O-Plan

User Guide

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1 Introduction

1.1 Contents of this Guide

The aim of this guide is to provide the user with an overview of setting up and running the O-Plan system. This guide assumes that the O-Plan system has been successfully extracted from the tar image file and installed and compiled correctly.

You should have installed O-Plan in a directory different from any directory used for an earlier version of O-Plan to avoid any confusion between files from different versions. The installation procedure is described in the `INSTALL` file included in the O-Plan distribution. In the remainder of this document it will sometimes be assumed that there is a shell command, `oplan`, that can be used to invoke O-Plan. The `INSTALL` file describes how to establish such a command.

This guide is divided into the following sections:

1. **Setting up to run O-Plan**: this section describes the O-Plan startup script and the environment variables used to run the system.
2. **Running O-Plan**: this section describes how to run the O-Plan system as a planning.
3. **Plan and World Interfaces**: this section describes the PlanWorld interface used by O-Plan to allow the user to examine on either the plan or world state.
4. **O-Plan Processes and Internal Structure**: this section provides an overview of the way in which an O-Plan agent is implemented in terms of the the mapping of *processes* to components and the way in which these components communicate.
5. **Typing Lisp Commands**: this section deals with inputting of Lisp commands into the O-Plan system, e.g. to turn on some of the debugging tools.
6. **Dealing with Lisp Errors**: this sections deals with Lisp errors which sometimes occur. These can either be caused by typing errors in entering Lisp commands or by errors in the O-Plan code. In the latter case they should be reported to the O-Plan development team.
7. **Control Panel and Trace Information within O-Plan**: this section deals with obtaining different levels of trace information within the O-Plan system.
8. **Example Demonstration**: this section provides step by step instructions on running an example demonstration.

2 Running O-Plan and its Interfaces

The aim of this section is to describe the environment variables and scripts which have been provided with the O-Plan system together with details of the interface which allows for developer access to the various components.

2.1 O-Plan Scripts

A single script has been provided to start the O-Plan system and this is as follows:

1. **oplan**
   This provides the basic O-Plan system with a textual interface for plan and world state browsing.

See Section 4 of this document for further details on the Plan and World Viewers.

2.2 Environment Variables used by O-Plan

In order to run the demonstrations the user should be in the X windows environment and if this is not the case the the user should issue the necessary commands to invoke it. In most cases, it is not necessary for users to set any environment variables themselves. However, the user may set some of the variables in order to change the defaults if that is desired. The following sections describe the environment variables which are used, their purpose and where necessary their setting or defaults.

- **setenv** OPLANDIR **<directory name>**
  The directory name should be the full name of the directory that contains the O-Plan system. This variable is set by the `oplan` script which should have been edited prior to the first invocation of O-Plan as part of the installation procedure. The script's value persists only for the duration of the run. Users may also wish to set this variable in their global environment as a shorthand way of specifying the top level of the O-Plan file structure. That is how it will be used below. However, that setting will have no effect on the value used by `oplan`.

- **setenv** OPLANTMPDIR **$**HOME**/oplan-tmp**
  Specifies the directory into which temporary files generated by the O-Plan system will be written. It is recommended that this environment variable be set to `oplan-tmp` in the users $HOME directory for uniformity with other O-Plan installations. Alternatively it may be:

  1. set to any user specified directory to which the user has the necessary read and write access privilege
  2. left unspecified in which case all temporary files will be written to the user's current working directory

2.3 Setting up to Run O-Plan

The O-Plan system is invoked from the startup script `oplan` which is held in the $OPLANDIR`/bin` directory. There are several ways to arrange for this script to be accessible as a shell command.

1. Define a shell alias, for shells that provide aliases. For instance, `tcsh` users can add the following line to their home directory's `.tcshrc` file:

   ```
   alias oplan "/applications/oplan/bin/oplan"
   ```

   Note that you do not have to use the name `oplan` for the alias.

2. Alter your `PATH` to include the directory containing the script.

3. Move the script to a directory which is on the users current `PATH`.

The O-Plan system is menu driven and requires the X Window System.

3 Running O-Plan

Once the setup steps have been carried out (defined in subsections 2.2 and 2.3) O-Plan can be invoked by typing the relevant command. For example:

```
oplan
```

When you start O-Plan, a number of windows should appear. The first window to appear (`O-Plan Running Processes`) displays the names of the currently running parts of O-Plan. This window is described later in this document in the Pseudo-processes section. After that, one window will appear for the Task Assigner (TA) and one for each of the components of the planner (IM, AM, DM, KP). Finally a control panel (CP) window will appear over the top of the IM window. The window in which you typed the `oplan` command will stay connected to O-Plan. When all the other windows have appeared, the prompt `form>` should appear in this window. You can type Lisp commands in this window and consequently it is called the Lisp interaction window. For more information see the section Typing Lisp Commands below.

The window configuration is specified by the `-config` argument to the `oplan` command. The default, screen-filling, configuration can also be specified by starting O-Plan as follows:

```
oplan -config oplan-planner-default
```

The planner will be brought up in its uninitialised state. This will be indicated by a message at the top of the TA window. The message will also indicate the date the image was created as well as the version number.

Each of the separate parts of the planner has its own window which allows the user to follow the plan as it is being generated. The major parts of the O-Plan systems are described in the Section 3.4.

3.1 O-Plan Command Line Arguments

The `oplan` startup script has been designed to accept a number of optional arguments which allow the user to customise certain aspects of the systems functions and display formats. A partial list of the arguments are as follows:

Argument	Description
-break	Enters the Lisp break loop. This allows the user to examine the state of the world before O-Plan starts up or to call O-Plan procedures without starting O-Plan.
-config <`filename`>	Use the indicated configuration file. A series of configuration files are provided in $OPLANDIR/`lib`.
-eval <`form`>	Evaluate <`form`>, where <`form`> is a Common Lisp expression.
-load filename	Load the indicated file.
-noinit	Do not load any `oplan-init` file.
-tfc <tfc-arg, ...>	Run the TF syntax checker rather than as O-Plan. All arguments after the `-tfc` will be processed by the syntax checker.

Note that all arguments are processed *before* O-Plan considers loading an `oplan-init` file. If you need something to happen earlier, use `-eval` or `-load`.

3.2 The oplan-init file

When O-Plan starts, it looks for a file named `oplan-init`, first in the current directory and then in the user's home directory. If the file exists, is is loaded into Lisp.

The oplan-init file can contain (Lisp) commands that customise certain aspects of O-Plan. At present, only a few such customisations are defined. See the sections on defining a PostScript viewer and on the whats-going-on file for details.

3.3 Exiting O-Plan

The standard way to exit is to use the Quit option in the Task Assigner menu or to press the Quit button in the control panel window. However, if something has gone wrong, these methods may not work. In that case, you have several options.

The fastest way to exit is to type the quit character (usually control and backslash) in the Lisp interaction window. All the other windows should vanish, and Lisp will exit, leaving you back at the shell. This is a hard exit. Lisp may not perform cleanup tasks such as flushing buffered output. Typing control and C in the Lisp interaction window will also cause all other windows to vanish, but in most cases Lisp will not exit. To exit from Lucid Common Lisp, type `(lcl:quit)`.

3.4 Major Components of the the O-Plan System

The screen image in Figure 1 shows the screen layout for the planner after the initial setup. O-Plan provides an interface which allows for developer access to the various components. These components are as follows:

- Task Assignment Window
  This window allows the user to give a range of top level commands, such as giving the

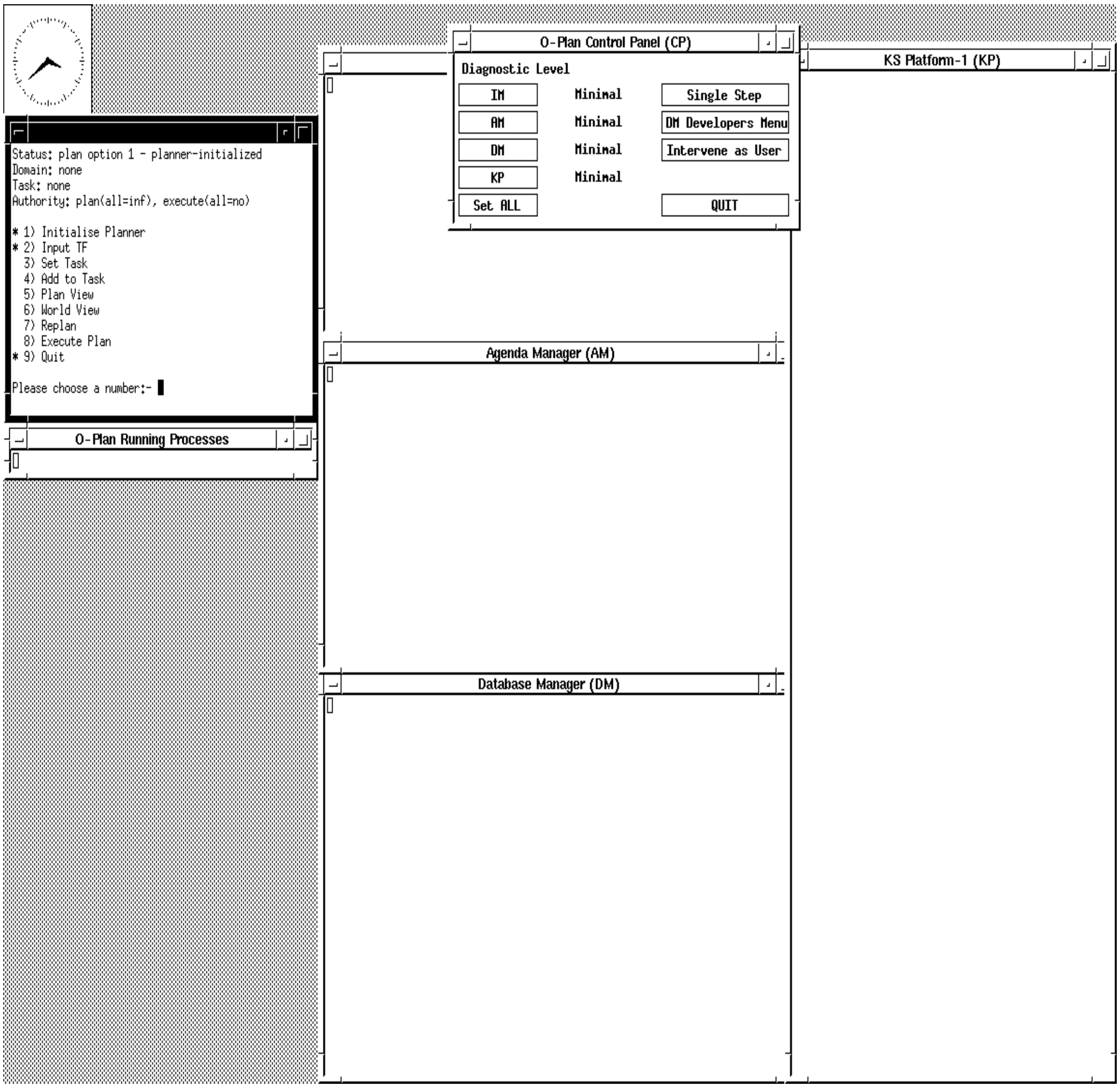

Figure 1: Example screen image from the O-Plan System

planner a new task, examining on certain aspects of the plan once it has been generated.

- Interface Manager
  The interface manager handles interactions with agents external to the planner, such as the task assignment agent. The control panel is part of the Interface Manager and is used to output changes in the levels of diagnostics.

- Agenda Manager
  The agenda manager keeps track of the current *issues* within the plan and decides which issue to tackle next. A issue describes a particular problem in the plan which needs to be addressed. For example, expand an action to a more detailed level, make sure that a condition of an action is satisfied at the right point, ensure enough resources are available for an action, etc.

- Database Manager
  The database manager provides the support routines required by the knowledge sources and holds the emerging plan as it is being generated.

- Knowledge Source Platform
  All decision making within O-Plan is carried out through knowledge sources. There is a separate knowledge source for each possible flaw type within a plan and the invocation of the appropriate knowledge sources is one of the functions of the agenda manager. Knowledge sources run on a knowledge source platform. In the current system there is only one such platform.

- Running lights
  The running lights window shows the user which component is currently active, and in the case of problems where the error may have occurred.

The user should identify each of the above components of the screen as they will be frequently referenced in the Example Demonstration Section.

3.5 Compiling O-Plan Domains

The input language used by the O-Plan system is Task Formalism (TF) which is used to describe the actions, their decomposition and constraints, tasks, resources in the domain, etc. In order to ensure that the *syntactic* description of a domain (in TF format) is correct a command has been provided. (This assumes the user has defined an alias `oplan` to invoke the O-Plan system. If an alternative method has been defined the command should be altered accordingly)

```
oplan -tfc
```

The command will provide a trace of the compilation process and will indicate via appropriate messages where syntax errors have occurred in the encoding of a domain. A full description of the TF language can be found in the O-Plan TF Manual.

3.6 O-Plan Sanity Checker

The O-Plan sanity checker can be run from the window in which the O-Plan system was invoked. After start-up the window remains attached to the O-Plan system and is capable of accepting Lisp expressions.

The sanity checker should be run after a plan has been produced and its function is to check that certain aspects of the plan are syntactically correct. For example, all conditions have a contributor, all actions which need expanding have been, etc. Any error reports will appear in the Lisp interaction window. The number of errors will be reported to the TA window, and the user will need to type return in the TA window to continue. To run the sanity checker type `(sanity-check)` in the Lisp-interaction window.

4 Plan and World Viewers

In addition to the default text based viewer O-Plan also provides the ability to view plans via a PostScript viewer. One of the plan-view options in the Task Assignment menu is `Plan View`. This causes a PostScript picture of the current plan nodes and their order relationships to be printed on a PostScript printer. It is assumed that the Unix command `lpr` refers to such a printer by default. (That is, `lpr` is called without a `-P` argument to select a non-default printer.)

However, a number of PostScript viewers are available, and they allow a user to display PostScript output on their screen rather than waiting for a hardcopy. It is possible to inform O-Plan of such a viewer by defining the `:ps-viewer` parameter in an `oplan-init` file. For instance, to use GhostView, a user would place the following line in their `oplan-init` file:

```
(set-parameter :ps-viewer "ghostview -landscape")
```

When this parameter has a value (the default is as above), a "Viewer one page" option will appear in the "Output format" menu (the menu that appears when a user selects `Print graph` as the plan display mode). Selecting this option will cause the viewer to be run. The viewer is run in the background, and O-Plan can continue independently. However, O-Plan might not exit completely until the viewer has exited as well.

If you have difficulty getting a viewer to work, it may help to know that the viewer and `lpr` are invoked using the Unix command

```
(viewer tmpfile ; /bin/rm tmpfile)&
```

where viewer is, e.g., `lpr` or `ghostview -landscape` and `tmpfile` is the name of a temporary file generated by O-Plan.

5 User Interaction with the Planner

The O-Plan planner allows the user to intervene at any time during the planning process to examine on the plan and world state and to set certain modes which allow the user to take choices on behalf of the planner. To intervene in the planning process the user needs to click in the `Intervene as User` button on the `O-Plan Control Panel`. As a result a menu will appear with the following options:

```
Plan View
World View
Set Modes
Break in
Poison
Quit
```

Each of the options will now be described in further detail.

Plan View : This requests a view of the Plan which can be generated in several different formats:

- Text to screen: the plan will appear in the PlanWorld Viewer window.
- Text to file: the plan will be sent to a user named file.
- Print Graph: the plan can be sent to an appropriate print device.

World View :This requests a view of the World at a particular point in the plan and can be generated in several different formats:

- Text to screen: the description will appear in the PlanWorld Viewer window.
- Text to file: the description will be sent to a user named file.

Set Modes : This allows the user to change the mode of *three* types of choice in the planner. The modes can be set to either `ask` or `auto` and can be changed by clicking on the option with the mouse. The modes are as follows:

Binding mode deals with the binding of specific values to variables in the plan state.

Schema selection mode deals with the choice of schema for an expansion of a node.

Poison Handler mode deals with the choice of an alternative plan state should the current one prove fruitless.

When the planner encounters a choice in a mode set to `ask` it will prompt the user with an appropriate menu from which the user must choose. The user is free to change mode as often as desired during the planning process.

Break in : This requests the planner to allow the user access to the O-Plan system. When this option is chosen a window will appear as follows: (`Planner User (KS-USER)`

```
>>Break: User Intervention

KS-USER-BREAK:
:C  0: Return from Break
    1: Return to pprocess scheduler

->
```

The user is allowed to type any Lisp expression which can be evaluated. The user must remember to return from the break by chosing the appropriate option from the menu[1].

Poison : This requests the planner to poison the current plan state and to provide the user with a list of alternative plan states from which the user must choose one. The planner will then continue the planning process from this new plan state.

[1]The option and number will vary according to the outcome of expressions typed by the user

6 O-Plan Processes and Internal Structure

Most of the time, users do not have to know anything about how O-Plan works internally. However, a reasonably accurate model of how the system works may make it easier to understand its behaviour, especially when something goes wrong. Since the processing model used in version 3.1 may not be familiar to all users, this section provides a brief description. It also serves to explain the contents of the "run-lights" window.

An O-Plan agent, such as the planning or execution agents, contains a number of components (Database Manager, Agenda Manager, etc) that run in a semi-independent fashion and accomplish certain tasks by sending each other messages.

O-Plan version 3.1 runs as a single invocation of Lisp as a single Unix process. Version 1 ran as several separate invocations of Lisp which communicated via sockets. Consequently, later versions are sometimes referred to as the "single-process" version. This has lower communication overheads and is easier to manage, but the appearance of independent operation is sometimes less complete.

In the single-process version of O-Plan, each component is implemented as a pseudo process or p-process. They are pseudo because, unlike real processes, they don't represent an independent thread of control. They are more like event handlers. An agent's main loop calls each p-process in turn so long as there is a message for it to handle. The p-process usually handles one message and then returns to the main loop.

When O-Plan is started, a small one-line window will appear before all of the other windows. This window is called the `Running Processes` window. It displays the names of the parts of O-Plan that are currently running or waiting for a running component to return a value. The window has the title "O-Plan Running Processes" and is usually placed just below the Task Assignment window.

Ordinarily, only one p-process is active at once and they run in turns in a round-robin fashion. However, in some cases (such as DM requests), one p-process calls another as a subroutine. In this case the calling p-process will be shown to the left of the one it calls. For instance, if the DM is running in the ordinary way, a user will see:

```
+----------------------+
|:DM                   |
+----------------------+
```

But if KP calls the AM and the AM calls the DM before returning, a user will see:

```
+----------------------+
|:KP :AM :DM           |
+----------------------+
```

In this case, only the DM is actually running. The AM is waiting for the DM to return some result, and KP is waiting for the AM.

Certain things cannot happen while the system is waiting for a p-process to return. In particular, no other p-processes can run. So if a button in pressed in the control panel, or an expression typed in the Lisp interaction window, or a "Plan View" or "World View" selected in the Task Assigner window, the requested effects may not happen immediately.

Whenever O-Plan does not seem to be responding as expected when something has been typed or selected from a menu entry, user should look at the "running processes" to see what part of O-Plan is currently running. It is possible that the user may have forgotten to answer a question or to select a menu entry, so that O-Plan is waiting for the user to do that before going on.

7 Typing Lisp Commands

When starting O-Plan, the window in which the `oplan` command was typed does not return to the shell prompt. Instead it functions as a read-eval-print loop in which a user can type Lisp commands. It is also used for some low-level messages from O-Plan. This window is called the "Lisp interaction window". Most of the time, a user can ignore it, but may have to use it from time to time, e.g. to turn on some of the debugging tools. Any Lisp expression can be typed as a command.

It's possible to type commands because there's a (pseudo-)process that waits for input from this window and evaluates it when it comes. When a command is typed, there may therefore be a delay, until the next time this pseudo-process gets to run, before the command is evaluated.

Note that if the input typed into the interaction window doesn't amount to a complete Lisp expression, the whole system will eventually stop and wait for the expression to be completed. In particular, this will happen if you `<return>` is typed in the interaction window. A user can see this has happened by looking at the one-line "Running processes" window. If nothing seems to be happening, but the :LISP-LISTENER process is running, it may be because the user has typed some incomplete input.

The listening p-process prints `form>` as a prompt, but the output that goes to the interaction window sometimes causes the prompt to go off the top of the screen.

If a Lisp error occurs during the evaluation of a command that was typed into this window, it is possible to get out of the error *break loop*, and hence allow O-Plan to continue running, by using a *restart* that has been set up for this purpose. Look for the option that says `Return to O-Plan`. A user can usually select this option by typing `:a` or `1`. An example will make this a bit clearer:

```
form> (not-a-function)
>>Error: The function NOT-A-FUNCTION is undefined

SYMBOL-FUNCTION:
   Required arg 0 (S): NOT-A-FUNCTION
:C  0: Try evaluating #'NOT-A-FUNCTION again
    1: Return to O-Plan
    2: Return to pprocess scheduler

-> :1
Return to O-Plan
NIL
t
form>
```

8 Dealing with Lisp Errors

By “a Lisp error” we mean that O-Plan or the Lisp system invokes the Lisp error signalling mechanism rather than, say, just printing a message. Unless the error is caused by an erroneous command typed into the Lisp interaction window, it is usually due to a bug in O-Plan and should be reported.

Your options for dealing with the Lisp error depend on what O-Plan was doing when it occurred.

When a Lisp error occurs in the TF compiler, a menu will appear to make sure you notice the error. There will be only one option, “ok”. Select “ok” to continue. The TF compiler will exit and report that the file contained an error. That is, a Lisp error is treated as if it were a single syntax error that applied to the whole TF file.

When the error occurs in some other part of the planner, there is typically no neat way to recover from it, and a more complex menu appears. It will look something like this:

```
Lisp error in process <process-name>
------------------------------------
Allow the error
Return to scheduler
Force global reset
```

`<Process-name>` will be replaced by the name of the process that was running when the error occurred: :AM, :DM, :KP, etc. You should look in the window associated with that process to see the error message. The meanings of the options are as follows:

Description Allow Lisp to handle the error. This will usually result in a “break loop” as described below. Select this option if you plan to report the bug, because the bug report should include a “backtrace” (also described below).

Return to scheduler Exit the process in which the error occurred so that the system can continue running. In most cases, this will not work very well, because the process in which the error occurred needed to finish some task that was interrupted by the error. This sort of recovery can also be attempted from a break loop, as described below (again).

Force global reset Attempt to reinitialise O-Plan. This will abandon the attempt to find a plan (or whatever O-Plan was doing) and start over as if you had selected the ”Initialise planner” option in the TA. It is equivalent to evaluating the Lisp expression (force-reset).

When the Lisp system handles an error, Lisp usually enters a “break loop” in one of the O-Plan windows. Ordinarily, you will see a menu first, as described above. In any case, you can tell that Lisp has entered a break by the following signs:

1. O-Plan will stop producing any output.

2. The one-line “running processes” window will stop changing.
3. There will be an error message in a window associated with the rightmost name in the “running processes” window.
4. The window will be displaying the “¿” prompt.

The first two can also happen when O-Plan is merely taking a long time to do something; the others cannot.

In a break loop, the normal ways of exiting O-Plan by using the control panel or the TA menu will not work. However, you can type Lisp debugger commands and Lisp expressions in the the window, after the “>” prompt. Typing

```
(exit-oplan)
```

should cause O-Plan to exit.

```
(force-reset)
```

attempts to reset the system by wiping out all pending messages, sending itself an `:INIT` message, and returning to the process scheduler.

If you're planing to report a bug, you should get a “backtrace” before exiting. It shows the nested Lisp procedure calls that led up to the error. Get a backtrace by typing “::b” after the “>” prompt. Grab the resulting output and the error message with the mouse and put them both in the bug report.

In some cases you can (and may want to) get O-Plan to continue after an error. This is most likely to be so when the error is in a relatively peripheral part of the planner, such as the PW viewer, but it can happen in other cases too.

In some cases, the Lisp system will offer you a reasonable way to continue from the error, so always look at the options that appear after the error message.

Another form of recovery that sometimes makes sense is to get O-Plan to abandon its current activity and allow other parts of the system to run. You can accomplish this by selecting “Return to pprocess scheduler” from the restart options presented after the Lisp error message. (This is equivalent to choosing ”Return to scheduler” from the menu appears when the error is first noticed.)

This approach should be tried only when the error occurs during a relatively self-contained activity. An example might be a Lisp error when the PlanWorld Viewer tried to display a plan. By returning control the the scheduler, you could get the viewer to abandon this attempt This would work fairly well because nothing else in the system depends very strongly on the viewer succeeding. On the other hand, it would not work very well if, for instance, the DM ran into an error somewhere deep in the World State manager. In such cases, you might try typing the command (force-reset) instead.

9 Control Panel and Trace Information within O-Plan

The control panel allows the developer to set the levels of diagnostic information and monitors within the system. Diagnostic levels can be set in a range of values from `none` through to `all` where all messages are printed. In most cases setting the level to `emergency only` is usually sufficient. The control panel also allows the developer to place the system into single step mode in which the developer is prompted on each agenda cycle to choose the next agenda to be processed. A description of the single step mechanism is given in step 6, (Agenda Manager Processing Options) of Section 10 which describes how to run an O-Plan demonstration.

The running lights process shows the developer which component is currently running and in the case of a problem allows the developer to easily identify in which component a problem has occurred. The running lights window is controlled from a variable which allows the output to be turned on and off. This can be achieved as follows:

To turn the running lights on (the default), have Lisp evaluate:

```
(run-lights-on)
```

To turn the running lights off, have Lisp evaluate:

```
(run-lights-off)
```

One way to get Lisp to evaluate these expressions is to type them in the Lisp interaction window; another is to put them in the user's "oplan-init" file. Note, however, that the oplan-init file is examined only when O-Plan first starts up.

10 Example Demonstration

The demonstrations allow the user to gain a gentle introduction to the O-Plan systems through a series of simple worked examples. This section describes the basic steps involved in running any of the demonstrations.

The O-Plan system is menu driven (via the Task Assignment Window) which allows the user to issue high level commands to the system. The Task Assignment Window contains the following menu items:

```
Status: Version <no> <date> <status of the planner> either:
        uninitialised, planner initialised, planning,
        replanning, executing, planner finished
Domain: one of none, <file> or <file> + <file>
Task  : one of none or <task name>
Authority: plan(all=inf), execute(all=no)

* 1) Initialise Planner
  2) Input Task
  3) Set Task
  4) Add to Task
  5) Plan View
  6) World View
  7) Replan
  8) Execute Plan
* 9) Quit

Please choose a number:-
```

In the Task Assignment Window items marked with a `*` are the only ones available from the planner at any point. A demonstration can be broken down into ten distinct stages:

1. **Initialising the System**
   Initialises the system ready for a new TF domain description to be accepted.

   In order to carry out this step the following should be used:

   > Move the mouse to the Task Assignment Window and enable the window for keyboard input. Enter 1, (followed by carriage return) and this will initialise the planner ready for the demonstration. Wait until the planner initialised message appears in the `Status` banner of the Task Assignment Window.

2. **Specifying the Domain**
   This part of the demonstration informs the planner of which domain is to be used, e.g. block stacking, house building, etc.

   In order to specify this information the following step should be used:

Enter 2 from the Task Assignment Window. This will cause a further menu to appear which describes the problem domains available in the $OPLANDIR/TF directory. Use the mouse pointer to either:

(a) choose the file which contains the domain description you wish to use.

(b) choose the `Change directory` option. The user will be presented with a menu listing the previous TF directories visited (where appropriate) and an option to type in a new directory name. The user must either chose a directory from the menu or type the name of a new directory after the prompt in the Task Assignment window. The TF files in the specified directory will now be displayed.

(c) choose the `Enter filename` option and type the name of the file after the prompt in the Task Assignment window.

Wait until the Task Assignment Window `Status` banner displays the message that is has successfully set up for the chosen domain.

3. **Specifying the Task**

   This part of the demonstration informs the planner of the particular task to be carried out within the domain. For example, the order of the completed stack of blocks, the type of house, etc.

   In order to specify this information the following step should be used:

   Enter 3 from the Task Assignment Window. This will cause a new menu to appear which describes the particular tasks in the domain you may choose from (the list of task schemas in the TF file). Use the mouse pointer to choose the task you wish the planner to solve.

4. **Adding a New Action to the Plan**

   This part of the demonstration informs the planner that the user wishes to add further requirements to the plan. These can be added once a plan has been generated and during the subsequent execution of the plan.

   In order to specify this information the following step should be used:

   Enter 4 from the Task Assignment Window. This will cause a new menu to appear which has a single option to "Add an action". Use the mouse pointer to choose the option. The Task Assignment Window will now be cleared to allow the input of the new action e.g. (evacuate Calypso 20), (install kitchen_equipment), etc.

5. **Running the Planner on the Task**

   This part of the demonstration usually involves little interaction from the user apart from watching the messages from various windows. However, the user is free to intervene as described in Section 5 should they wish to though it is not expected as part of a demonstration. As the planning processing moves forward text will appear in each of the interface manager, agenda manager, database manager and ks-platform windows respectively. The text gives a trace of the planner as it solves the problem. It is not necessary as part of the demonstration to understand the information as it is being displayed.

6. **Messages and Diagnostics**
   The level of messages will be the default (normally short one line messages). Greater or lesser levels of messages can be selected for O-Plan using the Interface Manager's Control Panel.

7. **Agenda Manager Processing Options**
   The user may also control the order in which outstanding tasks (agenda entries) are processed by the the O-Plan system. This is achieved by placing the O-Plan system into single step mode. This is achieved by chosing the `Single Step` button from the Control Panel. This will result in the following menu being displayed in the Agenda Manager window.

   Agenda Manager Interrogator:
   Stopped in cycle 61

   (a) `Display the Agenda Table`: Display current list of outstanding tasks
   (b) `Display the Untriggered Agenda Table`: Display the current list of untriggered agenda entries.
   (c) `Display the Alternatives Agenda Table`: Display the list of alternative plan state to explore
   (d) `Process the top agenda entry`: Send the top entry for processing
   (e) `Process any agenda entry`: Send a specified entry for processing
   (f) `Schedule KS-USER`: This will schedule the KS-USER knowledge source to run on the next cycle of the planner. This will allow the user to choose options from the menu described in Section 5.
   (g) `Break in`: This allows the user to interrogate the contents of particular datastructures within the LISP code. You may resume O-Plan by typing `0`
   (h) `Quit single step mode`

8. **Browsing on the Plan**
   Once the plan has been generated (or while it is being generated) by the O-Plan system it can be viewed in a number of ways. In order to specify the display mode Enter 5 from the Task Assignment Window. This will invoke[2] the PlanWorld window which will display information from the planner and allow the user to specify file names where necessary.

   The user will now be presented with a menu showing the different viewing formats available. These are as follows:

   (a) `Text to screen`: Send each node of the plan to the PlanWorld window in the following format:

```
Node Number: node-3-10-2
   Begin_end Predecessors : (end_of node-3-9-1 begin_of node-3-10)
   Begin_end Successors   : (end_of node-3-10-2)
```

[2]Assuming the window is not already present

```
End_end Predecessors   : (begin_of node-3-10-2)
End_end Successors     : (begin_of node-3-9-8 begin_of node-3-10-3)
Earliest_start_time    : 7~00:00:00
Latest_start_time      : infinity
Earliest_finish_time   : 9~00:00:00
Latest_finish_time     : infinity
Minimum_duration       : infinity
Maximum_duration       : infinity
Node_type              : action
Node_pattern           : "(pour basement floor)"
```

In most cases the size of the plan will cause information to be lost off the top of the window and the user is advised to place the window in `scroll mode` buy pressing the middle mouse button and the control key simultaneously and chosing the `Enable Scrollbar` option from the menu which appears.

(b) `Text to File`: Send the plan to the file name specified by the user and place it in the directory specified in the environment variable $OPLANTMPDIR. The user will be prompted for the file name via the PlanWorld window. The format of each node in the file is as follows:

```
node
  <node number>
  (<begin end predecessors>)
  (<begin end successors>)
  (<end end predecessors>)
  (<end end successors>)
  (<earliest-start> <latest-start> <earliest-finish> <latest-finish>
        <min-duration> <max-duration>)
  <node type>
  <node pattern>
end_node
```

An example of a node is as follows:

```
node
  node-3-4-1-2
  (end_of node-3-4-1-1)
  (end_of node-3-4-1-2 begin_of node-3-4-1-2-1)
  (begin_of node-3-4-1-2 end_of node-3-4-1-2-1)
  (begin_of node-3-4-1-3)
  (0 1728000 172800 1900800 172800 1900800)
  action
  "(ground_move 107th_acr_%byair ft_meade_port andrews_afb_naf_afb)"
end_node
```

(c) `PostScript Graph`: Send the plan to a Postscript printer for printing. The user will be presented with a second menu from which they must chose:

  i. `Single page`: Send a copy of the plan (scaled to fit on a single sheet of A4) directly to a specified hardcopy device.
  ii. `Multiple Pages`: Send a copy of the plan (split across multiple sheets of A4) directly to a specified hardcopy device.

  Once the user has chosen their required output format a further menu will appear indicating the number of levels. The user can either chose to display the plan to a required level or display all nodes of the plan by chosing the `all` option.

9. **Browsing on Plan State Information**
   Further information concerning the effects asserted in the plan and the goals satisfied during the generation of the plan, etc can be obtained through the Interface Manager's Control Panel. Two separate browsing menus are provided:

   Interrogate the Contents of the DM To view this information chose the **DM Developers Menu** option from the Control Panel window. This will result in a new menu appearing in the Database Manager window. The options in the menu are as follows:

   (a) `Display nodes`: Display the nodes of the plan together with their predecessors and successors.
   (b) `Display TOME`: Display the effects asserted in the plan.
   (c) `Display GOST`: Display the protected ranges over which preconditions must be preserved.
   (d) `Display PSV`: Display the plan state variables which are in the plan.
   (e) `Break in`: You may resume O-Plan by typing `O`.
   (f) Quit interrogation. Quit this menu

10. **Browsing on the World State**
    Information concerning the state of the world at a particular node in the plan graph can be obtained and viewed on the screen. In order to view this information Enter 6 from the Task Assignment Window. This will invoke[3] the PlanWorld window which will display information from the planner and allow the user to specify file names where necessary.

    The user will be prompted for a node number by the phrase `View at end_of node-` appearing in the Task Assignment Window. The user may then select the plan node of interest. Following the choice of `node_end` the user will be presented with a menu showing the different viewing formats available. These are as follows:

    (a) **Text to Screen**: The information concerning the specified node of the plan will appear in the `PlanWorld` window as a set of triples of the form `<pattern> = <value>`. For example:

```
{on a b} = true
{clear a} = true
{clear b} = false
```

[3] Assuming the window is not already present

(b) **Text to File**: Send the world view to the file name specified by the user and place it in the directory specified in the environment variable $OPLANTMPDIR. The user will be prompted for the file name via the PlanWorld window.