Framework: Rule-Based System Architecting

Application: EOSS (Earth Observing Satellite Systems)

Object of document: Explanation Facility

Type of document: User Manual

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Contents

Overview of document

This user manual provides an overview of the explanation facility developed for the application of the rule-based system architecting framework to EOSS.

The EOSS explanation facility

The goal of the EOSS explanation facility is to support the user of the EOSS rule-based architecting framework understand and interpret the results.

The EOSS EF has two types of functionality: graphics-based functionality and text-based functionality. The graphics-based component provides interactive support on the different graphics generated by the framework (e.g. obtaining information about an architecture by clicking on the corresponding point in the tradespace), while the text-based component allows querying the working memory of the rules engine from the Matlab prompt.

Graphics-based functionality

The following plot functions support graphics-based explanation functionality:

- **SEL_plot_results**: clicking on an point on the cost/science space shows the following information
    - Architecture: #instruments, names of selected instruments
    - Metrics: architecture id#, science, cost, risk, fairness, pareto ranking, utility

Arch = 221, utility = 0.895484, Science = 0.950458, Cost = 7005.975677, #instruments = 26
Pareto rank = 1, risk = 0.076923, fairness = 0.890000
Payload = ACRIM AIRS ALT-SSALT AMSR-E AMSU-A ASTER CERES DORIS EOSP GLRS HIRDLS HSB LIS MIMR MISR MLS MODIS MOPITT OMI SAGE-III SEAWIFS SEAWINDS SWIRLS TES TMR CERES-B

- **PACK_plot_results**: clicking on an point on the cost/science space shows the following information
    - Architecture: allocation of instruments to satellites, #sats, #instruments per satellite
    - Metrics: science, cost, programmatic risk, launch risk, pareto ranking, utility

Arch = 20, utility = 0.906070, Science = 0.808780, Cost = 1944.880600, Pareto rank = 1, risk = 0.400000, launch risk = 0.605140
Arch with 3 sats (6 5 5) w/assignment = AIRS AMSU-A HSB MLS MODIS TES & AMSR-E CERES-C HIRDLS MOPITT OMI & ASTER CERES CERES-B MISR MODIS-B

- **PACK_plot_science_cost_risk_space:** same as PACK_plot_results
- **SCHED_plot_results:** clicking on an point on the discounted benefit/data continuity space shows the following information
    - Architecture: sequence of missions
    - Metrics: discounted value (DV), data continuity (DC), fairness , pareto ranking, utility

Arch = 376, utility = 0.547476, DV = 1.012700, DC = 1.003000, Pareto rank = 3, risk = 0.000000, fairness = 17.275500
Sequence = TERRA ORBVIEW-SEAWIFS TRMM LANDSAT-7 AQUA AURA METEOR-SAGE-III ACRIMSAT EO-1-NMP ADEOS-II QUIKSCAT JASON-1 ICESAT GRACE OSTM CLOUDSAT SORCE CALIPSO

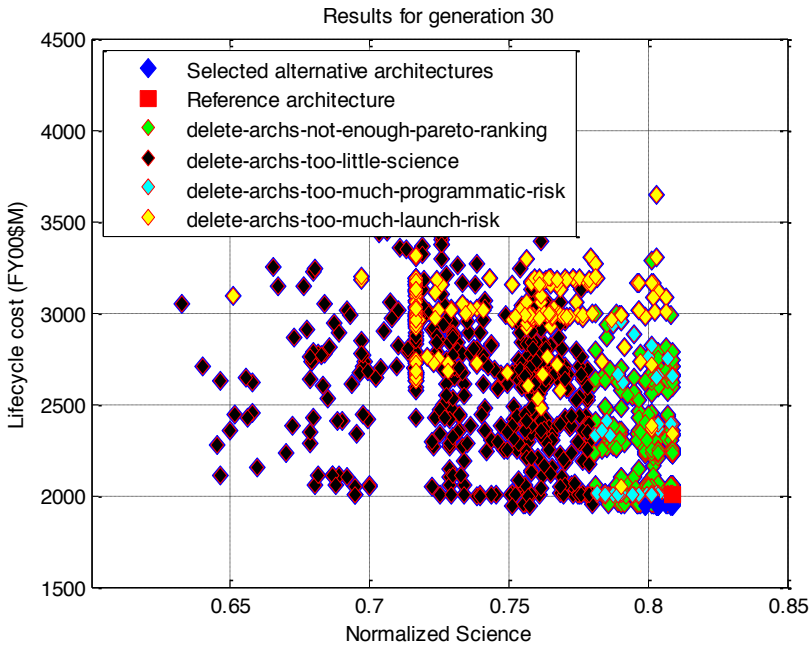
- **plot_data_continuity_matrix** clicking on an point on the measurement/year space shows names of all the satellite/instruments taking that measurement at that particular year, e.g.:

```
**************************************************************
Measurement " 1.9.2 Spectrally resolved IR r " taken in 2017.5 by the following 20 satellites:
**************************************************************
Meteosat-8/SEVIRI
Meteosat-9/SEVIRI
CloudSat/CPR (CloudSat)
Metop-A/IASI
NOAA-15/AMSU-A
Landsat-7/ETM+
NOAA-16/AMSU-A
NOAA-17/AMSU-A
NOAA-18/AMSU-A
Metop-A/AMSU-A, IASI
NOAA-15/AVHRR/3, HIRS/3
GOES-11/Imager
NOAA-16/AVHRR/3, HIRS/3, SBUV/2
GOES-12/Imager
NOAA-17/AVHRR/3, HIRS/3, SBUV/2
Meteosat-8/GERB
NOAA-18/AVHRR/3, HIRS/4, SBUV/2
Meteosat-9/GERB
GOES-13/Imager
Metop-A/AVHRR/3, GOME-2, HIRS/4, IASI
```

Text-based functionality

The following functions can be called from the Matlab prompt to query the working memory:

- **XXX_explain_down_selection (XXX=SEL,PACK,SCHED)**: Uses color to indicate reason why architectures were eliminated from the tradespace, e.g.:



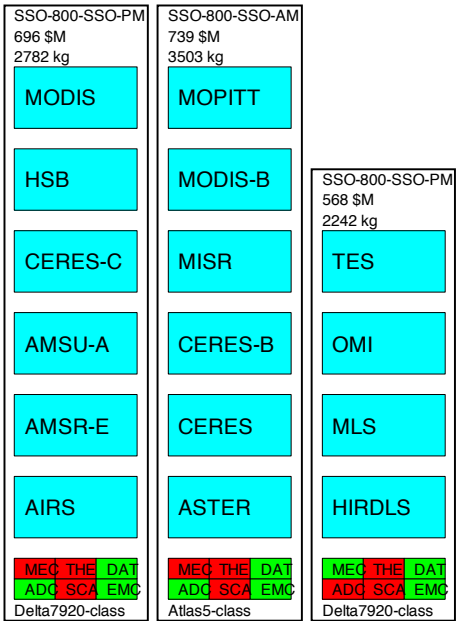
- **RBES_explain_score:** When used on a particular mission or instrument, it provides the following information:
    - Detailed panel scores
    - List of subobjectives satisfied, classified by level of satisfaction
        - Fully satisfied
        - Partially satisfied (provides score and reason why they are not fully satisfied, taken from the description field of the corresponding partial requirement satisfaction rule.
    - List of subobjectives that would potentially be satisfied but are completely missed: these are subobjectives that correspond to measurements that are taken by one or more of the instruments in the manifest, but at a level of performance that is not enough to satisfy any of the requirement satisfaction rules. This list also contains detailed information about what is missing in these data products in order to satisfy the subobjectives.

Overall scores for instrument test = 0.440686
****
Explanation of scores for instrument test
****
Panel WAE has a score of 0.532188 because the following subobjectives are satisfied:
WAE1-1 through "1.2.1 Atmospheric temperature fields"
WAE1-2 through "1.8.1 H2O"
Panel OCE has a score of 0.708333 because the following subobjectives are satisfied:
OCE1-1 through "3.1.1 Ocean color - 410-680nm -Chlorophyll absorption and fluorescence, pigments, phytoplankton, CDOM-"

OCE1-2 through "3.1.1 Ocean color - 410-680nm -Chlorophyll absorption and fluorescence, pigments, phytoplankton, CDOM-"
OCE1-3 through "1.8.3 CO2"
****
Subobjectives fully satisfied:
****
Fully satisfies WAE1-1 because it measures "1.2.1 Atmospheric temperature fields"
Fully satisfies WAE1-2 because it measures "1.8.1 H2O"
Fully satisfies WAE2-1 because it measures "1.5.3 Cloud amount/distribution -horizontal and vertical-"
Fully satisfies WAE2-3 because it measures "1.5.1 Cloud top temperature"
Fully satisfies WAE2-4 because it measures "1.7.1 Cloud liquid water and precipitation rate"
Fully satisfies WAE3-1 because it measures "1.7.1 Cloud liquid water and precipitation rate"
Fully satisfies WAE3-2 because it measures "1.7.3 Rain rate, tropical storms, and hurricanes"
Fully satisfies WAE4-3 because it measures "1.8.1 H2O"
Fully satisfies WAE5-2 because it measures "1.1.3 aerosol scattering properties"
Fully satisfies WAE6-5 because it measures "1.9.3 Spectrally resolved SW radiance -0.3-2um-"
Fully satisfies WAE6-6 because it measures "1.9.2 Spectrally resolved IR radiance -200-2000cm-1-"
****
Partially satisfied subobjectives by test:
****
Partially satisfies WAE1-3 (score = 0.500000) because it measures "3.4.1 Ocean surface wind speed"
Fact 1456 has attribute = insufficient accuracy
Partially satisfies WAE5-1 (score = 0.500000) because it measures "1.1.1 aerosol height/optical depth"
Fact 1487 has attribute = Insufficient vertical spatial resolution (none)
Partially satisfies WAE7-2 (score = 0.500000) because it measures "4.2.4 snow cover"
Fact 1727 has attribute = Insufficient accuracy
****
Potential but completely missed subobjectives by test:
****
Could satisfy GHG9-3 because it measures "1.6.2 cloud ice particle size distribution" but it completely misses it
Required: Temporal-resolution = Medium-1day-3days)
Fact 1253 has Temporal-resolution = Medium-1day-3days
****
Required: Accuracy = High
Fact 1253 has Accuracy = Medium
****
****
Required: sensitivity-in-cirrus = High
Fact 1253 has sensitivity-in-cirrus = nil

- **RBES_show_penalties2**: When used on a particular packaging architecture, it graphically represents the packaging architecture and provides the following information:
    - Detailed cost breakdown for each mission in architecture including bus, payload, launch, ops cost amongst others.
    - Active complexity penalties
    - Mass, orbit, and launch vehicle for each satellite

Cost breakdown mission EOS1: payload = 193, bus = 140, launch = 65, program = 102, IA&T = 73, ops = 68, total = 696
Cost breakdown mission EOS2: payload = 184, bus = 140, launch = 110, program = 99, IA&T = 79, ops = 68, total = 739
Cost breakdown mission EOS3: payload = 108, bus = 140, launch = 65, program = 78, IA&T = 56, ops = 52, total = 568
Total mass = 8526.793998, total cost = 2002.602470, total launch cost = 240.000000



- **RBES_who_satisfies2**: finds which instruments can measure a certain measurement

candidate_instruments = RBES_who_satisfies2('"3.2.2 seafloor topography"')
candidate_instruments =

[ALT-SSALT, GRACE, POSEIDON-3]

- **RBES_why_not2**: Explains why a mission/architecture does not satisfy a given subobjective

[missing] = RBES_why_not2('WAE1-1')
Could satisfy WAE1-1 because it measures "1.2.1 Atmospheric temperature fields" but it completely misses it
Required: Temporal-resolution >= High-12h-24h Vertical-Spatial-Resolution >= Medium-200m-2km Accuracy = High All-weather = yes cloud-cleared = yes Coverage-of-region-of-interest = Global sensitivity-in-low-troposphere-PBL = High Spectral-sampling = Hyperspectral-100-channels-or-more

```
Achieved:
Fact 1447 has taken-by = TES-HIRDLS-disaggregated-syn-MLS-TES-disaggregated
Fact 2135 has taken-by = HIRDLS-syn-MLS
Fact 1448 has taken-by = TES-HIRDLS-disaggregated-syn-MLS-TES-disaggregated
Fact 2136 has taken-by = HIRDLS-syn-MLS-syn-TES
```

- **RBES_how_is_subobj_satisfied2**: Explains how a mission/architecture satisfies a given subobjective

```
who = RBES_how_is_subobj_satisfied2('WAE1-1')
Subobj WAE1-1 is partially satisfied by AIRS-MODIS, score = 0.660000

who =

AIRS-MODIS
```