axiom™

The 30 Year Horizon

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Contents

New Foreword

On October 1, 2001 Axiom was withdrawn from the market and ended life as a commercial product.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

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

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

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

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

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

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

Chapter 1

Overview

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

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

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

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

Chapter 2

The axiom Command

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

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

In detail, the command options are:

2.0.1   [-ht | -noht]

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

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

2.0.2   [-gr | -nogr]

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

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

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

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

2.0.3   [-clef | -noclef]

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

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

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

and this will automatically be expanded to:

```
x:DenavitHartenbergMatrix
```

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

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

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

2.0.4   [-noiw | -iw]

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

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

```
axiom -iw
```

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

```
)frame names
```

you will see:

```
  The names of the existing frames are:
          frame0
          frame1
          initial
      The current frame is the first one listed.
```

In the second window, if you type

```
 )frame names
```

you will see:

```
   The names of the existing frames are:
           frame1
           frame0
           initial
       The current frame is the first one listed.
```

Setting

```
 x:=3
```

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

```
 x
```

gives:

```
   (1)  x
```
$$\text{Type: Variable x}$$

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
```
$$\text{Type: PositiveInteger}$$

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

2.0.5   [-ihere | -noihere]

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

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

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

However, used alone, as in:

```
 axiom -noihere &
```

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

2.0.6   [-nox]

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

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

2.0.7   [-go | -nogo]

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

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

```
 axiom -nogo -iw
```

does not start Axiom but types out:

```
Would now start the processes.
exec ~/mnt/linux/bin/sman -iw -ws ~/mnt/linux/bin/AXIOMsys
```

2.0.8   [-ws wsname]

```
[-ws wsname]          use named workspace
```

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

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

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

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

2.0.9   [-list]

```
[-list]               list workspaces only
```

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

2.0.10   [-grprog fname]

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

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

2.0.11   [-htprog fname]

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

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

2.0.12   [-clefprog fname]

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

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

2.0.13   [-sessionprog fname]

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

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

2.0.14   [-clientprog fname]

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

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

2.0.15   [-h]

```
[-h]                      show usage
```

— **axiomcmd** —

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

———-

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

— **axiomcmd** —

```
MALLOCTYPE=3.1
export MALLOCTYPE
```

———-

— **axiomcmd** —

```
HOST=`hostname`
export HOST
```

———-

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

— **axiomcmd** —

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

———-

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

— **axiomcmd** —

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

———-

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

— **axiomcmd** —

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

———-

List the various workspaces if asked.

— **axiomcmd** —

```
listwspaces()
{
        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** —

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

————-

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

— **axiomcmd** —

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

————-

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

— **axiomcmd** —

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

————-

The user wanted help so we will not execute.

— **axiomcmd** —

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

——————-

The user is confused. Complain and exit.

— **axiomcmd** —

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

——————-

Move to the next option and loop.

— **axiomcmd** —

```
shift
done
```

——————-

Step 3. Handle options that require special case handling.

The user just wanted to know what workspaces are available.

— **axiomcmd** —

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

——————-

Try to ensure a suitable workspace on this host.

— **axiomcmd** —

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

——————-

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

— **axiomcmd** —

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

——————-

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

— **axiomcmd** —

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

————-

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

— **axiomcmd** —

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

————-

Chapter 3

The sman program

3.1 include files

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

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

————-

3.1.1   include/sman.h

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

—— **include/sman.h** ——

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

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

```
#define CleanHypertexSocket 4

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

———-

3.1.2 include/com.h

— include/com.h —

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

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

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

#define MaxClients     150

/* possible socket types (purpose) */

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

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

#define Acknowledge     255

/* Timeout value for connection to remote socket */

#define Forever 0

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

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


#define MASK_SIZE       (NBBY*sizeof(fd_set))


/* table of dedicated socket types */

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

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

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

#define CreateFrameAnswer   50

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

#define ReceiveInputLine    100
#define TestLine            101

#endif
```

———-

3.1.3   include/bsdsignal.h

— include/bsdsignal.h —

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

#define RestartSystemCalls 1
#define DontRestartSystemCalls 0

typedef void (* SignalHandlerFunc)(int);

#endif     /* _BSDSIGNAL */
```

———-

3.1.4   include/bsdsignal.h1

— include/bsdsignal.h1 —

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

———-

3.1.5   include/openpty.h1

— include/openpty.h1 —

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

———-

3.1.6   include/sman.h1

— include/sman.h1 —

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

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

———————-

3.1.7   include/session.h1

— **include/session.h1** —

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

———————-

— **include/spadclient.h1** —

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

————-

3.2 sman.c

3.2.1 includes

— **sman.includes** —

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

#if defined(SUN4OS5platform) || defined(HP10platform)
#include <sys/stropts.h>
#endif

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

————-

3.2.2 variables

— **sman.variables** —

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

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

——————-

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

— **sman.variables** —

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


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

\getchunk{the viewman command line}
\getchunk{the 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 death_signal = 0;
```

———-

3.2.3   process_arguments

— **sman.processarguments** —

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

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

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

——————-

3.2.4 should_I_clef

— **sman.shouldIclef** —

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

——————-

3.2.5 in_X

— **sman.inX** —

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

——————-

3.2.6   set_up_defaults

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

— **sman.setupdefaults** —

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

———-

3.2.7   process_options

— **sman.processoptions** —

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

———-

3.2.8   death_handler

— **sman.deathhandler** —

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

———-

3.2.9   sman_catch_signals

— **sman.smancatchsignals** —

```
static void
sman_catch_signals(void)
{

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

}
```

———-

3.2.10   fix_env

insert SPADSERVER and SPADNUM variables into the environemnt

— **sman.fixenv** —

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

———-

3.2.11   init_term_io

— **sman.inittermio** —

```
static void
```

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

———-

3.2.12   strPrefix

— **sman.strPrefix** —

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

———-

3.2.13   check_spad_proc

— **sman.checkspadproc** —

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

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

————-

3.2.14   clean_up_old_sockets

— **sman.cleanupoldsockets** —

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

————-

3.2.15   fork_you

— **sman.forkyou** —

```
static SpadProcess *
fork_you(int death_action)
```

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

————-

3.2.16   exec_command_env

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

— **sman.execcommandenv** —

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

————-

3.2.17   spawn_of_hell

— **sman.spawnofhell** —

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

————-

3.2.18   start_the_spadclient

run a AXIOM client in the main process
                — **sman.startthespadclient** —

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

————-

3.2.19   start_the_local_spadclient

                — **sman.startthelocalspadclient** —

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

————-

3.2.20   start_the_session_manager

— **sman.startthesessionmanager** —

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

————-

3.2.21   start_the_hypertex

— **sman.startthehypertex** —

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

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

————-

3.2.22   start_the_graphics

— **sman.startthegraphics** —

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

```
{
  spawn_of_hell(GraphicsProgram, DoItAgain);
}
```

———-

3.2.23   fork_Axiom

— **sman.forkAxiom** —

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

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

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

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

    if ((ptsNum =  open(ptsPath, O_RDWR)) < 0 ) {
      perror("fork_Axiom: Failed to reopen server");
      exit(-1);
    }
#if defined(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);
  }
}
```

———-

3.2.24   start_the_Axiom

— **sman.starttheAxiom** —

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

```
}
```

———-

3.2.25   clean_up_sockets

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

— **sman.cleanupsockets** —

```
static void
clean_hypertex_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_hypertex_socket();
}
```

———-

3.2.26   read_from_spad_io

— **sman.readfromspadio** —

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

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

———-

3.2.27   read_from_manager

— **sman.readfrommanager** —

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

———-

3.2.28   manage_spad_io

— **sman.managespadio** —

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

```
  while (1) {
    rd = socket_mask;
    FD_SET(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);
    }
  }
}
```

————-

3.2.29   init_spad_process_list

— **sman.initspadprocesslist** —

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

————-

3.2.30   print_spad_process_list

— **sman.printspadprocesslist** —

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

————-

3.2.31   find_child

— **sman.findchild** —

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

————-

3.2.32   kill_all_children

— **sman.killallchildren** —

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


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

}
```

———-

3.2.33 clean_up_terminal

— **sman.cleanupterminal** —

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

———-

3.2.34 monitor_children

— **sman.monitorchildren** —

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

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

—————-

3.2.35   main sman

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

— **sman.result** —

```
  return(0);
```

—————-

— **sman.main** —

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

  init_term_io();
  init_spad_process_list();
  start_the_Axiom(envp);
  if (open_server(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_ht)               start_the_hypertex();
  if (start_graphics)         start_the_graphics();
```

```
  sleep(1);

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

————-

3.2.36   sman.c

— **sman.c** —

```
#define _SMAN_C

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

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

————-

Chapter 4

Support Routines

4.1 Command Completion

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

Chapter 5

The `viewman` program

———-

Chapter 6

The hypertex program

— the hypertex command line —

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

————-

Chapter 7

The `clef` program

<div align="center">— the clef command line —</div>

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

<div align="center">————-</div>

Chapter 8

The session program

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

————-

8.1 session

8.1.1 includes

— ses.includes —

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

————-

8.1.2 variables

— ses.variables —

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

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

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

Sock_List *plSock = (Sock_List *) 0;

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

————-

8.1.3   usr1_handler

— **ses.usr1handler** —

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

————-

8.1.4   usr2_handler

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

— **ses.usr2handler** —

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

————-

8.1.5   term_handler

— **ses.termhandler** —

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

————-

8.1.6   pr

— **ses.pr** —

```
static void
pr()
{
  Sock_List *pSock;

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

————-

8.1.7   close_client

— **ses.closeclient** —

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

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

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

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

  /* now check the rest */

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

```
#endif
}
```

————-

8.1.8   read_SpadServer_command

— ses.readSpadServercommand —

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

————-

8.1.9   test_sock_for_process

— ses.testsockforprocess —

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

————-

8.1.10   read_menu_client_command

— **ses.readmenuclientcommand** —

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

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

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

```
  }
}
```

————-

8.1.11 read_from_spad_io

— **ses.readfromspadio** —

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

————-

8.1.12 kill_spad

— **ses.killspad** —

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

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

————-

8.1.13   accept_session_connection

— **ses.acceptsessionconnection** —

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

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

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

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

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

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

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

```
        {
            int command = get_int(spad_server);
            /* XXX hack -- the whole protocol looks broken, we just
            try to detect losage */
            if (command != CreateFrameAnswer) {
                fprintf(stderr, "session: non-fatal, got out of sync "
                                "with Spad server\n  (lost race)\n");
            /*    exit(1); */
            }
        }
        plSock->Socket.frame = get_int(spad_server);
        active_session = (Sock *)plSock;
        get_string_buf(spad_server, big_bad_buf, BufSize);
        ret_code = swrite((Sock *)plSock, big_bad_buf, strlen(big_bad_buf)+1,
"session: writing to InterpWindow");
        if (ret_code == -1)
return -1;
        num_active_clients++;
#ifdef DEBUG
pr();
#endif
        return plSock->Socket.purpose;
    }
    return (-1);
}
```

———-

8.1.14   read_from_session

— **ses.readfromsession** —

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

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

——————-

8.1.15   manage_sessions

— ses.managesessions —

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

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

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

    /* Allow the active_session if set */
    if (active_session) FD_SET(active_session->socket, &rd);
#ifdef DEBUG
fprintf(stderr,"[rd=%u ",*((long *)rd.fds_bits));
#endif

    ret_code = sselect(FD_SETSIZE, &rd, &wr, &ex, NULL);
    if (ret_code == -1) {
break;
    }
#ifdef DEBUG
fprintf(stderr,"rd=%u]\n",*((long *)rd.fds_bits));
#endif

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

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


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


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


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

———-

8.1.16   main sessionmanager

— **ses.main** —

```
int
main(void)
{

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

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

```
#endif
    FD_SET(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);
}
```

————-

8.1.17   session

— **session.c** —

```
/* #define DEBUG */
#define _SESSION_C
```

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

————-

Chapter 9

The `spadclient` program

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

————-

9.1   spadclient

— spadclient.c —

```
#define _SPADCLIENT_C

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

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

Sock *sock;

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


int
main(void)
{
```

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

————-

Chapter 10

The Command Completion List

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

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

```
apply
applyQuote
applyRules
approximants
approximate
approxNthRoot
approxSqrt
aQuadratic
aQuartic
areEquivalent?
arg1
arg2
argscript
argument
argumentList!
argumentListOf
arity
aromberg
arrayStack
asec
asech
asechIfCan
asecIfCan
asimpson
asin
asinh
asinhIfCan
asinIfCan
aspFilename
assert
assign
assoc
associatedEquations
associatedSystem
associates?
associative?
associator
associatorDependence
atan
atanh
atanhIfCan
atanIfCan
atom?
atoms
atrapezoidal
att2Result
augment
autoReduced?
axes
axesColorDefault
B1solve
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
changeThreshhold
changeVar
changeWeightLevel
char
character?
characteristic
characteristicPolynomial
characteristicSerie
characteristicSet
charClass
charpol
charthRoot
chebyshevT
chebyshevU
check
checkCxResult
checkForZero
checkMxCDF
checkMxDF
checkPrecision
checkResult
checkRur
child
```

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

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

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

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

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

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

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

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

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

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

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

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

```
FormatRoman
formula
fortran
fortranCarriageReturn
fortranCharacter
fortranCompilerName
fortranComplex
fortranDouble
fortranDoubleComplex
fortranInteger
fortranLinkerArgs
fortranLiteral
fortranLiteralLine
fortranLogical
fortranReal
fortranTypeOf
fprindINFO
fracPart
fractionFreeGauss!
fractionPart
fractRadix
fractRagits
freeOf?
Frobenius
frobenius
front
froot
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?
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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
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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

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TopLevelDrawFunctionsForCompiledFunctions
TopLevelDrawFunctionsForPoints
TopLevelThreeSpace
TranscendentalHermiteIntegration
TranscendentalIntegration
TranscendentalManipulations
TranscendentalRischDE
TranscendentalRischDESystem
TransSolvePackage
TransSolvePackageService
TriangularMatrixOperations
TrigonometricManipulations
TubePlotTools
TwoDimensionalPlotClipping
TwoFactorize
UnivariateFactorize
UnivariateLaurentSeriesFunctions2
UnivariatePolynomialCategoryFunctions2
UnivariatePolynomialCommonDenominator
UnivariatePolynomialDecompositionPackage
UnivariatePolynomialDivisionPackage
UnivariatePolynomialFunctions2
UnivariatePolynomialMultiplicationPackage
UnivariatePolynomialSquareFree
UnivariatePuiseuxSeriesFunctions2
UnivariateSkewPolynomialCategoryOps
UnivariateTaylorSeriesFunctions2
UnivariateTaylorSeriesODESolver
UniversalSegmentFunctions2
UserDefinedPartialOrdering
UserDefinedVariableOrdering
UTSodetools
VectorFunctions2
ViewDefaultsPackage
ViewportPackage
WeierstrassPreparation
WildFunctionFieldIntegralBasis
XExponentialPackage
ZeroDimensionalSolvePackage
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Chapter 11

Research Topics

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

11.1 Proofs

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

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

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

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

11.2 Indefinites

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

11.3 Provisos

We would like to create "provisos" on statements such as:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Chapter 12

Makefile

<center>—— * ——</center>

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

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

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

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

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

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

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

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

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

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

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

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


        ————-
```

Bibliography

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