New York ISBN 0-201-  
52983-1
- [6] Ramsey, Norman  
“Noweb – A Simple, Extensible Tool for Literate Programming”  
**<http://www.eecs.harvard.edu/~nr/noweb>**
- [7] Axiom Book Volume 7 – Hyperdoc  
**<file:///usr/local/axiom/src/hyper/bookvol7.pamphlet>**
- [8] Axiom Book Volume 8 – Graphics  
**<file:///usr/local/axiom/src/graph/bookvol8.pamphlet>**
- [9] AIX Version 3.2 and 4 Performance Tuning Guide  
**[http://www.rs6000.ibm.com/doc\\_link/en\\_US/  
a\\_doc\\_lib/aixbman/prftungd/toc.htm](http://www.rs6000.ibm.com/doc_link/en_US/a_doc_lib/aixbman/prftungd/toc.htm)**