Semantic Integration Prototype for Wearable Devices in Health Care
WoT group goals

- **General goals**
  - Integration of semantic technologies
    - To augment sensor analysis
    - Support sensor plug and play, plug and automate
    - Support sensor interactions in M2M contexts
    - Support vertical integration in siloed application contexts

- **Event/Information platform**
  - An Activity Streams model for lightweight data->event consumption/production
  - A common Activity model to disambiguate activities from disparate sources
  - Semantic models addressable on demand, as needed
  - Support for event aggregation in vertical integration
  - Support for both ‘offline’ and ‘online’ type operations

- **Approach**
  - Build demonstrators for various use cases to flesh out the architecture
    - Today’s topic: Health care
Prototype goals

• **Use case**: Healthcare professional to recommend wearable devices for a patient with a disease

• **Needed information**
  • Wearable devices – devices that measure biomedical quantities
  • Quantities
  • Anatomical parts
  • Symptoms
  • Diseases

• **Intended usage**
  • Mate with wearable device sensor data indirectly
  • Provide background knowledge
  • Hypothesis generation from search (which devices would be appropriate?)

• **Problems**
  • This information resides in different models/repositories and ‘locations’
  • Models are large
  • Health care professionals do not have the time to search for related information
  • Information must be reliable

• **Prototype solution**
  • Integrate existing/curated models/information
  • Construct a single interface to access the information
  • Demonstrate ability to access wearable devices given a disease
  • Demonstrate ability to access background knowledge from lightweight sensor events
Wearable devices and SSN

- **Wearable device**: A device which can measure a biomedical quantity such as heart rate
- **Suited to SSN**
  - A composite of sensing devices (e.g., heart rate monitor, body temperature, blood pressure)
  - Observable phenomena
  - Measurable quantities
  - Want to later index more aspects of the Stimulus-Sensor-Observation (SSO) pattern
Prototype strategy for ontology selection

• Select domain ontologies
• Select ontologies that have the information we need (e.g., biomedical quantities)
• Select ontologies with rich content models (e.g., not Snomed)
• Select ontologies with unique identifiers
• Select integrated ontologies over independent ontologies
• Select ontologies that have instance repositories as well as a taxonomy over those that don’t
Prototype ontologies selected

- Wearables – Subclass SSN (semantic sensor network ontology - w3.org)
- Quantities – QUDT (quantities, units, dimensions and datatypes ontology - qudt.org)
- Anatomical parts – FMA (foundational model of anatomy ontology - obofoundry.org)
- Symptoms – SYMP (symptom ontology - obofoundry.org)
- Diseases – DOID (human disease ontology - obofoundry.org)
Use case semantic workflow

• Semantic Workflow for use case
  • Diseases exhibit symptoms and pertain to anatomical body parts
  • Symptoms can be identified with measurable biomedical quantities
  • Wearable devices will have sensors that measure biomedical properties
  • There may be an intersection of these relationships
Model integration
Use case illustrated

- DOID (diseases)
  - obo:DOID_6000 congestive heart disease

- SSN (sensor information)

- QUDT (quantities, units, dimensions, datatypes)
  - quantity:HeartRate

- SYMP (symptom taxonomy)
  - obo:SYMP_0019151
  - obo:SYMP_0019177
  - obo:SYMP_0000868
  - obo:SYMP_0000099
  - obo:SYMP_0000187 tiredness

- FMA (anatomy)
  - default:Heart

- DOIDs

- FMA (anatomy)

- SYMP (symptom taxonomy)

- device:HRM

- Devis

- QUODT (quantities, units, dimensions, datatypes)
Semantic integration issues

- Ontologies are generally dissimilar in design approach
  - Some have substantial structure representing content, others don’t
  - Some provide only taxonomies
- The biomedical ontologies are standalone and not indexed to or integrated with one another
- The biomedical ontologies are large
- Some of these models are not domain ontologies
  - Hooks for integration but no actual integration
    - ssn:Property
    - doid:has_symptom
Integration issue resolution

- Automatic ontology matching/mapping not attempted
  - No existing/proposed approach is 100%
  - For usefulness generated mappings would have to be checked manually by SMEs anyway
- Ontology sizes precluded using the full ontologies where they reside
  - First copied them locally and made TDB databases
  - Ultimately used only a subset of the entire set of classes
- Wearable device model invented as a subclass to ssn:SensingDevice
  - Populated with Vandrico device data
- Ssn:Property indexed to qudt:Quantity
- Bridge ontologies created and populated from curated ontologies
  - Disease <-> Symptom
  - Symptom <-> Quantity
  - Disease/Symptom <-> Anatomy
Resolutions to integration issues

- Automatic ontology matching/mapping not attempted
  - No existing/proposed approach is 100%
  - For usefulness generated mappings would have to be checked manually by SMEs anyway
- Ontology sizes precluded using the full ontologies where they reside
  - First copied them locally and made TDB databases
  - Ultimately used only a subset of the entire set of classes
DOID ↔ SYMP ↔ FMA bridge ontologies
Wearable device ↔ QUDT, FMA bridge ontologies
Demo front end

Wearables Search
Siemens NEC WOT-US

Quantities
- uses:
  - Quantities
  - Units
  - Dimensions
  - Data Types: 609 (Quantities)

Wearables
- uses & extends:
  - Semantic
  - Sensor
  - Network: 209

Body parts
- uses:
  - Foundation
  - Model of Anatomy: 237.598

Symptoms
- uses:
  - SYMPtom Ontology
  - 937

Diseases
- uses:
  - Human Disease Ontology
  - ID: 8751

Models & Repositories by
The Open Biological and Biomedical Ontologies: http://www.obofoundry.org/ - QUDT: qudt.org - SSN: http://www.w3.org/2005/Incubator/ssn/ssnx/ssn