National Aeronautics and Space Administration

Improving Plan Specification Language Usability and Applying Language to Model Autonomous Interplanetary Communications

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PLEXIL Overview/Background:
PLEXIL (Plan Execution Interchange Language) “is a rich concurrent and reactive language developed by NASA to support autonomous commanding and monitoring for a variety of space systems” [1]. It is currently a mature product available on the open-source platform Sourceforge. PLEXIL has already been utilized in “robotics, control of unmanned vehicles, automation of operations in human habitats, and systems and simulations involving intelligent software agents” [2].

[2]

Objectives (PLEXIL):
- Update and Improve sample application to be used as a template for PLEXIL engineers.
- Enable PLEXIL to build under the Windows Subsystem for Linux.
- Develop an editing support extension for proper syntax highlighting and indentation in Emacs.

Results (PLEXIL):

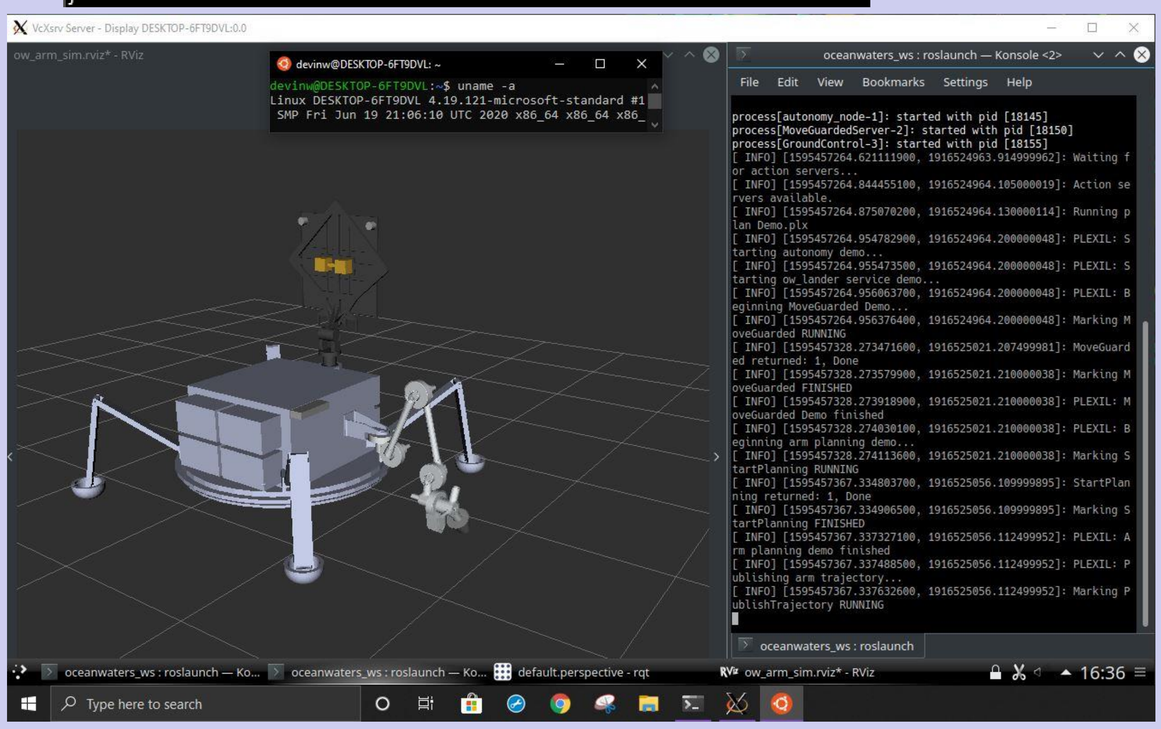
```
  (command-node "A" (command "pprint" "---- Beginning commands..."))
  (concurrence "Commands"
    (command-node "B" (command "Hello"))
    (command-node "C" (command-with-return (intvar "result") "Square" 4))
    (command-node "D" (command "SetSpeed" 10))
    (command-node "E" (command "SetSize" 10.0))
    (command-node "F" (command "SetColor" "Green"))
    (command-node "G" (command "Move" "Waypoint1" 1 1)))
  (command-node "H" (command "pprint" "Speed and size:"
                             (lookup "Speed") (lookup "Size")))))
```

A PLEXIL excerpt from sample application in outdated syntax.

```
A: pprint ("---- Beginning commands...");

Commands: Concurrence
{
  B: Hello();
  C: result = Square(4);
  D: SetSpeed(10);
  E: SetSize(10.0);
  F: SetColor("Green");
  G: Move("Waypoint1", 1, 1);
  H: pprint("Speed and size:",Lookup(Speed),Lookup(Size));
  I: SetName("Robert");
}
```

A PLEXIL excerpt from sample application after adding editor support.



Running a PLEXIL plan in OceanWATERS in WSL

OceanWATERS Overview/Background:
Ocean Worlds Autonomy Testbed for Exploration Research and Simulation, is a project at Ames that “provides environment (e.g., lighting and surface material properties) and lander (hardware and software) simulation capabilities against which autonomy software can be tested. ” [4] Currently, the project is focused on the proposed Europa Lander mission. The autonomy for OceanWATERS is implemented using PLEXIL.

Objectives (OceanWATERS):
- Model and simulate communications between the Lander and Earth.
- Speed up the simulation time without negative side-effects.

[5]

Results (OceanWATERS):

Lander: Blue

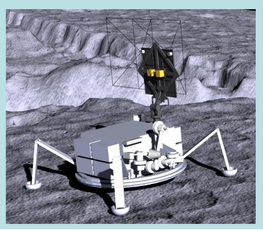
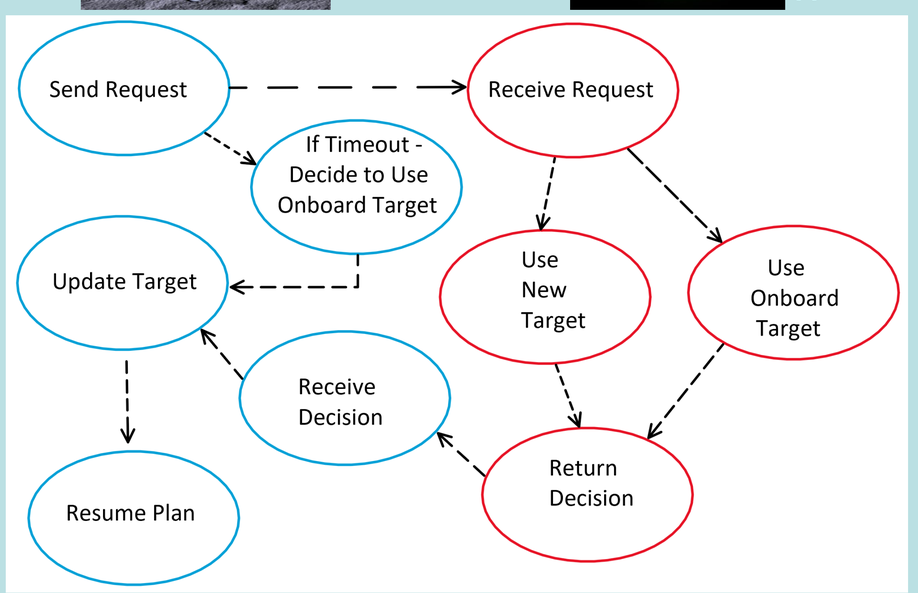


Image taken in OceanWATERS simulation

Ground Control: Red

[3]




```
[ INFO] [1595266015.880584225]: PLEXIL: Waiting for FWD link from Ground Control.
[ INFO] [1595266046.662786594]: GroundControl: Received message, [Request for FWD link]
[ INFO] [1595266046.663335589]: GroundControl: Making Decision.
[ INFO] [1595266082.663453810]: GroundControl: Sending Decision.
[ INFO] [1595266112.880631945]: Lander: Received decision, Use onboard Target.
[ INFO] [1595266112.880683464]: PLEXIL: Target updated.
[ INFO] [1595266113.542505978]: PLEXIL: Resuming plan.
```

Output from a simulation of the modeled communications system.

Conclusion (PLEXIL):
- Sample Application is more usable.
- Windows Subsystem for Linux support enlarges user base.
- Editing support extension:
  - Enhances PLEXIL development in Emacs.
  - Makes Sample Application more intuitive, readable, and usable.

Conclusion (OceanWATERS):
- Bidirectional communication implemented with appropriate time delay simulation.
- Decisions on Earth simulated, returned to Lander, and properly handled.
- While an accelerated simulation on lengthy plans take a long time, a probable solution has been targeted.

References:
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[4] L. Edwards, U. Wong, K. Dalal, C. Kulkarni, A. Rogg, A. Tardy, T. Stucky, O. Umurhan, D. Catanoso, T. Welsh. (2020). An Autonomy Software Testbed Simulation for Ocean Worlds Missions
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