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Provenance in Systems for Situation Awareness in Environmental Monitoring

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Introduction

- Environmental monitoring systems increasingly
  - Build on environmental sensor networks
  - Automate measurement, collection, processing
  - Also automated analysis
  - Obtain and maintain situation awareness
- As automation increases
  - Support automated provenance representation
  - Can increase confidence in system correctness

Introduction

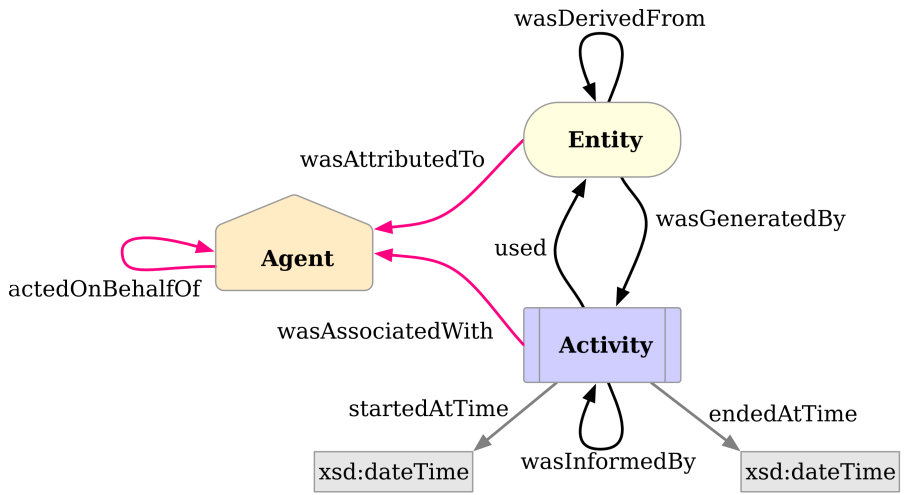
- Situation awareness
  - Various definitions and models
  - Endsley most prevalent in literature
  - Perception, comprehension, projection
- Situation
  - Structured parts of reality
  - Formalized in situation theory
  - Mathematical object to represent situations
  - In particular, information about situations
- Environmental monitoring systems
  - Observe structured parts of reality
  - Obtain knowledge about situations

Aims

- Present an alignment of ontologies
  - The PROV ontology
  - With SSN, QB, and STO
- Demonstrate the alignment
  - Concrete scenario
  - Situation awareness in environmental monitoring

Provenance

- PROV is a specification for provenance
  - Trace the origin of digital objects, i.e. entities
  - From what entity is an entity derived
  - In what activity is an entity generated
  - To what agent is an entity attributed
  - To what agent is an activity associated



(Source: http://www.w3.org/TR/prov-o/)

Alignment

- SSN, QB, STO alignment proposed[1]
- SSN and PROV, see Compton et al.[2]
  - SSN Observation is a PROV Entity
  - SSN Stimulus is a PROV Activity
  - SSN Sensor is a PROV Agent
  - Observations are
    - Generated by stimuli
    - Attributed to sensors
  - Stimuli are associated with sensors

Alignment

- QB and PROV
  - QB Observation is a PROV Entity
    - Derived from SSN or QB observations
    - Attributed to operators
    - Generated by operations
  - Operators are PROV agents
  - Operations are PROV activities
  - Example operations
    - Translation SSN→QB observations
    - Processing QB→QB observations
  - QB DataSet is a PROV Entity
  - Datasets can be derived from datasets

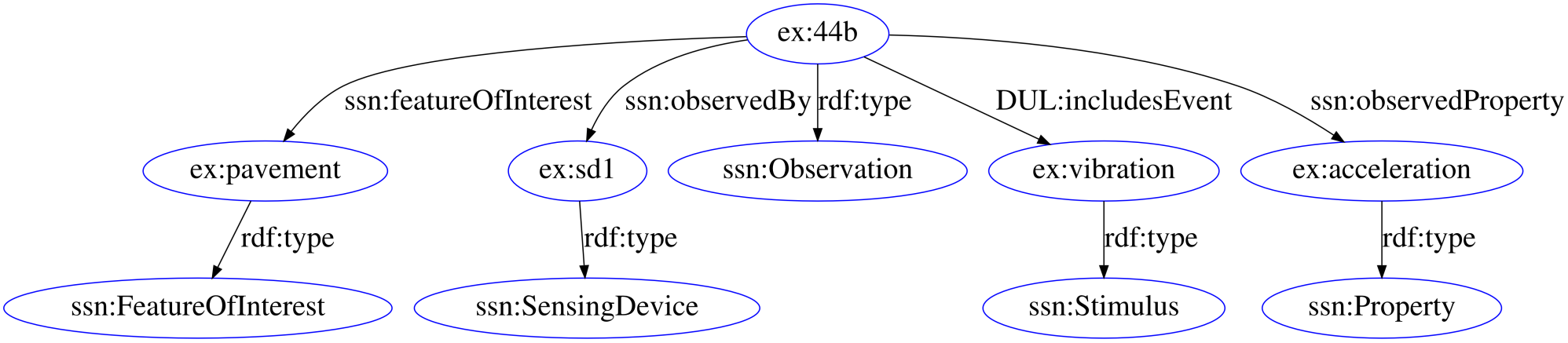
Alignment

- STO and PROV
  - STO Situation is a PROV Entity
  - As well as other STO objects
    - infons, relations, individuals, attributes, values
  - These objects may be derived from QB observations
  - May also be derived from STO objects
- Example operations
  - Extraction QB observations→STO objects, e.g.
  - Classification operation with ML classifier

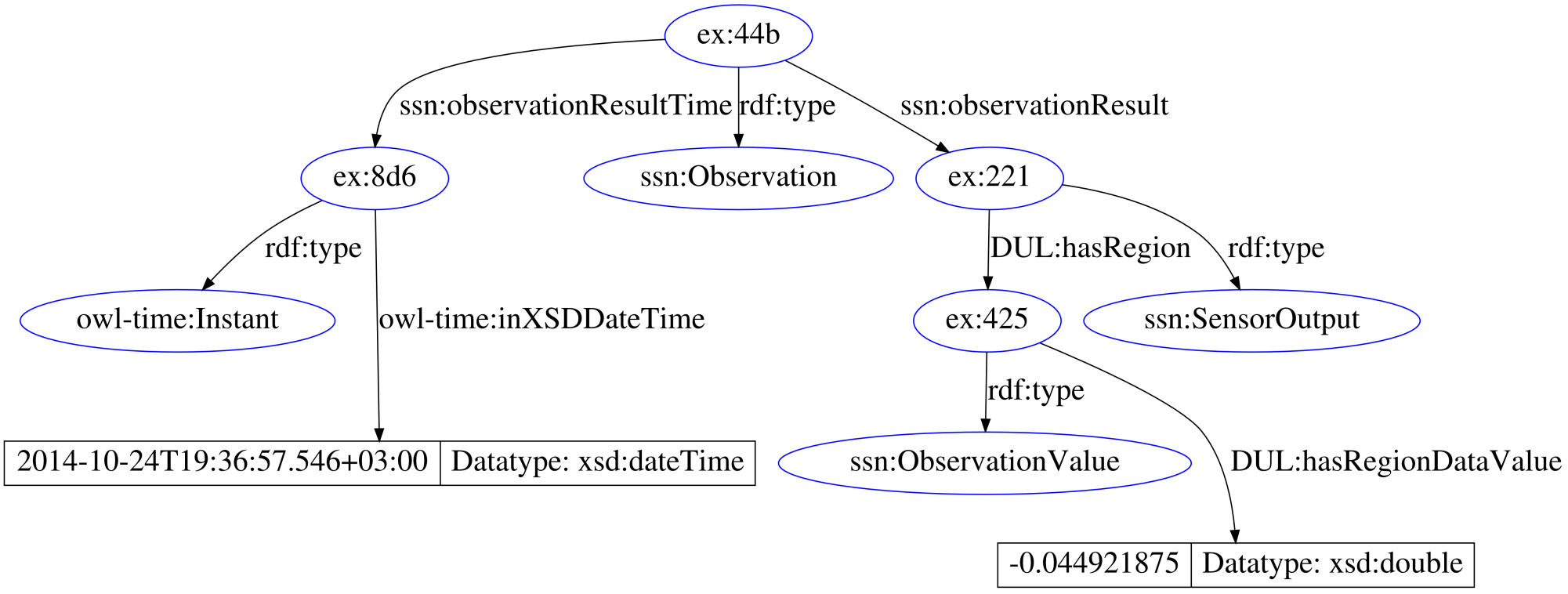
Use case

- Intelligent transportation systems
- Road-pavement vibration measured using sensor network
- Measured vibration patterns induced by vehicles
- ML classifier used to detect and characterize vehicles
- Characterization is for ‘light’ or ‘heavy’ vehicle
- Situations are structured parts of reality
  - Monitored road section is the part
  - Vehicles, pavement, sensors form structure
  - Vehicles are ‘near’ sensors in situations

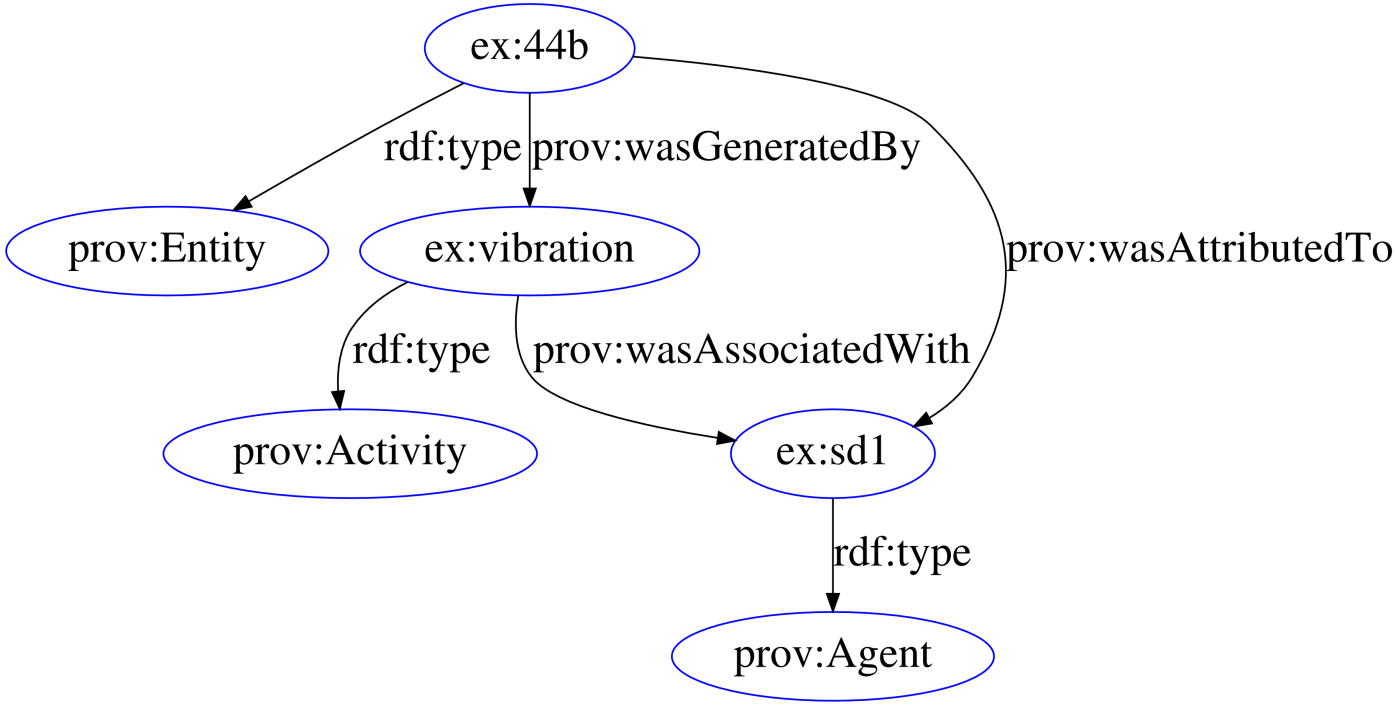
SSN observation
Sensor, feature, stimulus, property



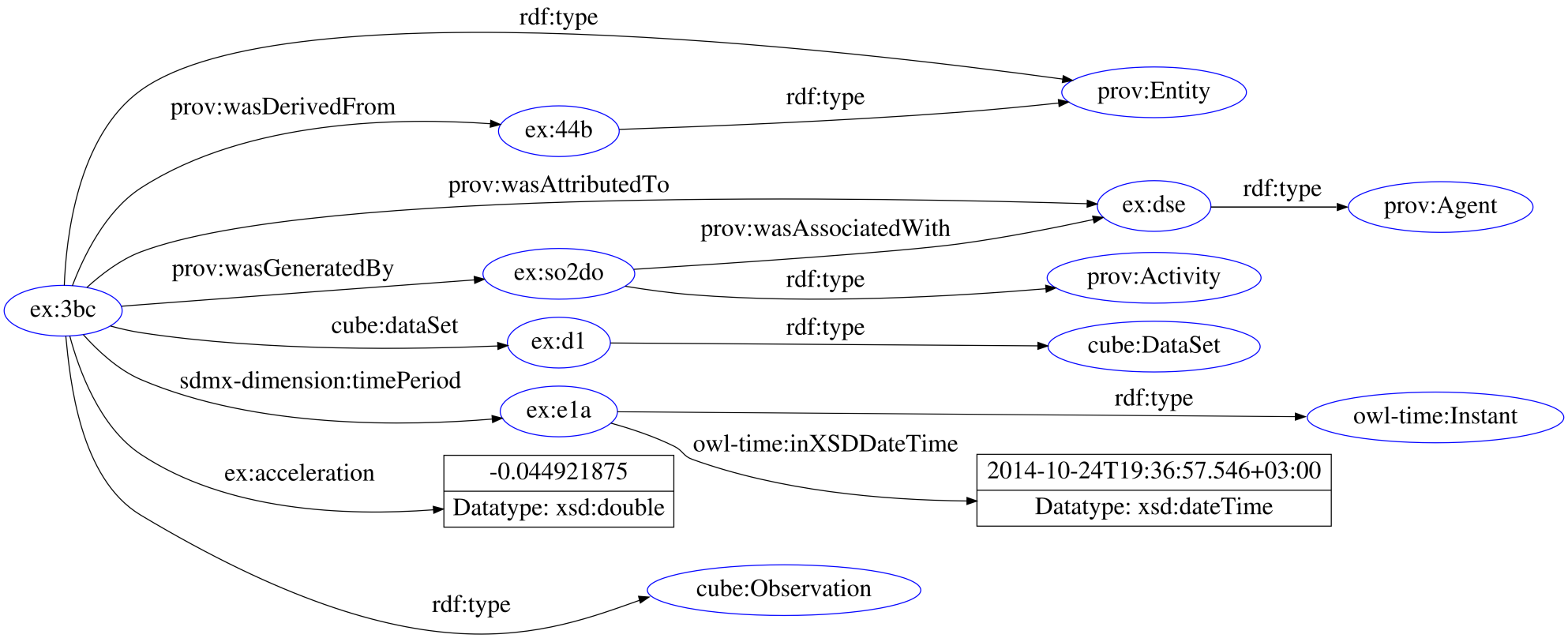
SSN observation
Time and observation value



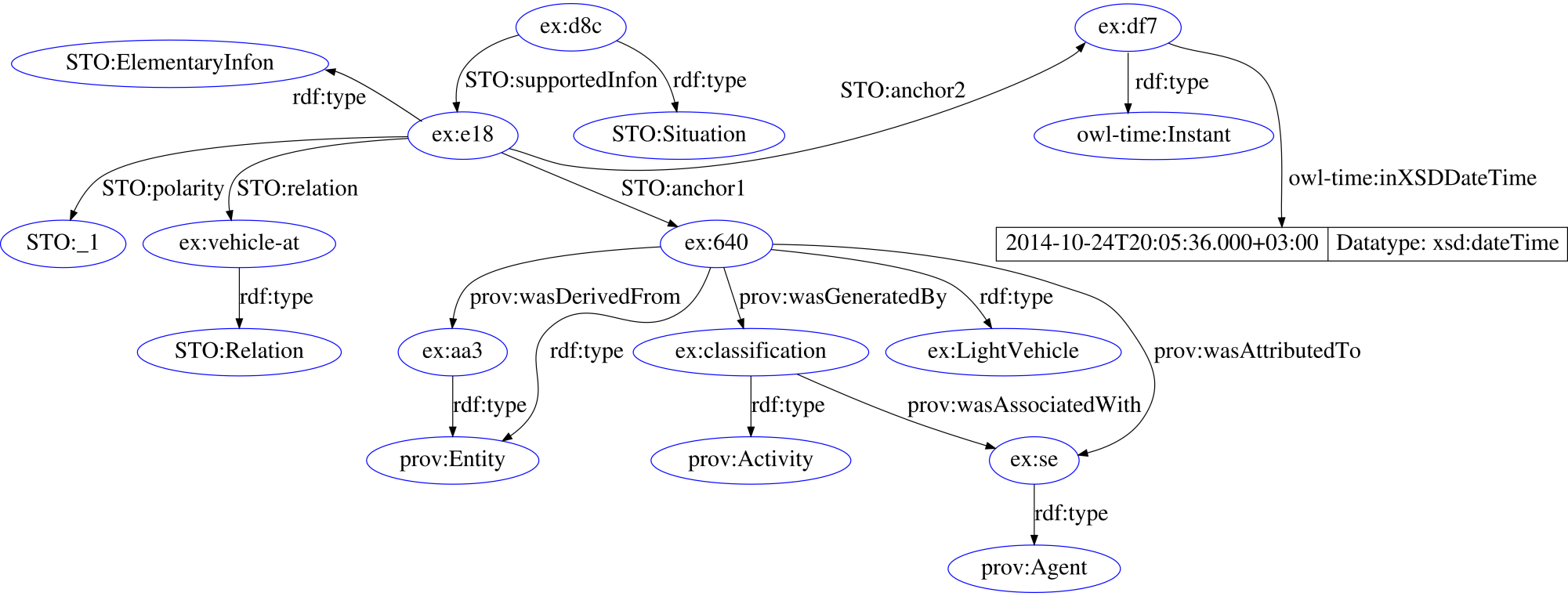
SSN observation
Provenance information



QB observation
Data and provenance information



STO situation
Knowledge and provenance information



Related work

- PROV is a W3C Recommendation
- Used in workflows, also scientific (e-science)
- Proposed ontology alignments: SSN-PROV, SSN-QB
- Situation awareness theory and systems[3,4,5]
- SSN is rather popular, QB and STO less so

Take aways

- Situation-aware environmental monitoring systems
- Automate environmental sensor network data collection
- Also processing and, importantly, analysis/interpretation
- Interpretation can be situational knowledge acquisition
- Model also provenance in such systems
- Provides a traceable account for data processing
- As well as (situational) knowledge acquisition

References

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[4] Salmon, P.M., Stanton, N.A., Jenkins, D.P., Walker, G.H., Young, M.S., Aujla, A.: What Really Is Going on? Review, Critique and Extension of Situation Awareness Theory. In: Harris, D. (ed.) Engineering Psychology and Cognitive Ergonomics, Lecture Notes in Computer Science, vol. 4562, pp. 407-416. Springer Berlin Heidelberg (2007)

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