Automatic Planning for Supply Chain Management

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Problem

- Supply chain is a network composed of organizations that exchange products in order to attend the final consumer.

- Retail and Industry (Vendor)

- Win-win situation

- The organizations in a supply chain must avoid situations such as stock-out and excess of stock

Solution

- Using Automated Planning to generate a set of actions that helps in stock management

- Create a Domain Model using PDDL

- Plan Metrics

Domain Definition

- Retailer and Vendor

- Predicate:
  - Connected

- Actions:
  - Order
  - Replenish
  - Produce
  - Attend Monthly Demand

Predicate *Connected*

- (connected ?v - vendor ?r - retail)

- Informs whether a retailer **R** and vendor **V** can exchange products.

Order

- Order made by a retailer **R** requesting products from the vendor **V**

```
(:action order
  :parameters (?r − retail ?i − vendor)
  :precondition (and
    (connected ?i ?r)
  )
  :effect (and
    (increase (received−orders ?i ?r) 1)
    (increase (total−orders ?i) 1)
    (increase (total−cost) 1)
  )
)
```

Replenish

- Action made by a vendor to replenish their items in the retail stock

```
(:action replenish
  :parameters (?i - vendor ?r - retail)
  :precondition (and
    (> (made-items ?i) 0)
    (>= (received-orders ?i ?r) 1)
  )
  :effect (and
    (increase (stock ?r ?i) 1)
    (decrease (made-items ?i) 1)
    (decrease (received-orders ?i ?r) 1)
  )
)
```

Produce

- Action made by a vendor to produce items to replenish all of the connected retailers

```
(:action produce-low
  :parameters (?i - vendor)
  :precondition (and
    (>= (total-orders ?i) 1)
    (< (made-items ?i) (storage-limit ?i))
  )
  :effect (and
    (increase (made-items ?i) 1)
    (increase (total-cost) 1)
    (decrease (total-orders ?i) 1)
  )
)
```

Attend Monthly Demand

- Action that represents the monthly demand of a retailer, given the products of a related vendor

```
(:action attend−monthly−demand
  :parameters (?r − retail ?i − vendor)
  :precondition (and
    (>= (stock ?r ?i)
    (monthly−demand ?r ?i))
  )
  :effect (and
   (decrease (stock ?r ?i) (monthly−demand ?r ?i)
   (increase (demand ?r ?i) 1)
  )
)
```

Planners

Planner	Numeric	Plan Metric	Typing
ENHSP	Support	Support	Support
LPG-TD	Support	Partially	Support
Metric-FF	Support	Partially	Support
Fast Downward	No	No	No

Simple Problem

- 1 retailer

- 1 vendor

- Goal: Attend the demand of 1 month

```
(define (problem simple-problem)

(:domain supply-chain)

(:objects
    walmart - retail
    procter - vendor
)

(:init
    (= (total-cost) 0)

    (= (total-orders procter) 0)
    (= (made-items procter) 0)
    (= (storage-limit procter) 10)
    (= (max-capacity procter) 3)

    (connected procter walmart)

    (= (stock walmart procter) 0)
    (= (monthly-demand walmart procter) 5)
    (= (demand walmart procter) 0)

    (= (received-orders procter walmart) 0)
)

(:goal (and (= (demand walmart procter) 1)))

(:metric minimize (total-cost))
)
```

Simple Problem - Results

Plan without Metric

```
(order-high walmart procter)
(produce-high procter)
(order-high walmart procter)
(produce-high procter)
(replenish-high procter walmart)
(replenish-high procter walmart)
(attend-monthly-demand walmart procter)
```

- Retailer stock level: 6 products

Plan with Metric

```
(order-low walmart procter)
(order-low walmart procter )
(produce-low procter)
(replenish-low procter walmart)
(replenish-low procter walmart)
(replenish-low procter walmart)
(order-high walmart procter)
(produce-high procter)
(replenish-high procter walmart)
(attend-monthly-demand walmart procter)
```

- Retail stock level: 5 products

Near Real Problem

- 2 retailers

- 2 vendors

- 1 retailer connected with 2 vendors

- 1 retailer connected with 1 vendor

Near Real Problem - Results

Approach	Evaluated States	Duration	Metric
Inadmissible Heuristic	427	648	-
Inadmissible Heuristic + Plan Metric	355	558	29
Admissible Heuristic	595155	159708	-
Admissible Heuristic + Plan Metric	1066431	292866	22

Conclusion and Future Work

- With a existing planner, our domain definition results in a set of actions that help the parties in a supply chain

- Item category may be approached

- Temporal Planning