2017

Tartarus
-Users' Manual

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Foreword

Embedding intelligence on real decentralized and distributed systems calls for an agent platform that features tools for programming intelligence. It was thus thought that the creation of such a platform using an AI language would best suit the purpose. The first attempt to realize this, at the Robotics Lab. of the Dept. of Computer Science and Engineering, Indian Institute of Technology Guwahati, culminated in the creation of Typhon, a mobile agent platform. Typhon was built over the Chimera (static) agent system ported with LPA Prolog[1]. While Typhon was used to realize and demonstrate several decentralized applications, it had several issues that could not be sorted out due to its proprietary compiler. An alternative became mandatory. Typhon was thus revamped and re-coded using SWI-Prolog and bundled with better and enhanced features and christened Tartarus. This new platform supports a host of features and unlike its predecessor can also be used in conjunction with embedded systems such as the Raspberry Pi and Lego NXT robots. Contrary to Typhon, agents in Tartarus run as threads and thus provide for better concurrency. It can also carry more payload than its predecessor and can be run on both Windows and Linux operating systems.

The use of Tartarus running on Raspberry Pi boards, nicknamed AgPi, increases the dimensionality of its applications. Such systems can now be organized and connected to form either an **Internet of Things (IoT)** or a **Cyber Physical System (CPS)**. The current version can be used for a plethora of intelligent applications that encompass the areas of networking, robotics, computing architectures, big data and the like. It is hoped that Tartarus will encourage researchers to graduate from mere simulations to emulations of the systems they endeavour to build and come up with real workable decentralized and distributed algorithms and their associated real-world applications.

This manual assumes that the reader is aware of the use of SWI Prolog[2] and has the same installed in the system on which s/he intends to install Tartarus.

Cheers!

The Tartarus Team

[1] www.lpa.co.uk

[2] www.swi-prolog.org

The names of those who prominently contributed to the currently available versions include:
Tartarus: Vivek Singh, Manoj Bode, Tushar Semwal, Shivashankar B. Nair
Typhon: Jatin Matani, Shashi Shekhar Jha, Shivashankar B. Nair

Authors using this software and desirous of publishing their work are obliged to cite the following papers:

Tushar Semwal, Nikhil S., Shashi Shekhar Jha, Shivashankar B. Nair, *TARTARUS: A Multi• Agent Platform for Bridging the gap between Cyber and Physical Systems*, Proceedings of the 2016 Autonomous Agents and Multi Agent Systems Conference, International Foundation for Autonomous Agents and Multiagent Systems, pp. 1493-1495, Singapore.

Tushar Semwal, Shivashankar B. Nair, *AgPi: Agents on Raspberry Pi*, Special Issue of the Journal – Electronics: "Raspberry Pi Technology", MDPI Open Access.

Contents

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Chapter 1
Getting Started

Since Tartarus runs over SWI-Prolog the first step is to ensure that you have the latter installed in your system. SWI-Prolog can be downloaded from www.swi-prolog.org. Also ensure that you have Java installed, in case you need to use Lego NXT Robots.

Note: All through this manual, the terms *Tartarus* and *Platform* have been used interchangeably.

1.1 Installing and Loading the Tartarus platform

(i) For Windows OS

Follow the steps below to install Tartarus on your Windows based machine:

1. Download and install the SWI-Prolog on your system. SWI-Prolog can be downloaded from http://www.swi-prolog.org/download/stable.
2. Run the Tartarus installer file which can be downloaded from the link: http://www.iitg.ernet.in/cse/robotics/?page_id=2302
3. There are two ways to load the Tartarus platform on SWI-Prolog:
    a. If you are new to SWI-Prolog, just double click on the Tartarus icon. This will open an SWI-Prolog instantiation with Tartarus pre-loaded onto it. You can now go ahead to use Tartarus.
    b. For others who use SWI-Prolog, just **consult (load)** the **platform.pl** file resident in the Tartarus directory.

(ii) For Debian based OS (Ubuntu, Raspbian Jessie)

1. Install SWI-Prolog using the command:
   sudo apt-get install swipl
2. Download the tar ball from the link: http://www.iitg.ernet.in/cse/robotics/?page_id=2302
3. Untar the tar ball to any desired location in your system. Use the following command to untar the tar ball:
   tar -xvf <tar ball> -C <desired location>
4. In a new command line terminal, type: **swipl**
5. This will start a SWI-Prolog session. Now to load the Tartarus platform, enter the command:
   consult('/home/<Installed Tartarus directory>/platform.pl').

Chapter 2
Tartarus Built-in Predicates

Introduction

This chapter describes the various predicates supported by Tartarus. These are generic predicates which can be used when running the Tartarus platforms on Windows, Linux or the Raspberry Pi. For each predicate the arity is represented by a number /n after the predicate name in the form -

predicate_name/n

The description of each of these arguments is provided next as **<DATA_TYPE, X>** where X indicates the manner in which the data passed to the predicate needs to appear and can assume three symbols viz. ?, + and -. Their meanings are conveyed below -

'?' indicates that the value can be passed to the predicate; if not, the same will be assigned after a call to the predicate.
'+' indicates that the value needs to be passed to predicate (**mandatory**).
'-' indicates that value will be assigned by a call to the predicate.
The predicates listed below have been bunched based on their approximate functionalities.

Tartarus provides a range of predicates to be used in conjunction with agent programming. They have been categorized below for convenience.

Platform predicates	Agent predicates	Log Server	Miscellaneous
start_tartarus/3	create_mobile_agent/4	set_log_server/2	get_new_name/2
close_tartarus/0	create_static_agent/4	send_log/2	get_new_name_alpha/1
reset_tartarus/0	purge_agent/1		
print_tartarus_status/0	execute_agent/3		
assert_file_to_tartarus/1	execute_agent /4		
get_tartarus_details/3	add_payload/2		
set_token/1	remove_payload/2		
load_tartarus_state/1	clone_agent/3		
save_tartarus_state/1	move_agent/2		
	save_agent/2		
	isexist_agent/3		
	list_ agent/0		

Tartarus also provides special predicates to control Lego NXT Mindstorms which are presented and explained in a separate manual provided with along with the software. When used in conjunction with Raspberry Pi, the Tartarus equivalent AgPi supports the various predicates to access the hardware on-board. This predicates and their functionalities have also been presented as a separate manual.

Predicates pertaining to the Tartarus platform

(i) start_tartarus/3

start_tartarus(IP, Port,Token). % Starts a Tartarus platform or instance. %

Arity types:
IP: <atom + >,
Port: <integer +>
Token:<integer +>

Description:
This predicate is used for starting a Tartarus platform. It initializes all global variables and stack and starts the platform on the given IP address and Port number. It also sets the platform token. The IP address is the address of the system on the network. This predicate must be executed before creating any static or mobile agents. One can start multiple platforms on the same IP provided the Port numbers are different.

Example:
?- start_tartarus (localhost,6000,1).% Creates a Tartarus platform on the localhost running on port 6000 and platform token set to 1.

?- start_tartarus (localhost,7000,2).% Creates a Tartarus platform on the localhost running on port 7000 and platform token set to 2.

?- start_tartarus ('10.9.23.28',6000,1). % Creates a Tartarus platform on the machine with IP 10.9.23.28 at port 6000 with token as 1.

If the first predicate above is successful, the SWI-Prolog terminal will display the following message:

==========
Welcome to Tartarus Multi-Agent Platform
This platform is running on localhost: 6000
==========

CAUTION: If you intend to run several platforms in the same machine ensure to use different ports else the system will throw an error.

(ii) close_tartarus/0

close_tartarus. % Shuts down a Tartarus platform. %

Description:
When run within a platform, this predicate terminates all the agents and removes all code running on the platform. It closes all open sockets before closing the platform. After closing platform, you can once again start a fresh platform on different IP and/or Port.

Example:
?- close_tartarus.
After successful closing of platform, the SWI-Prolog terminal will display following message:

Platform has been closed.

(iii) reset_tartarus/0

reset_tartarus. % Resets the existing Tartarus platform within which the predicate is executed. %

Description:

This predicate is used for resetting the platform to the state when it was first started. Unlike *close_tartarus*/0 which merely closes the platform, this predicate closes the platform and restarts it afresh using the same IP and Port.

Example:

?- reset_tartarus.

After successful reset, the SWI-Prolog terminal will display the message:

```
**********************************************
Welcome to Tartarus Multi-Agent Platform ..
(Ver.1.1, 30th January 2017).

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Dept. of Computer Science & Engg.,.
Indian Institute of Technology Guwahati,.

For any query contact:
semwaltushar@gmail.com
sbnair.tartarus@gmail.com.in
Note: Relevant manuals are available inside the User Manuals folder.
      of the installation directory of Tartarus..
**********************************************

==============================================
     Tartarus Platform launched!
                @
     Running on IP = localhost, Port = 12211
==============================================
```

(iv) print_tartarus_status/0

print_tartarus_status. %Prints the status and parameters of the platform on the console. %

Description:

This predicate can be used for debugging. It prints all the values asserted in Tartarus platform, all the agent codes and threads currently associated with the platform, payloads carried by agents, token of the platform and other information related to platform.

Example:

?- print_tartarus_status.

Executing this predicate will list the platform details as follows:

platform_Ip : localhost platform_port : 6000

transit_GUID: a1|handler|localhost,6000

guid_threadid: t_worker|4

guid_threadid: t_acceptor|5

guid_threadid: t_clean|3

(v) assert_file_to_tartarus/1

assert_file_to_tartarus(File_name.pl). % Asserts a file with the name File_name.pl on the Tartarus platform.

Arity types:
File_name: <atom + >

Description:

This predicate is used for asserting the handler codes of the concerned agents by specifying the name of the file viz. *File_name* (variable) which contains the agent code. The handler predicates listed in the file - *File_name* are asserted as generic predicates. When the agents are created (see agent_create) these generic predicates are converted into agent-specific predicates.

Example:
?- assert_file_to_tartarus('handler_file.pl').

(vi) get_tartarus_details/3

get_tartarus_details(IP,Port,OS). % The predicate provides details of the IP ,Port and OS of the Tartarus platform. %

The predicate provides details of the IP and Port of the platform.

Arity types:
IP: <atom ->,
Port: <integer ->,
OS:<atom ->

Description:

It gives the IP, Port number and OS of platform set using tartarus/3. The predicate comes handy when an agent or program requires to know the details of the platform where it is executing.

Example:
?- get_tartarus_details(Platform_IP, Platform_Port,OS).

The output will be as follows:

Platform_IP = localhost,

Platform_Port = 6000,

OS = Windows.

Here, we will the get IP address,Port number and OS of that specific platform in *Platform_IP* , *Platform_Port and OS* respectively.

(vii) set_token/1

set_token(Token) % Sets a token in the current platform. %

Arity types:
Token: <integer + >

Description:

Whenever a platform is started a token value is assigned to it. This is used as a ticket to enter the platform. Unless an agent has this token within itself, it is not permitted entry into the platform. Agents can thus migrate to only those platforms whose tokens they carry within themselves. Tokens thus can be used to restrict /allow entry of agents to specific platforms and constitute a level of security.

Example:
?- set_token(9595).
Any incoming mobile agent should have 9595 as one of its tokens else it will not be allowed to enter this platform.

(viii) save_tartarus_state/1

save_tartarus_state(FileName) % Saves the current state of the platform in a file %

Arity types:
FileName: <atom + >

Description:
This predicate saves the current state of platform into a file with name **FileName**. All associated asserted code along with facts and running agents are stored in this file. The state of platform can be resumed by calling another predicate **load_tartarus_state/1** .

Example:
?- save_tartarus_state('E:\\platform_state.txt').

On successful execution of the above predicate, a file is created in the specified location containing the state of platform. (In above example, .txt extension has been used. However, one may use any file format).

(ix) load_tartarus_state/1

load_tartarus_state(FileName) % Loads the state of the platform saved in a file. %

Arity types:
FileName: <atom +>

Description:
This predicate is used in conjunction with **save_tartarus_state/1**. The state of the platform can be resumed by calling this predicate. It asserts all the associated predicates within the file FileName and asserts all the agents and related handler code. It also restarts all agents which were running at the

time of **save_tartarus_state/1** predicate was called.

Example:
?- load_tartarus_state('E:\\platform_state.txt').

Predicates pertaining to Agents

(i) create_mobile_agent/4

create_mobile_agent(Agent_name, (IP, Port), Handler,Token_list).
% Creates a mobile agent within the platform specified by the IP and Port, confers it a name and allocates its handler and a list of tokens. %

Arity types:

Agent_name: <atom ? >
IP: <atom +>,
Port: <integer +>
Handler: <atom + >
Token_list:<integer+

Description:
This predicate creates a mobile agent with the name *Agent_name* given by the user. It allocates the handler (which is a predicate specified by the user) *Handler*. It is also given a list of tokens which is required to enter a platform. The agent is created in the platform running at the IP and Port specified within. This predicate automatically creates the agent specific predicates and asserts them within the specified platform. If the platform already contains an agent with the same name, it overwrites the same with this new agent having the specified name and handler.

In case the name of the agent is not specified by the user, then the predicate automatically calls get_new_name_alpha/1 and then assigns a new name to this agent.

Example:
Let the handler predicate for an agent be ***agent handler*** .

```
agent_handler(guid,(IP,Port),main):-
writeln("hello!!"),
writeln("I am the handler").
```

1. create_mobile_agent (myagent, (localhost, 6000), agent_handler,[1,2]).
   This command will create an agent with name "myagent" as specified by the user carrying code specified by the handler "agent_handler" . On successful execution of the predicate, the prolog terminal will display following result:

Agent with name myagent created.

2. create_mobile_agent (Agent_name, (localhost, 6000), agent_handler,[1,2]).

   In this, the *Agent_name* is generated by calling get_new_name_alpha/1. Platform will automatically generate a name for agent and then with that name agent is created. On successful creation of agent, the predicate will display following result:

   Agent with name cvfzap created
   Agent_name = cvfzap.

   where 'cvfzap' is the randomly generated agent name.

(ii) create_mobile_agent/3

create_mobile_agent(Agent_name, Handler,Token_list).

% Creates a mobile agent within the current working platform by conferring it a name and allocating its handler and a list of tokens. %

Arity types:
Agent_name: <atom ? >
Handler: <atom + >
Token_list:<integer+>

Description: This is a spin-off from the earlier used create_mobile_agent/4 with less number of arguments. Through this predicate, the mobile agent is created within the current working platform.

(iii) create_static_agent/4

create_static_agent(Agent_name,(IP,Port),Handler,Token_list).

%Creates a static agent within the platform specified by the IP and Port, confers it a name and allocates its handler and a list of tokens. %

Arity types:
Agent_name: <atom ? >
IP: <atom +>,
Port: <integer +>
Handler: <atom + >
Token_list:<integer+

Description:

This predicate creates a static agent with the name *Agent_name* given by the user. It allocates the handler (which is a predicate specified by the user) *Handler*. It also adds a token list to the agent which might be required by the agent for cloning to another platform. The agent is created in the platform running at the IP and Port specified within. This predicate automatically creates the agent specific predicates and asserts them within the specified platform. If the platform already contains an agent with the same name, it overwrites the same with this new agent having the specified name,

handler.

Example:

1. ?- create_static_agent(myagent, (localhost, 4545), function,[1,2]).
2. ?- create_static_agent (Agent_name, (localhost, 4545), function,[1,2]).

In 1., the predicate creates all the agent-specific predicates and asserts them within the platform running in the localhost at port 4545. The agent name is *myagent*. In the second example, the name of the agent is unbound. The predicate automatically calls get_new_name_alpha/1 and then assigns a new name to this agent.

(iv) add_token/2

add_token(Agent_name, Token List) % adds a list of tokens to an agent %

Arity types:

Agent_name: <atom +>

Token List: <List +>

Description:

This predicate is used to add a list of token to a given agent. When a mobile agent enters a platform, the platform first checks the members of this list of tokens with the token of its own platform. If a match if found, the agent is allowed to enter the platform otherwise a negative acknowledgement is given to the sender platform.

Example:

?- add_token(myagent,[1111,2222,3333]).

?- add_token(Agent_name,[7878]).

(v) purge_agent/1

purge_agent(Agent_name). % Terminates the agent and its associated predicates within the current platform. %

Arity types:
Agent_name: <atom +>

Description:
This predicate is used to kill and retract all associated agent code from the current platform. The Agent_name is the name of agent to be terminated. purge_agent /1 purges all the threads associated with the specified agent after which all agent-specific code is retracted.

Example:
?- purge_agent(myagent).

(vi) execute_agent/3

?- execute_agent(Agent_name,(IP, Port), Handler) % Executes the *default* handler code of the agent at the specified platform. %

Arity types:
Agent_name: <atom + >
IP: <atom + >
Port: <integer +>
Handler: <atom +>

Description:
This predicate is used for starting the executing of an agent which has already been created (and is not executing) on the specified platform. The predicate calls the associated handler predicate with the default 'main' keyword within its arguments. Before execution it removes any running agent with the same name in the platform. The **Agent_name** is the agent name of agent on the platform, **IP** is the IP address and **Port** is port number of platform where the **Handler** is to be executed.

Example:
Assume that an agent named *myagent* is already created. Let the agent's handler code be as below:

```
agent_handler(guid,(IP,Port),main):-
writeln('Agent's main function called!!'),
N is 0,
writeln('Value of N is '),
writeln(N).
```

```
?-  execute_agent(myagent,  (localhost,6000),agent_handler).
```

On successful execution of the above predicate, the result will be:

Agent's main function called!!
Value of N is 0

Note: The *guid* atom as the first argument to the handler code is replaced by the name of the agent whenever agent_create/3 is executed. Hence, in agent_execute/3, only name of the agent to be executed is provided.

(vii) execute_agent/4

execute_agent(Agent_name, (IP, Port), Handler, Start_function).
% Executes a *specified* handler code of the agent at the specified platform. %

Arity types:

IP: <atom + >
Port: <integer +>
Handler: <atom + >
Start_function: <atom + >

Description:

This predicate is similar to agent_execute/3 but instead of calling the default handler predicate with keyword *main* as a parameter, it will execute the one with *Start_function* as a parameter.
Example:
?- agent_execute(myagent, (localhost,6000), agent_handler, initialize).

Here, **Start function** is set to **initialize.** Thus it will call the following handler predicate instead of default 'main' function:

agent_ handler(myagent,(localhost,9595),initialize):- <Your agent behaviour code goes here>

(viii) add_payload/2.

add_payload(Agent_name, PredList) % Adds the list of predicates *PredList* whose clauses need to be carried by the specified agent as it migrates. %

Arity types:
Agent_name: <atom+>
AddList: <atom list +>

Description:

add_payload /2 add the payload to the agent. The payload predicate should have *guid* as one of the argument.

For Example: *ability(guid,X):-*

print(X).

Here *ability(guid,X)* is a payload having arity 2 with guid as the first argument. Thus when command add_payload/2 is invoked, the *guid* is replaced with the actual identifier/name of the agent. *AddList* is list of predicate name and arity as *[(<predicatename1>,<number of arity>),(<predicatename2>,<number of arity>),...].*

Example:
Let square_coordinate/2 and point/1 be predicates defined as follows:

?- square_coordinate(0,0).
?- square_coordinate(0,10).
?- square_coordinate(10,10).

?- square_coordinate(10,0).

?- point(1).

Suppose the payload to be carried by an agent are the clauses for square_coordinate/2 and point/1. The following add_payload predicate ensures that the clauses for the above two predicates are carried with the agent named myagent as and when it migrates to another platform.

add_payload(myagent, [(square_coordinate,2), (point,1)]).

Note that the second argument is a list comprising a tuple that contains the name of the predicate and its arity. Thus in a generalized way, we can define the **add_payload** predicate as follows:

add_payload(AgentName, [(<predicate1>,<Arity>), (<predicate1>,<Arity>), ...]).

CAUTION: All predicates within the **PredList** have to be declared **dynamic**.

(ix) remove_payload/2

remove_payload(Agent_name, RemovePredList) % Removes all clauses for the predicates specified in the RemovePredList %

Arity types:
Agent_name: <atom + >
RemovePredList: <atom list>

Description:
This predicate is used to remove the payload associated with the agent named **Agent_name**. The **RemovePredList** is the list of payload predicates which are to be removed. The structure of **RemovePredList** the same as specified in **PredList** of the **add_payload** predicate.

Example:
?- remove_payload(myagent,[(square_coordinate,2),(point,1)]).

In a generalized way, we can define the remove_payload predicate as follows:
remove_payload(Agent_name, [(<predicate1>,<Arity>), ...]).

(x) clone_agent/3

clone_agent(Agent_name, (Destination_IP, Destination_Port), Clone_name)
% Clones the designated agent at a specified platform and confers it a new name. %

Arity types:
Agent_name1: <atom +>,
Destination_ip: <atom + >,
Destination_port: <integer +>
Agent_name2: <atom ->

Description:
This predicate is used for cloning of agents. The agent named **Agent_name** is cloned at **Destination_IP** and **Destination_Port** address specified by the user. The clone's name is returned in the variable **Clone_name**.

Example:
?- clone_agent(myagent,(localhost,5656),Clone_name). Clone_name = myagent.

(xi) save_ agent/2

save_agent(GUID, FileName) % Saves the predicates associated to the specified agent into a file. %

Arity types:
Agent_name: <atom + >
FileName: <atom + >

Description:
This predicate is used to save all the predicates, payload and facts associated with the agent named
Agent_name specified by user. The definitions are stored in the file with name *FileName*.

Example:
Let the agent handler code be:

```
agent_handler(guid,(IP,Port),mai
        n):- writeln("I am the
        handler"), N is 1,
        writeln(N).
```

?- agent_save(myagent,'E:\\save_agent_state.txt').

On successful execution of above predicate, a text file is created in the specified location containing agent code. The **save_agent_state .txt** file will save the agent state as:

```
agent_handler(myagent,(___, __),main):-
        writeln("I am the handler"),
        N is 1,
        writeln(N).
```

The user can use the desired file type (eg. .pl, .txt).

(xii) list_agent/0

list_agent. % Lists all the agent in the current platform. %

Description:
This predicate lists all agents existing in the current platform along with details of the agent viz. - its name, handler and port number on which agent resides. In case of a mobile agent the port number will be same as the platform port number in which it currently resides.

Example:

?- list_agent.

==========Agent list==========

Agent Name :agent1, handler name:mobileagent1, residing on port:5658 Agent Name :agent2, handler name:mobileagent2, residing on port:5658 Agent Name :agent3, handler name:staticagent1, residing on port:5659

==========

true.

(xiii) isexist_agent/3

isexist_agent(Agent_name,(IP,Port),Handler) % The predicate can be used to check the existence of a specific agent in a platform. %

Arity types:
Agent _name: <atom ?>
IP: <atom ?>
Port: <integer ?>
Handler: <atom ?>

Description:
This predicate checks if any agent exists with the name provided within the predicate. If so, it provides details regarding its IP, Port number and handler. The predicate fails otherwise.

Example:

?- isexist_agent(agent1,(IP,Port),Handler).

?- IP = localhost,

?- Port = 5658,

?- Handler = mobileagent.

?- isexist_agent(agent1,(IP,5658),Handler).

?-IP = localhost,

?- Handler = mobileagent.

(xiv) move_agent/2

move_agent(Agent_name,(Receiver_ip, Receiver_port))

Arity types:
Agent_name: <atom + >,
Receiver_ip: <atom +>,
Receiver_port: <integer +>

Description:
This predicate is used for mobility of agents the agent named *Agent_name* is moved to *Receiver_ip*

and *Receiver_port* specified by user. The predicate tries to move the agent if the movement fails then agent is restarted at the same platform otherwise if movement is successful then the agent code is retracted from platform.

Example:
?- move_agent(myagent, (localhost,6767)).

(xv)post_agent/3

post_agent(platform, (Receiver_ip, Receiver_port), Predicate_list)

Arity types:
platform: <keyword>
Receiver_ip: <atom +>
Receiver_port: <integer +>
Predicate_list: <List+>

Description:
This predicate is used for sending messages across platforms or between agents. '*platform*' is key word which used to tell that it is handler of platform. *Receiver_ip* is the IP address of destination platform where we want to send message, *Receiver_port* is Port number of destination platform. The *Predicate_list* is the list with handler name followed by handler parameters in sequence. The using list the predicate is created and called at destination platform.

Caution: Too many concurrent post_agent/3 executions may cause socket errors especially in Windows environment.

Example:
?- post_agent(platform, (localhost,4545),[handler,myagent, (localhost,4545), sum(45,67)]).

Here *Predicate_list* is *[handler,myagent, (localhost,4545), sum(45,67)]* then predicate '*handler(myagent,(localhost,4545),sum(45,67)*' will be called on destination platform.

2.4. Predicates pertaining to Log Server

(i) set_log_server/2

set_log_server(IP , Port) % Sets the IP and Port number of the log server. %

Arity types:
IP: <atom+>
Port: <atom +>

Description:
This predicate is used for setting the IP address and Port number of a log server. The IP and Port address of the log server are asserted on the platform where this predicate is invoked so that all agents within this platform can use this information to send messages to the log server using send_log/2.

Example:
?- set_log_server (localhost, 6666).

(ii) send_log/2

send_log (Agent_name, Message) % It causes the specified agent to send a message to the log server. %

Arity types:
Agent_name: <atom +>,
Message: <atom +>

Description:
This predicate is used by agents to send log messages to log server. The log server displays these messages on its terminal. The **Agent_name** is the agent sending the message to the log server.

CAUTION: The IP address and port number of log server has to be known to the concerned platform. Do not forget to set the log server (**set_log_server/2**) for the same.

Example:
send_log(myagent, 'Hello log server').

The log file format is as below:
<Time in seconds> <Agent name> <IP address of the platform from which log was sent> <port number of the platform from which log was sent> <Message>

Example log file format:

1406530660.314867 hlxyll localhost 5656 Hello log server 1406530660.321872 hlxyll localhost 5657 Hello log server 1406530660.331881 hlxyll localhost 5658 Hello log server 1406530660.337885 hlxyll localhost 5659 Hello log server.

2.5 Miscellaneous predicates

(i) get_new_name/2

get_new_name(Agent_name, New_agent_name) % Generates a new name for an agent %

Arity types:
Agent_name: <atom + >,
New_agent_name: <atom - >

Description:
This predicate is used for generating a unique name for an agent. The names generated by this predicate are of form <Agent_name><random number>_<IP>_<Port>. The returned value is

assigned in the variable New_agent_name.

Example:
?- get_new_name(agenta,X)

?- X = agenta1_localhost_5658.

(ii) get_new_name_alpha/1

get_new_name_alpha(Agent_name) % The predicate provides a new alphabetic name that can be used to christen an agent. %

Arity types:
Agent _name: <atom - >

Description:
This predicate returns the 6-character random alphabetic name to be used for an agent.

Example:
?-get_new_name_alpha(New_Name).
?- New_Name = wqcfsd.

Chapter 3
Sample programs

Sample 1

Create static agent which will be sitting on platform and when executed prints "Agent executed".

Steps:

1. Open SWI-prolog terminal
2. Consult (load) platform.pl file

```
?-consult('path to platform.pl  file').
```

Platform.pl can also be directly consulted by opening platform.pl file through prolog terminal.

3. Start the platform on specific IP and Port using

```
?-
start_tartarus('172.112.23.4',6000,1).
Or
?- start_tartarus(localhost,6000,1).
```

4. Load static agent code. Suppose static agent code is in agent.pl file. Then consult (load) agent.pl.

```
?- consult('agent.pl').
?-  platform_tartarus_file('agent.pl').
```

5. Create static agent using *create_static_agent/4* predicate.

```
?-  create_static_agent(agent1,(localhost,5657),myagent,[1,2]).
```

It will create static agent agent1 on IP address localhost and port number 5657 with agent handler name myagent.

6. To execute agent use

```
?-  execute_agent(agent1,(localhost,5657),myagent). true.
==========================
Agent code executed IP:localhost Port:6000
==========================
```

It will start execution from myagent handler. It calls myagent(guid,(IP,Port),main) predicate.

Sample 2

Create mobile agent which moves from first platform to second and vice versa.

Steps:

1. Using steps 1-5 as mentioned in Sample 1 start two Tartarus platforms. (For our case, we are assuming that Receiver's Private IP is '1.1.1.1' and Receiver's Public IP is '2.2.2.2')

2. Load mobileagent.pl file on one of the platform.
3. Create mobile agent using

```
?- create_mobile_agent(myagent,(localhost,5656),mobileagent,[1,2]).
```

Here agent with name *myagent* is created. Third parameter *mobileagent* is name of the handler.

```
%*** mobileagent.pl - Contains mobile agent's handler code ***%
:-dynamic mobileagent/3. mobileagent(guid,(IP,Port),main):-
    writeln('Agent  has reached!').
```

4. Start executing mobile agent using

```
?- execute_agent(myagent,(localhost,5656),mobileagent).
```

The execution will start from mobileagent(guid,(IP,Port),main).

5. After step-5 the other Tartarus platform will show:

```
?- Agent has reached!
```

Sample 3

Create mobile agent that will carry a payload and will move from one platform to other.

Steps:

1. Use Step 1-5 to start two platform(If you are starting both platform on same system then make sure that the port of both platform should be different otherwise it will through socket_error exception)(For our case, platforms are started on port 6001 and 6002)
2. Load agent_handler.pl file on both platforms (Assuming that the Receiver's Private IP is '1.1.1.1' and Receiver's Public IP is '2.2.2.2')

agent_handler.pl code :

```
:-dynamic agent_handler/3.
agent_handler(guid,(IP,Port),main):-
        writeln('I am the
         handler'),
         (Port=6001->
        current(guid,1,X,
        Y), writeln(X),
        writeln(Y),
        write('On platform 6001'),
        agent_move_file(guid,('1.1.1.1','2.2.2.2'))
        ;
        writeln('Not on platform
        6001'),
        current(guid,2,X,Y),
        writeln(X),
```

```
writeln(Y)
)
```

3. Load main.pl file on one of the platform.
   main.pl file code:

```
current(guid,1,150,650).
current(guid,2,250,350).

start :- get_platform_details(IP, Port,OS),
agent_create(referee, (IP, Port),
agent_handler), add_token(referee,
[5656]),
add_payload(referee, [(current, 4)]),
agent_execute(referee, (IP, Port),
agent_handler).
```

4. Start execution by typing
   ?- start.

(This will start executing all the statements within the predicate start in main.pl)

5. If main.pl is consulted at platform 6001 then output will be

```
At platform
6001: I am the
handler 150
650
On platform 6001

At platform 6002:


Not on platform
6001 250
350
```

And, if the main.pl file is consulted at platform 6002 then output will be:

```
At platform
6002: Not on
platform 6001
250
350
```

At platform 6001:

(No output-as agent will not go there)

(Note: Notice the fact that the current/4 predicate is defined only on main.pl and and consulted only once on one platform but still as we are attaching it as payload with agent so when agent will move from one platform to other platform then the payload(In this example, current/4) will also move and is accessible to the destination platform)

Chapter 4
Tartarus: Billboards & Dialogs

4.1 Introduction

In Tartarus terminology, billboards are actually windows onto which one can write and display information. Billboard predicates are basically wrappers of their XPCE equivalent that are made to suit the needs of Tartarus. This section also includes dialogs which can be called from Tartarus. These utilities provide for the bare necessities while programming in Tartarus/AgPi. For further information, users may refer to the XPCE documentation available on the SWI-Prolog site.

(i) create_billboard/5

Usage:
create_billboard(Bill_Name, Txt2bWritten,X,Y,Time)

Arity types:
Bill_Name: <atom + >,
Txt2bWritten: <atom+>
X: <integer +>
Y: <integer +>
Time: <integer +>

Bill_Name: Apart from being the ID of the billboard, it also is the title of the billboard. Billboard names need to be unique. *Bill_Name* is an atom and therefore should be enclosed within single quotes.

Txt2bWritten: It is the text that needs to be written onto the billboard. It should also be enclosed in single quote.

X,Y: Co-ordinates of the beginning of the above text.

Time: If Time is a non-zero positive value then the billboard has a life equal to Time msec. Else if it is zero, then the billboard will remain active till it is eventually closed using close_billboard/1 or close_billboards/0.

Function: Creates a billboard with the name *Bill_Name* and displays the text at the co-ordinates (X,Y). The billboard life time is decided by Time. If Time is zero, it will continue to remain active till it is closed by other predicates.

Example:
create_billboard('Hello','Hi, I am a Tartarus billboard!',10,10,0)

(ii) write2billboard/4

Usage:
write2billboard(Bill_Name, Txt2bWritten,X,Y)

Arity types:
Bill_Name: <atom + >
Txt2bWritten: <atom+>
X: <integer +>
Y: <integer +>

Bill_Name: Apart from being the ID of the Billboard, it also is the title of the billboard. *Bill_Name* is an atom and therefore should be enclosed within single quotes.

Txt2bWritten: It is the text that needs to be written onto the billboard. It should also be enclosed in single quote.

X,Y: Co-ordinates of the beginning of the above text.

Function: Facilitates the writing of the text (*Txt2bWritten*) onto the billboard named Bill_Name, commencing from the co-ordinate (*X,Y*).

Example:
write2billboard('Hello','You can write what you wish on me!',10,20).

(iii) clear_billboard/1

Usage:
clear_billboard(Bill_Name)

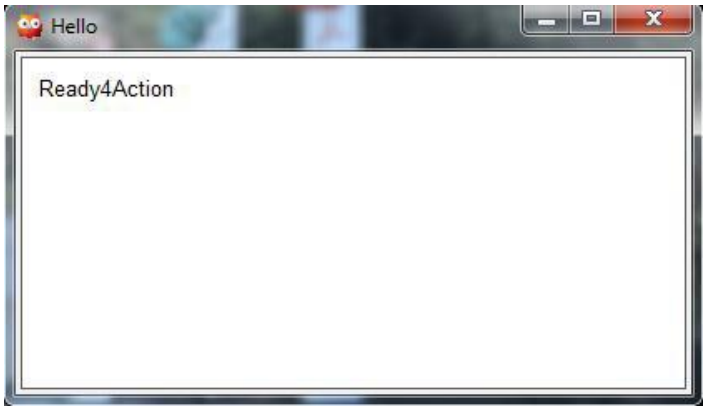
Arity type:
Bill_Name: <atom + >

Bill_Name: Apart from being the ID of the Billboard, it also is the title of the billboard. Bill_Name is an atom and therefore should be enclosed within single quotes.

Function: Clears the entire content of the billboard with name *Bill_Name*.

Example:

clear_billboard('Hello').



(iv) close_billboard/1

Usage:
close_billboard(Bill_Name)

Arity type:
Bill_Name: <atom + >

Bill_Name: Apart from being the ID of the Billboard, it also is the title of the billboard. Bill_Name is an atom and therefore should be enclosed within single quotes.

Function: Closes or terminates the billboard with name Bill_Name.

close_billboards/0

Usage:
close_billboards.

Function: Closes or terminates all active billboards.
CAUTION: This predicate will also close the billboard associated to the platform.
Dialogs

(v) create_dlg/3

Usage
create_dlg(DialogID, DialogTitle, ComponentList)

Arity types:
DialogID: <atom - >,
DialogTitle: <atom+>
ComponentList: <integer +>

Function:
The predicate facilitates the creation of the main dialogs – Text item, Menu, Slider and Buttons. A main dialog can be populated by all these using a single create_dlg/3 predicate. Explanations to each of the arguments are provided below.

DialogID: It is an unbound variable that will form the ID of the dialog.

DialogTitle:
This needs to be provided by the user and will be what appears at the top of the dialog window.

ComponentList: This is a list of components that the dialog holds. The manner in which a member of the list is represented depends on whether it is an text item, a menu, a slider or a button.
The format for each is given below:

Text item:
(text_item, Text_item_Class_ID, Text_Label, DefaultTextWithinBox)

Arity types:
Text_item_Class_ID: <atom - >,
Text_Label: <string+>
DefaultTextWithinBox: <string +>

The first argument needs to be typed as it is while the second has to be an unbound variable.
The second forms the ID of the text item and is used to get the data provided using Name_Class_ID?selection explained later in the button format.
The third argument is a string which forms the default text that needs to be displayed in the text box which can then can be edited in run-time.
E.g. (text_item,NameClass,name,'TypeHere')

Slider:
(slider,Slider_Class_ID,slider(Slider_Label, X,Y,Z)

Arity types:
Slider _Class_ID: <atom - >,
Slider_Label: <string+>
X,Y,Z: <integer +>

The first argument needs to be typed as it is while the second has to be an unbound variable.
The second forms the ID of the slider and is used to get the data provided using Slider_Class_ID?selection explained later in the button format.
In the third argument Slider_Label has to be bound to the label describing it. This label appears alongside the slider.
X,Y and Z, all numerical values, refer to the starting, ending and current position of the slider. X,Y and Z need to be bound.

Menu:
(menu,Menu_Class_ID,mymenu,MenuList)

Arity types:
Menu_Class_ID: <atom - >,
Menu_Label: <string+>
MenuList: <list +>

The first argument needs to be typed as it is while the second has to be an unbound variable.
The second forms the ID of the menu and is used to get the data provided using Menu_Class_ID?selection explained later in the button format.
The third is the name of the menu or the text that is indicative of the menu. This has to be bound to a string.

The fourth, MenuList, is a list takes the form
[class(menu_option_1),class(menu_option_2),...,class(menu_option_n)]
where the menu_option_i indicates the string that has to appear as an item name in the menu. MenuList should be bound.
E.g.:
(menu,MenuClass,mymenu,[class(dosa),class(idli),class(sandwich),class(paratha)])

Button:
(button,ButtonLabel,message(@prolog,dialog_handler,NameClass?selection,SliderClass?selection,MenuClass?selection)

Arity types:
ButtonLabel: <string+ >,

The first argument needs to be typed as it is as it indicates a button.
The second has to be label/text that needs to appear on the button and thus needs to be bound.
The third is a bit complex and changes based on the requirement.
The message predicate actually invokes the event handler viz. dialog_handler written by the user in Prolog, when the button is pressed/activated.
The remaining arguments form the arity of the predicate dialog_handler. Note the form in which they need to be written:
Dialog_Class_ID?selection where Dialog_Class_ID could be any of the second arguments of the text, slider or menu items in the dialog.

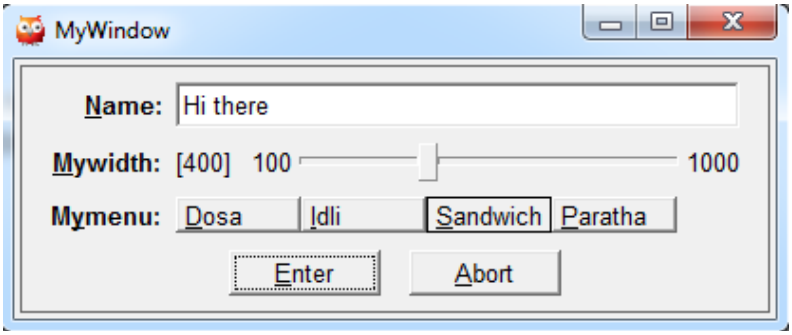
Note:
A couple of message formats are given below for ready reference:
message(DialogID,destroy) % The third argument is missing since the handler here does not need it.
message(@prolog, format, 'Hi There~n'))

Example:

my_dialog:
create_dlg(DialogID,'MyWindow',
[(text_item,NameClass,name,'TypeHere'),(slider,SliderClass,slider(mywidth, 100, 1000, 400)),
(menu,MenuClass,mymenu,[class(dosa),class(idli),class(sandwich),class(paratha)]),
(button,enter,message(@prolog,dialog_handler,NameClass?selection,SliderClass?selection,MenuClass?selection)),
(button,abort, message(DialogID,destroy))]).

dialog_handler(Class, Label, Width) :- writeln(Class), writeln(Label), writeln(Width).

?- my_dialog.
true



Hi there
400
@sandwich_class

Error Messages

Error No.	Error Message	Explanation
t1	Not an integer	Platform port number should be an integer.
t2	Not an integer	Platform token should be an integer.
t3	Not a positive number	Platform port number should be positive.
td1	Not a variable	The IP of the platform will be stored in the variable.
td2	Not a variable	The port number of the platform will be stored in the variable.
sa1	Not an integer	Port number for a static agent should be an integer.
sa2	Not a positive number	Port number of a static agent should be positive.
sa3	Not an atom	Handler name should be an atom.
sa4	Not a list	Tokens should be provided in the form of a list.
sa5	Not an integer	All the tokens should be an integer.
ea1	Not an atom	Agent name should be an atom.
ea2	Not an integer	Destination port number should be an integer.
ea3	Not an atom	Handler name should be an atom.
ea4	Not a positive number	Port number should be positive.
ea5	Not an atom	Agent name should be an atom.
ea6	Not an integer	Destination port number should be an integer.
ea7	Not an atom	Handler name should be an atom.
ea8	Not an atom	Start function should be an atom in execute agent.
ea9	Not a positive number	Port number should be positive.
ma21	Not an atom	Handler name should be an atom.
ma22	Not a list	Token should be given in the form of a list.
ma23	Not an integer	All the tokens should be an integer.
ma1	Not an integer	Port should be an integer.
ma2	Not an atom	Handler should be an atom.
ma3	Not a list	All tokens should be given in the form of a list.
ma4	Not an integer	All tokens should be an integer.
ma5	Not a positive number	Port number should be positive.
mov1	Not an atom	Agent name should be an atom.
mov2	Not an integer	Port number should be an integer.
mov3	Not a positive number	Port number should be positive.
ca1	Not an atom	Agent name should be an atom.
ca2	Not an integer	Port number should be an integer.
ca3	Not a variable	A variable should be used to get the cloned name of the agent.
ca4	Not a positive number	Port number should be positive.
ap1	Not an atom	Agent name should be an atom.
ap2	Not a list	PredList should be a list containing the predicate name and its arity.
rp1	Not an atom	Agent name should be an atom.
rp2	Not a list	RemovePredList should be a list containing the predicate name and its arity.
sav1	Not an atom	Agent name should be an atom.
sav2	Not an atom	File name should be an atom.
gnma1	Not a variable	To get a random agent name, a variable should be used.

tf1	Not an atom	File name should be an atom.