EUROPA
Knowledge Engineering Tools

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Lots of stuff – little time

We will be at the System Demo for further questions!
Javier Barreiro – EUROPA Lead will be there!

EUROPA Invited Talk @ PSTL Workshop
June 26 (Tomorrow) @ 10:00 AM
What is EUROPA?

- Class library and tool set for building, customizing, and analyzing planners
  - Constraint-based Temporal Planning
  - Lifted Partial-Order Planning framework
  - Timeline-based state/plan representation

- Mainly used for NASA applications
- NDDL modeling language
- Open-sourced
EUROPA History

- HSTS (1998) - Initial DDL and planning paradigm.
- RAX (1999) – first deployment
  - RAX won NASA software-of-the-year
- EUROPA (2002) - Initial implementation of current approach
- EUROPA 2 (2005) - Modular architecture, more robust implementation
- EUROPA 2.1 (2007) - Open source, architecture evolution, moved to Google Code, strong documentation
- EUROPA 2.6 (2012) – API, KE tools
15+ NASA Applications, such as:
- Science activity planning
  - Airborne observatory SOFIA
  - Remote Agent Experiment (RAX)
  - Mars Exploration Rovers (MER)
  - Phoenix Mars Mission.
- SACE
- Planning and scheduling support for experiments
  - Life in the Atacama (LITA)
  - Bed Rest study.

MBARI: underwater autonomous vehicle
Willow Garage: autonomous robot navigation
Other applications noticed in the EUROPA mailing list
EUROPA Architecture

**KE Tools - Analysis:**
- Plan progress
- Plans

**KE Tools - Preparation:**
- NDDL & ANML model support
- Client application integration assistant

**EUROPA Framework**

**Client API**

**Built-in Extensions**
- Constraint Library
- Temporal Network
- Resources Management
- Chronological Backtracking Solver
- Modeling Language Implementation (NDDL, ANML)

**EUROPA Kernel**
- Constraint Engine
- Plan Database
- Rule Engine
- Solvers
- Model Interpreter
Design Process Track

1. Elicitation & Modeling
2. Model Validation & Verification
3. Plan/Schedule Analysis
KE Tools “Platform”

**Eclipse Plugins**
- Take advantage of Eclipse bells & whistles (we use Eclipse a lot)

**PSUI Package**
- No Eclipse requirement
- Much more customizable through BSH
Presentation Outline

- Example: Mars Rover
- Modeling support:
  - NDDL
  - ANML
- Plan visualization and analysis
- Planning process analysis support
- Client Application Integration Support
David Smith introduced a simplified PDDL version used in IPC’02, 06
Presentation/Demo Outline

- Example: Mars Rover
- **Modeling support:**
  - NDDL
  - ANML
- Plan visualization and analysis
- Planning process analysis support
- Client Application Integration Support
Modeling Support: Eclipse Plugin (no PSUI)

New Domain Description Language (NDDL)
Eclipse Plugin by Ames PSG

Action Notation Modeling Language (ANML)
Eclipse Plugin by Stottler Henke company

translator by Stottler Henke

[Smith et al]
[Bernadini & Smith]

E-Translator by Adventium Lab

PDDL
NDDL Example

**NDDL**

```java
class Rover {
    Navigator navigator;
    Instrument instrument;
    Battery mainBattery;

    action Go { Location dest; }
    action TakeSample { Location rock; }
    action PhoneHome{}
    action PhoneLander{}
}

class Navigator extends Timeline {
    predicate At { Location location; }
    predicate Going {
        Location from, to;
        neq(from, to);
    }
}

Rover::Go {
    contained_by(condition object.instrument.location.Stowed);
    met_by(condition object.navigator.At _from);
    meets(effect object.navigator.At _to);
    eq(_to.location, dest);

    equals(effect object.navigator.Going going);
    eq(going.to, dest);

    starts(effect object.mainBattery.consume tx);
    eq(tx.quantity, path.cost);
}
```

**PDDL**

```plaintext
:types
    Navigator Instrument Battery – RoverComponent
    RoverComponent Rover – object

:predicates
    component_of(RoverComponent,Rover)

:constant (Going – location)

:functions
    At(Rover) - Location

:duration-action Go
:condition
    (and (over all (stowed(instrument)))
     (at start (= At(?Rover) _from)))
:effect
    (and (at start (= At(?Rover) Going))
     (at end (= At(Rover) _to))
     (at start (decrease MainBattery(?Rover) tx))
```

Object-oriented Language          Lisp-like Language
Modeling Support: NDDL

Switch to Eclipse Environment

- Syntax highlight
- Object outline
- Error markers
ANML Example

ANML ↔ NDDL + PDDL + ADL

PDDL

:types
Navigator Instrument Battery – RoverComponent
RoverComponent Rover – object

:predicates
component_of(RoverComponent, Rover)

:functions
At(Rover) – Location

:action
Go (location from, to)
{
  duration := 5
  [all] { instrument == stowed;
    location == from :-> to;
    MainBattery :consumes tx;}
}

[Smith et al] & [Bernadini & Smith] on ANML-PDDL translation
Modeling Support: ANML

Switch to Eclipse Environment

- Text-based ANML editor
  - Highlight, quick-fix, type-hierarchy, auto-completion suggestion
- ANML to PDDL translation
- Action Timeline Summary
- Fluent Action Timeline Summary
- Action Variable Matrix
- Causal chain
- Resource analysis

analyze action-fluent relationships
Presentation Outline

- Example: Mars Rover
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Timeline-based Plan Representation

Tokens: changes happen to object state over time
Plan Visualization & Analysis: EclipseIDE (SWT) & PM/IDE

Switch to Eclipse Environment

• From either NDDL or ANML editor
• Gantt charts on plan timeline
• Plan viewer with pop-up details about plan & token
• Graphs on resource profiles
Switch to PSUI Package (no Eclipse) for Rovers Domain

- **PSGantt**: tokens on timeline as a Gantt chart
- **PSChart**: resource profiles as charts
- **Action Details & Action Violation**
Presentation Outline

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Planning Process Analysis: PSUI

Switch to PSUI Package for Visualization Of:

- **Search statistic:** # of steps, time for each step
- **Individual step analysis:** # of flaws, details of each flaw possible resolutions, selected resolution
Switch to Plugin to run/analyze EUROPAL within Eclipse

- **Search statistic**: # of steps, time for each step
- **Individual step analysis**: # of flaws, details of each flaw, possible resolutions, selected resolution
Presentation Outline

- Example: Mars Rover
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- Client Application Integration Support
Assist Client Application Integration

- **Makeproject**: quick integration template, template C++ & Java code for utilizing API for various important functions (solving, showing/analyzing flaws, displaying)
- **BSH**: quickly customize the domain analysis & debugging graphical interface
Summary

- **Modeling support: NDDL & ANML**
  - Error highlight, code auto-completion, PDDL auto-translation (limited), type hierarchy, object outline, references (reader/writer) lookup, filtering, online help
  - Multiple views: action timeline, fluent-action timeline summary, action-variable matrix, action causal relationship analysis, resource profile analysis

- **Plan Analysis:**
  - Plan = tokens on timeline: Gantt charts
  - Resource profiles: graphs/charts

- **Planning process Analysis:**
  - Graphical and text details on: processing time, #flaws, #flaws handled, possible/selected resolutions

- **Client (C++ or Java) application integration:**
  - Makeproject: template building
  - BSH shell: easy shell-script experimenting
Conclusion

• Pros:
  ○ Long history of integrating in multiple NASA missions:
    ▪ Well-documented (EUROPA Wiki), well-tested
    ▪ Automated build & unit-test for all popular platforms (Windows, Mac, Linux 32/64 bits)
    ▪ Different ways to test and integrate with native applications
    ▪ Open-sourced

• Cons:
  ○ KE tools spread between several different environments
  ○ No native support for PDDL (yet)
Questions?

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