A Weather Ontology for Predictive Control in Smart Homes

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Outline

Introduction

Existing work
    Ontologies
    Weather data
    Ontology design methodologies

Results
    SmartHomeWeather
    Weather Importer
    Conclusion

Smart Homes

- Smart homes are equipped with some kind of intelligence to perform tasks on their own.
- Components: Sensors, actuators, communications network, intelligent control.

Goals:

- Support with routine tasks.
- Maintaining or increasing comfort.
- Reduction of energy consumption.

Problems of smart homes

There are many smart home projects: Mozer's adaptive house, Georgia Tech Aware Home, Gator Tech Smart Home, . . .
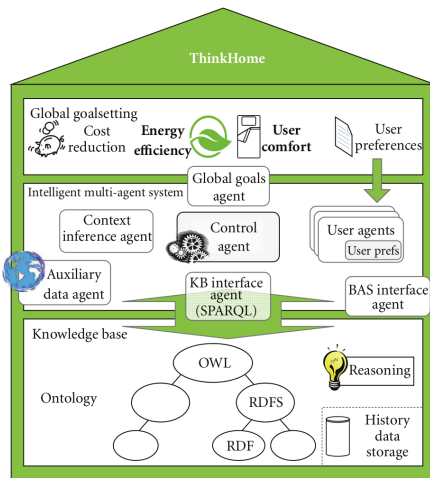
However, in many cases there are several problems:

- High complexity.
- Optimisations and customisations are difficult.
- Missing powerfulness and flexibility.

In many cases, the full potential of smart homes is not exploited.

An ontological approach

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Weather data

Processes in and around a dwelling influenced by weather, e.g.:

- Heating, ventilation, and air conditioning (HVAC).
- Optimal utilisation of solar and wind power.
- Irrigation.
- Preparations for severe weather.

SmartHomeWeather is an ontology covering current and future weather data.

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Weather ontologies

Several ontologies cover weather data:

- Semantic Sensor Web
- SSN Ontology
- SWEET
- NNEW
- . . .

Unfortunately, none of them was found to be suitable for smart homes.
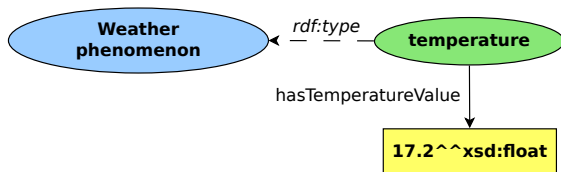
Related ontologies

- Location: Basic WGS84 (lat/lon) Vocabulary
- Date and time: OWL-Time
- Units of Measurement:
    - Measurement Units Ontology
    - Ontology of Units of Measure and Related Concepts
    - ...

However, all these ontologies come with various drawbacks.

Measurement Units Ontology (1)

Measurement Units Ontology (2)

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Sensors and services

SmartHomeWeather retrieves data from local weather sensors and Internet weather services.

- Arbitrary number of sources possible.
- Assignment of priority values to weather data.
- Current data from sensors and services.
- Forecast data from services.
- Time range for forecasts: 24 hours.

Weather sensors

Sensors are commonly accessed via fieldbus systems (KNX, LonWorks, BACnet, . . .). A variety of sensors is available:

- Barometer
- Photometer
- Hygrometer
- Rain gauge
- Pyranometer
- Thermometer
- Wind wane, anemometer

Weather services

- Weather services evaluated: DWD, Google Weather Feed, METAR, NWS, Weather.com, Weather Underground, World Weather Online, Yahoo! Weather, yr.no.

- Criteria for evaluation: Coverage area, data format, data access, access restrictions, terms of use, documentation, stability, weather elements, time frame, weather updates.

- Conclusion: Reference implementation using yr.no

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Weather elements

Weather elements currently used in *SmartHomeWeather*:

- Temperature
- Relative humidity
- Dew point
- Cloud coverage (altitude and amount cloud cover)
- Precipitation (intensity and probability)
- Wind (speed and direction)
- Atmospheric pressure
- Solar radiation
- Position of the sun (azimuth, elevation angle)
- Weather condition (sunshine, rain, snow, . . .)

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Methodologies

- Ontology 101
- Uschold and King
- TOronto Visual Enterprise
- UPON
- METHONTOLOGY

METHONTOLOGY
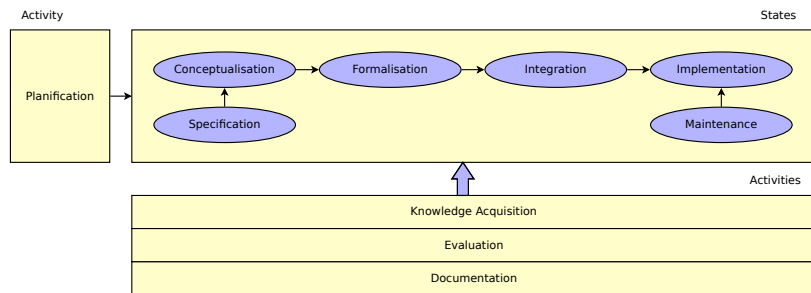
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Competency questions

- What will the weather situation be in one hour, in two hours, . . . , in 24 hours?

- What will be the minimum temperature, humidity, . . . over the next 24 hours? What about maximum values?

- Will the weather change? Will the temperature, humidity, . . . rise or fall?

- Does it rain? Will it rain in the next hours? Will it rain today?

- Will temperature drop/stay below $0\,^{\circ}C$?

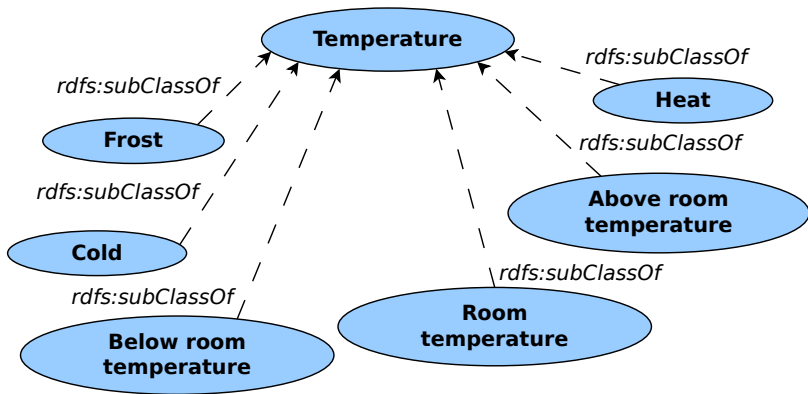- When can we open windows and when do we have to keep them shut?

Overview
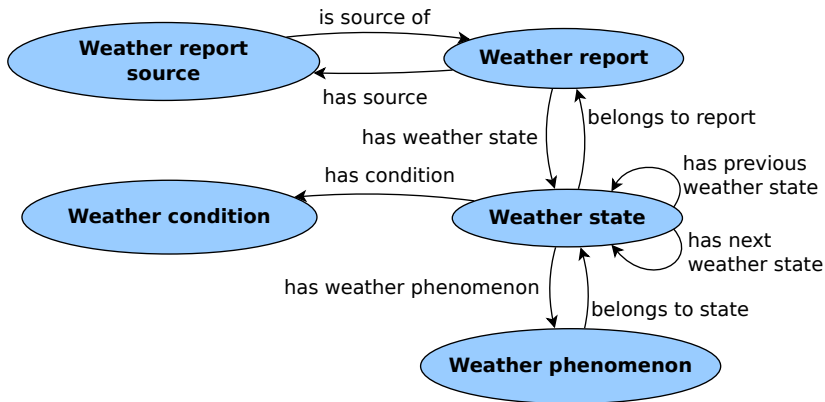
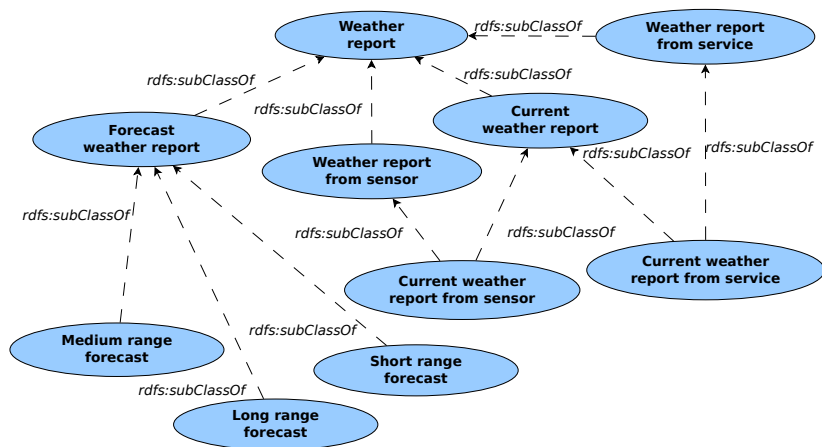# Concept hierarchies: Weather phenomenon
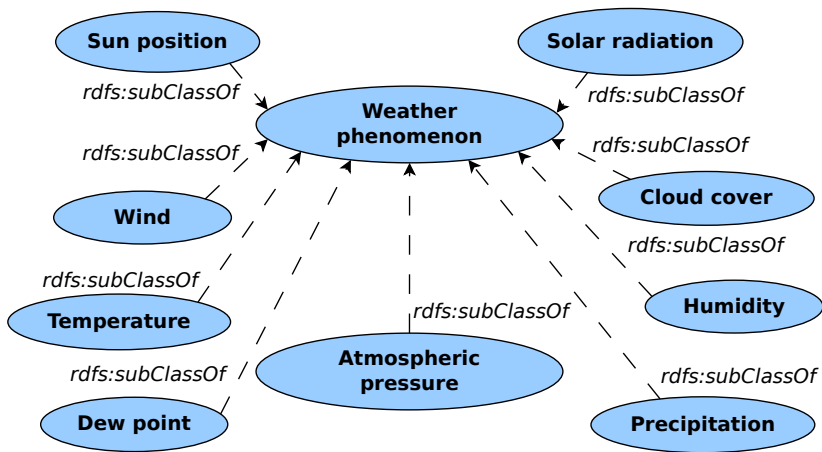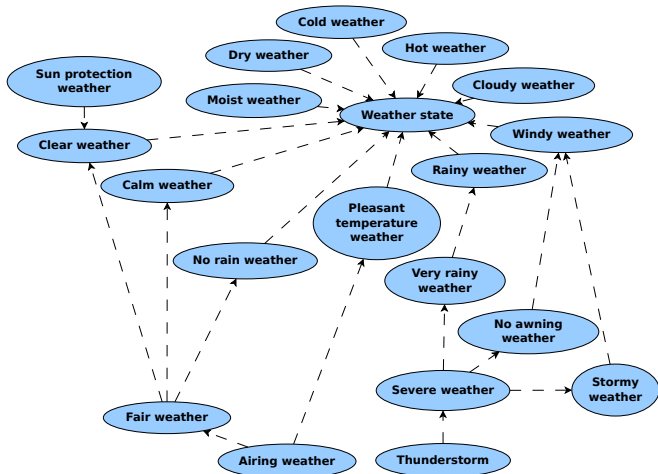
Concept hierarchies: Temperature

Concept hierarchies: Weather report

Concept hierarchies: Weather state

SPARQL and SWRL (1)

```
SELECT ?s
WHERE {
    ?s weather:hasWeatherPhenomenon ?p.
    ?p a weather:Frost.
    ?s weather:belongsToWeatherReport ?r.
    ?r a weather:ShortRangeForecastReport.
}
```

SPARQL and SWRL (2)

```
hasWeatherPhenomenon(?s1, ?t1) ∧
  hasTemperatureValue(?t1, ?v1) ∧
  numericalValue(?v1, ?m1) ∧
  hasWeatherPhenomenon(?s2, ?t2) ∧
  hasTemperatureValue(?t2, ?v2) ∧
  numericalValue(?v2, ?m2) ∧
  greaterThan(?m2, ?m1) ∧
  hasNextWeatherState(?s1, ?s2)
    ⇒ increasingTemperature(?s1, ?s2)
```

Outline
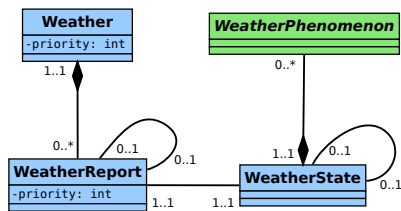
Weather Importer

- Import from sensors and Internet services.
- Unit tests for *SmartHomeWeather* and Weather Importer.

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Conclusion

Results:

- *SmartHomeWeather* allows predictive control based on weather data within smart homes.
- Weather Importer retrieves weather data from various sources into *SmartHomeWeather*.

Future work:

- Interoperability with other data sources.
- Smart Cities.

The End

Thanks for your attention.

Questions?