

# axiom<sup>TM</sup>



## The 30 Year Horizon

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VOLUME 6: AXIOM COMMAND

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## 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On October 1, 2001 Axiom was withdrawn from the market and ended life as a commercial product.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[7] is the documentation tool for Axiom. The `-ht` option, enabled by default, will start this tool. See Jenks[1] 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

— axiomcmd —

```
#!/bin/sh
```

---

The `MALLOCTYPE` shell variable is an IBM AIX shell variable that controls buckets based extensions in the default memory allocator which may enhance performance. AIX uses a new memory management routine that does not zero `malloc` memory and does not round up to the nearest power of 2, unlike most non-AIX systems. This can cause failures so we protect against that here. See the AIX Performance Tuning Guide[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 hypertext dies, clean its socket */
#define CleanHypertextSocket 4

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

—————



## 3.2 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(SUN4OS5platform) || 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 hypertext */
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 hypertex 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);
    execle("/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.startthespadclient —

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

### 3.2.20 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\_hypertext

— sman.startthehypertext —

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

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

---

### 3.2.24 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) {
            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 SUN4OS5platform || 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 —

#ifdef 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.cleantpterminal —

```
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(SessionIName) == -2) {
        fprintf(stderr, "Fatal error opening I/O socket\n");
        clean_up_sockets();
        exit(-1);
    }
    start_the_session_manager();
    if (start_spadclient)      start_the_spadclient();
    if (start_local_spadclient) start_the_local_spadclient();
    if (start_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.startthehypertext}
\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==DO)
        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 hypertext program

— the hypertext command line —

```
char *HypertextProgram = "$AXIOM/bin/hypertext -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(spada_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(spada_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(spada_server, num);
    }
}

```

```

        break;
    case CloseClient:
        frame = get_int(spada_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
        ret_code = sselect(FD_SETSIZE, &rd, &wr, &ex, NULL);
        if (ret_code == -1) {
            break;
        }
    }
}

```

```

#ifdef DEBUG
fprintf(stderr,"rd=%u]\n",*((long *)rd.fds_bits));
#endif

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

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

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

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

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

```

### 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 hypertext (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 —

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

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

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## 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:

$$\begin{aligned} \frac{1}{x} \text{ such that } x \in [-\infty, 0) \\ \frac{1}{x} \text{ such that } x \in (0, 0) \\ \frac{1}{x} \text{ such that } x \in (0, \infty] \end{aligned}$$

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:

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

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}

```

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# 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)**