The New gist Model for Quantitative Data

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Every Enterprise can benefit from having a simple, standard way to represent quantitative data. In this blog post, we will provide examples of how to use the new gist model of quantitative data released in gist version 13. After illustrating key concepts, we will look at how all the pieces fit together and provide one concrete end-to-end example.

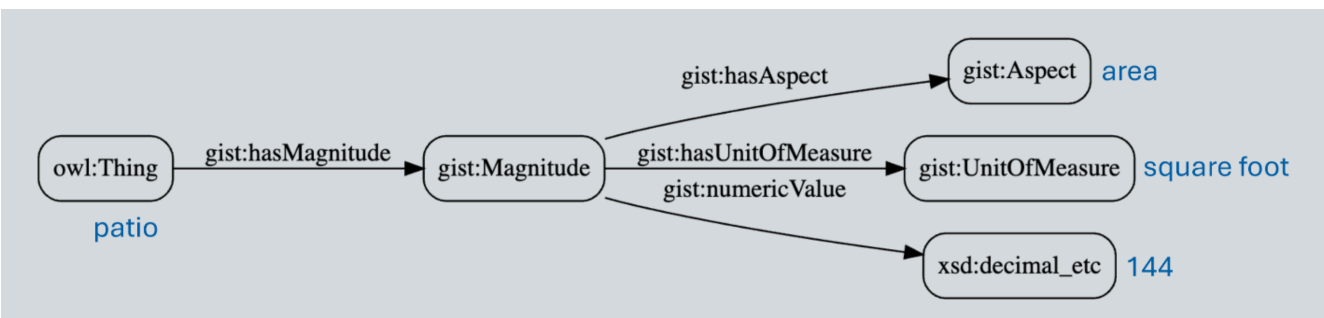
Let's examine the following:

1. How is a measurement represented?
2. Which units can be used to measure a given characteristic?
3. How do I convert a value from one unit to another?
4. How are units defined in terms of the International System of Units?

First, we want to be able to represent a fact like:

"The patio has an area of 144 square feet."

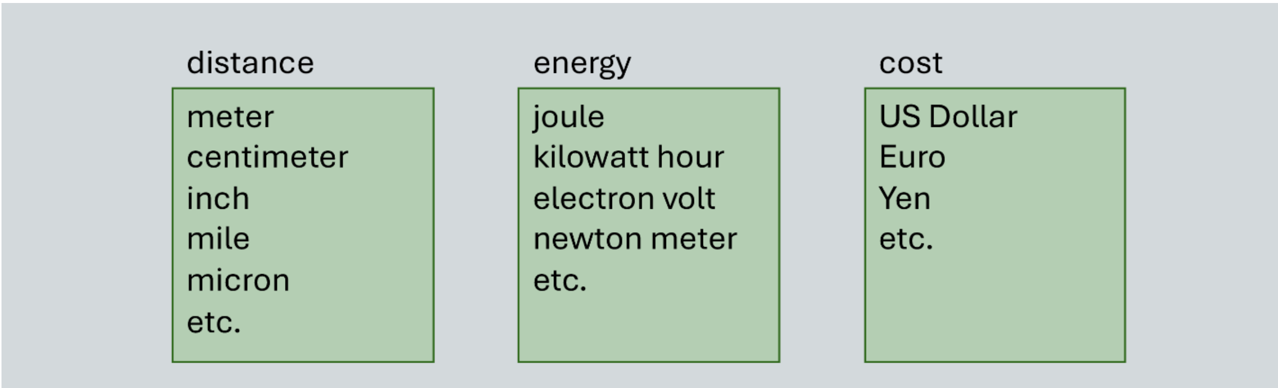
The area of the patio is represented using this pattern:



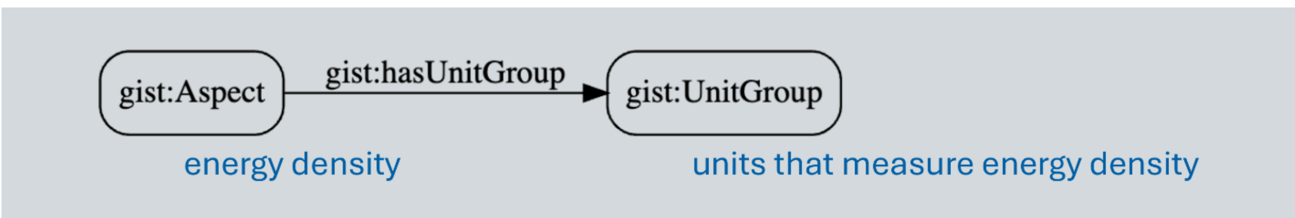
… where:

- A *magnitude* is an amount of some measurable characteristic.
- An *aspect* is a measurable characteristic like cost, area, or mass.
- A *unit of measure* is a standard amount used to measure or specify things, like US dollar, meter, or kilogram.

Second, we need to be able to identify which units are applicable for measuring a given aspect. Consider a few simple examples, the aspects distance, energy, and cost:



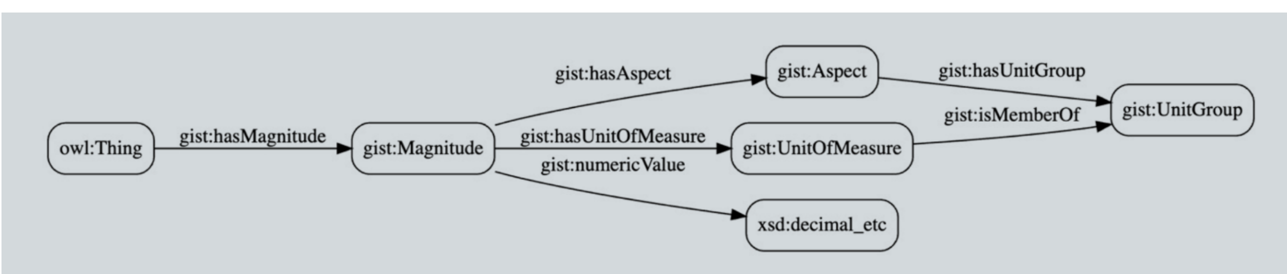
For every aspect there is a group of applicable units. For example, there is a group of units that measure energy density:



... where:

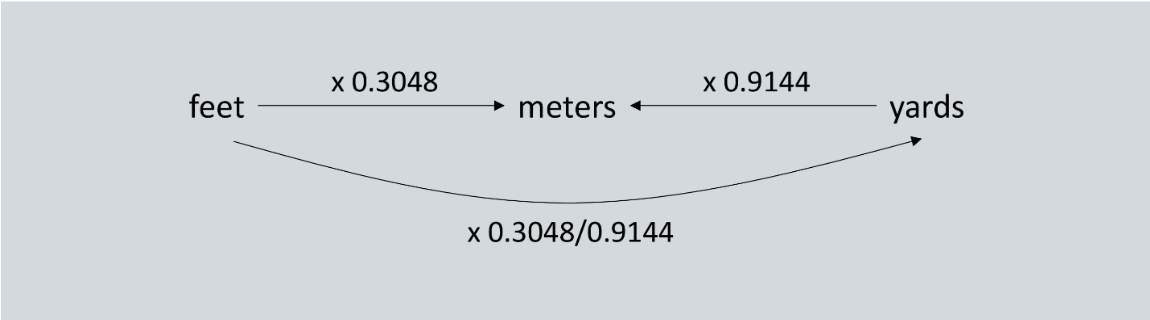
A *unit group* is a collection of units that can be used to measure the same aspect.

A common scenario is that we want to validate the combination of aspect and unit of measure. All we need to do is check to see if the unit of measure is a member of the unit group for the aspect:



Next, we want to be able to convert measurements from one unit to another. A conversion like this makes sense only when the two units measure the same aspect. For example, we can convert pounds to kilograms because they both measure mass, but we can't convert pounds to seconds. When a conversion is possible, the rule is simple:

> **To convert a numeric value from one unit of measure to another, multiply by the conversion factor of the first unit and then divide by the conversion factor of the second unit. For example, to convert 27 feet to yards using meter as an intermediate:**
>
> **1 foot = 0.03088 meters**
> **1 yard = 0.9144 meters**
>
> **the conversion factor of foot is 0.3048 (more about that in a moment)**
> **the conversion factor of yard is 0.9144**
>
> **so**
>
> **27 feet = (27 x 0.3048) / 0.9144 = 9 yards**
>
> **As a diagram:**



There is an exception to the rule above for units of measure that do not have a common zero value. For example, 0 degrees Fahrenheit is not the same temperature as 0 degrees Kelvin.

> **To convert from Fahrenheit to Kelvin, first add the conversion offset of Fahrenheit and then multiply by its conversion factor:**
>
> **20 degrees Fahrenheit = (20 + 459.6696) x 5/9 degrees Kelvin**
> **= 266.483 degrees Kelvin**

1. To convert from Kelvin to Fahrenheit, reverse the steps: first divide by the conversion factor and then subtract the offset.
2. To convert a value from Fahrenheit to Celsius, first use the conversion above to convert to Kelvin, and then convert from Kelvin to Celsius.

Next, we will look at how units of measure are related to the International System of Units, which defines a small set of base units (kilogram, meter, second, Kelvin, etc.) and states:

"Derived units are defined as products of powers of the base units."

For example:

1 watt = 1 kilogram meter^2 per second^3

We can represent the expression on the right side as follows:

```
gist:exponentOfKilogram "1"^^xsd:decimal
gist:exponentOfMeter    "2"^^xsd:decimal
gist:exponentOfSecond  "-3"^^xsd:decimal
```

If we look at other units in the same unit group, we see a pattern:

```
1 watt                 =         1 kilogram meter² per second³
1 kilowatt             =      1000 kilogram meter² per second³
1 horsepower (metric) =  735.4988 kilogram meter² per second³
1 erg per second       = 0.0000001 kilogram meter² per second³
```

Notice that every expression on the right side is a multiple of *kilogram meter^2 per second^3*. We can avoid redundancy by "attaching" the exponents of base units to the unit group. That way, when adding a new unit of measure to the unit group for power there is no need to re-enter the data for the exponents.

The example also illustrates the conversion factors; each conversion factor appears as the initial number on the right-hand side. In other words:

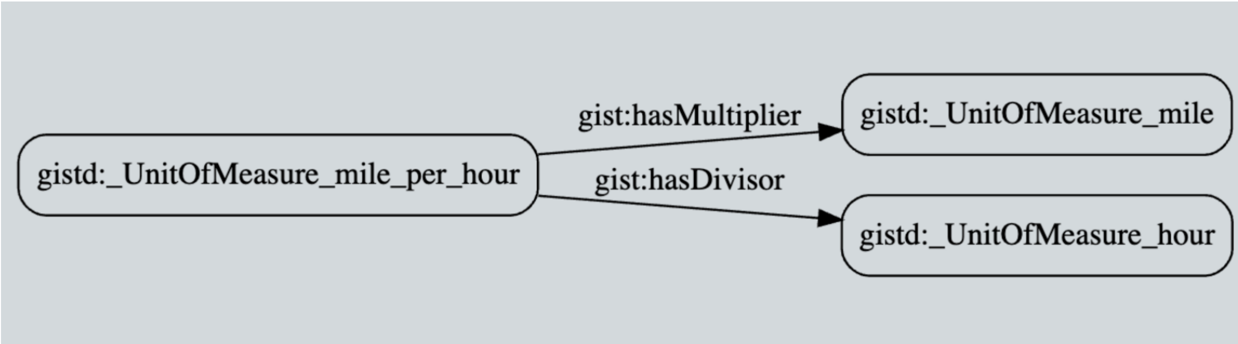
Unit of measure	Conversion factor
watt	1
kilowatt	1000
horsepower (metric)	735.4988
erg per second	0.0000001

The conversion factors and exponents allow units of measure to be expressed in terms of the International System of Units, which acts as something of a Rosetta Stone for understanding units of measure.

One additional bit of modeling allows calculations of the form:

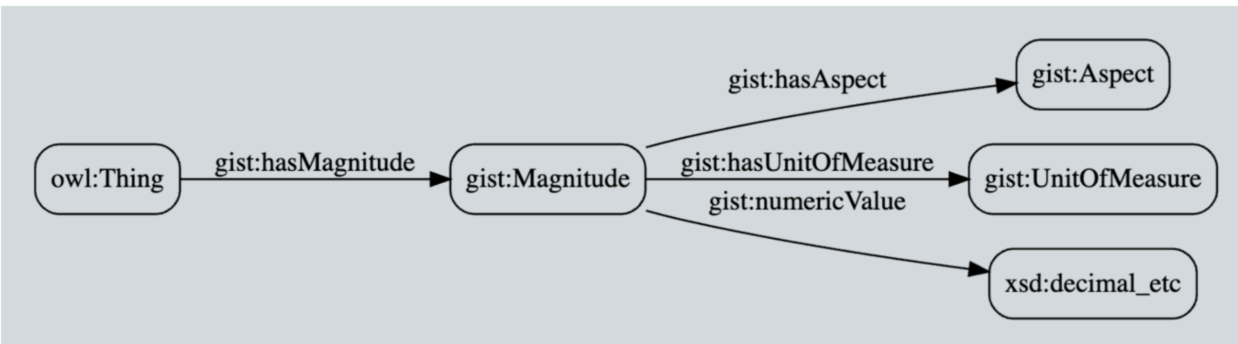
(45 miles per hour) x 3 hours = 135 miles

To enable this type of math, we represent miles per hour directly in terms of miles and hours:

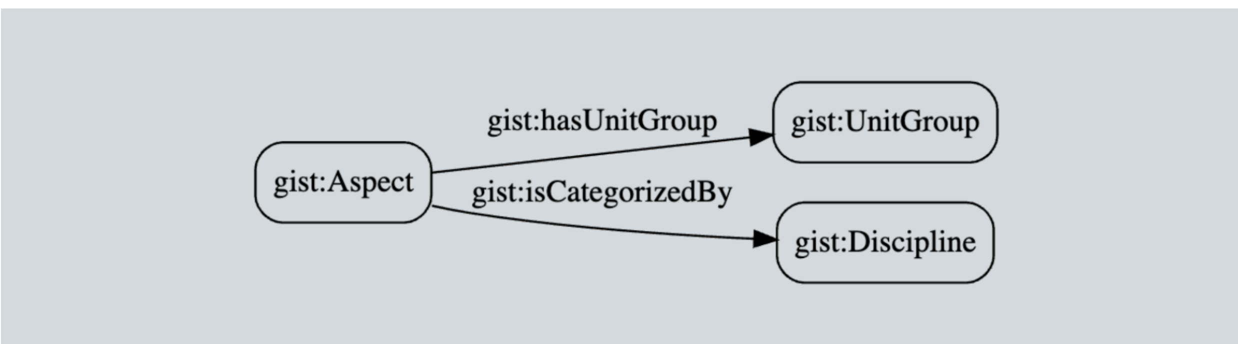


Putting the pieces together:

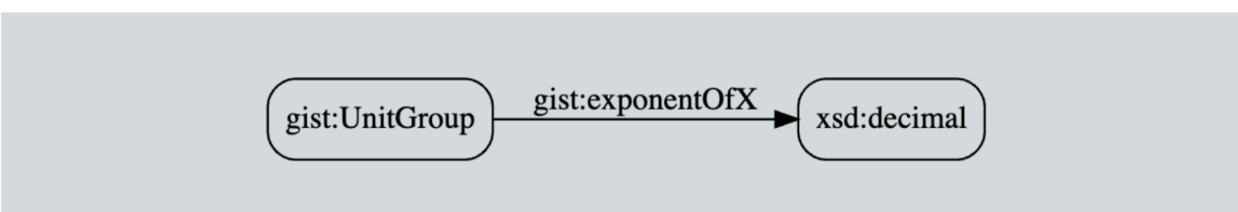
Here is the standard representation of a magnitude:



Every aspect has a group of units that can be used to measure it:



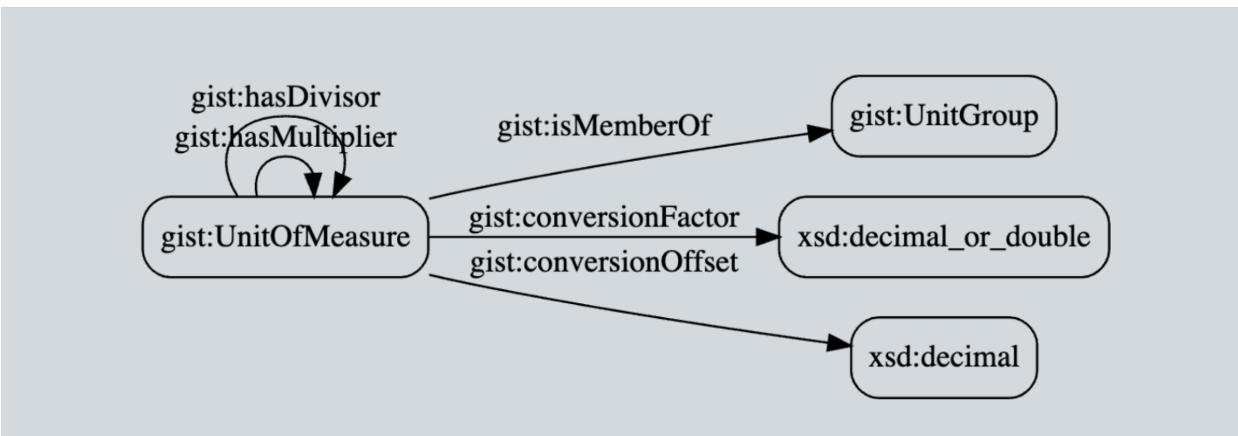
Every member of a unit group can be represented as a multiple of the same product of powers of base units of the International System of Units:



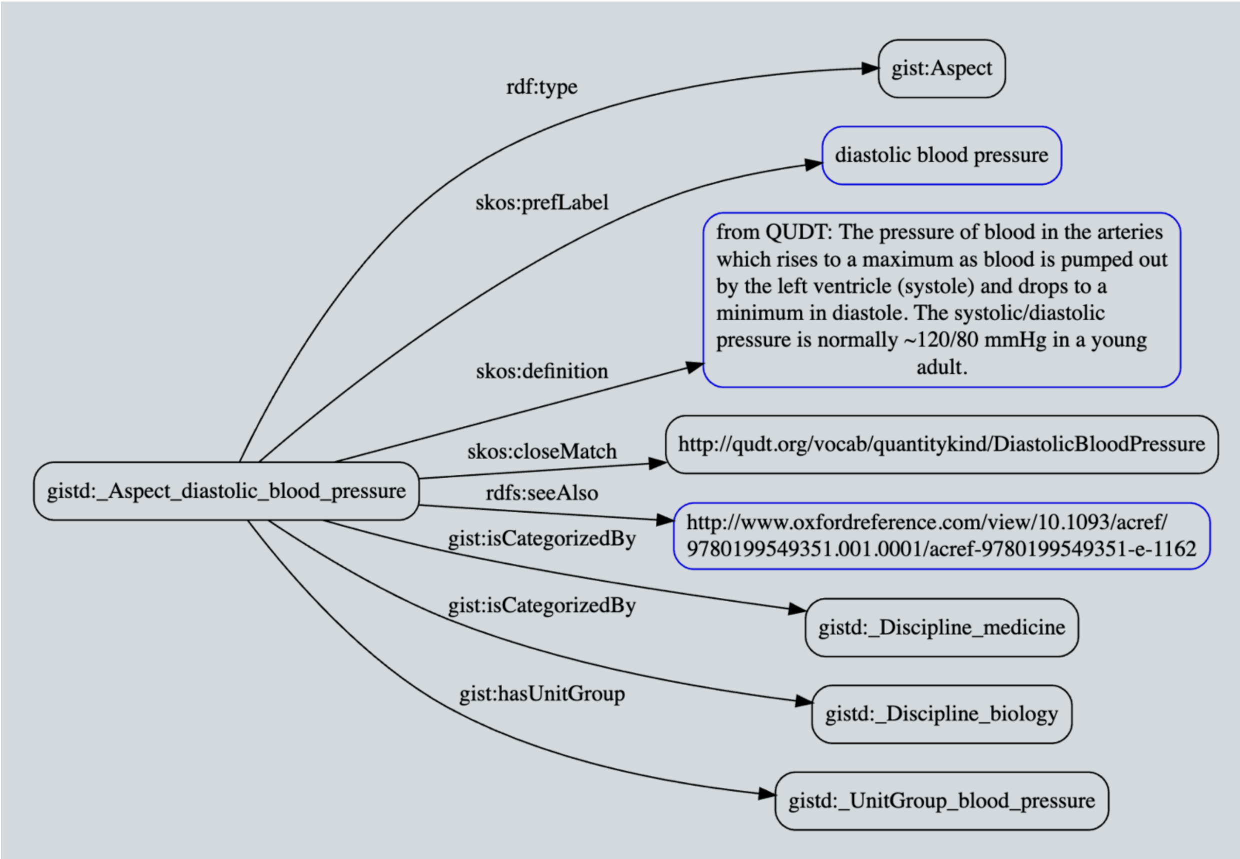
where X can be:

- Ampere
- Bit
- Candela
- Kelvin
- Kilogram
- Meter
- Mole
- Number
- Other
- Radian
- Second
- Steradian
- USDollar

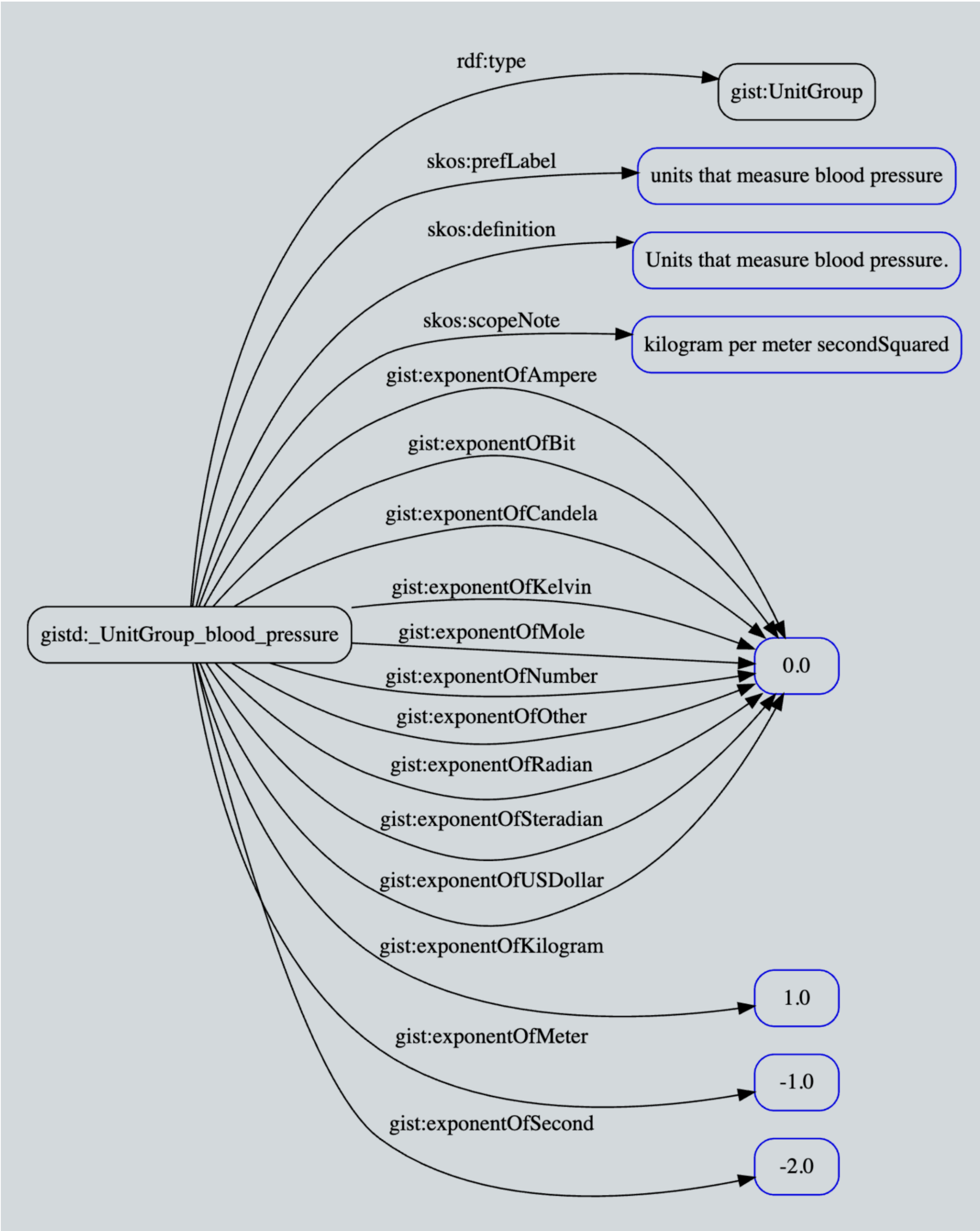
Every unit of measure belongs to one or more unit groups, and if can be defined in terms of other units acting as multipliers and divisors:



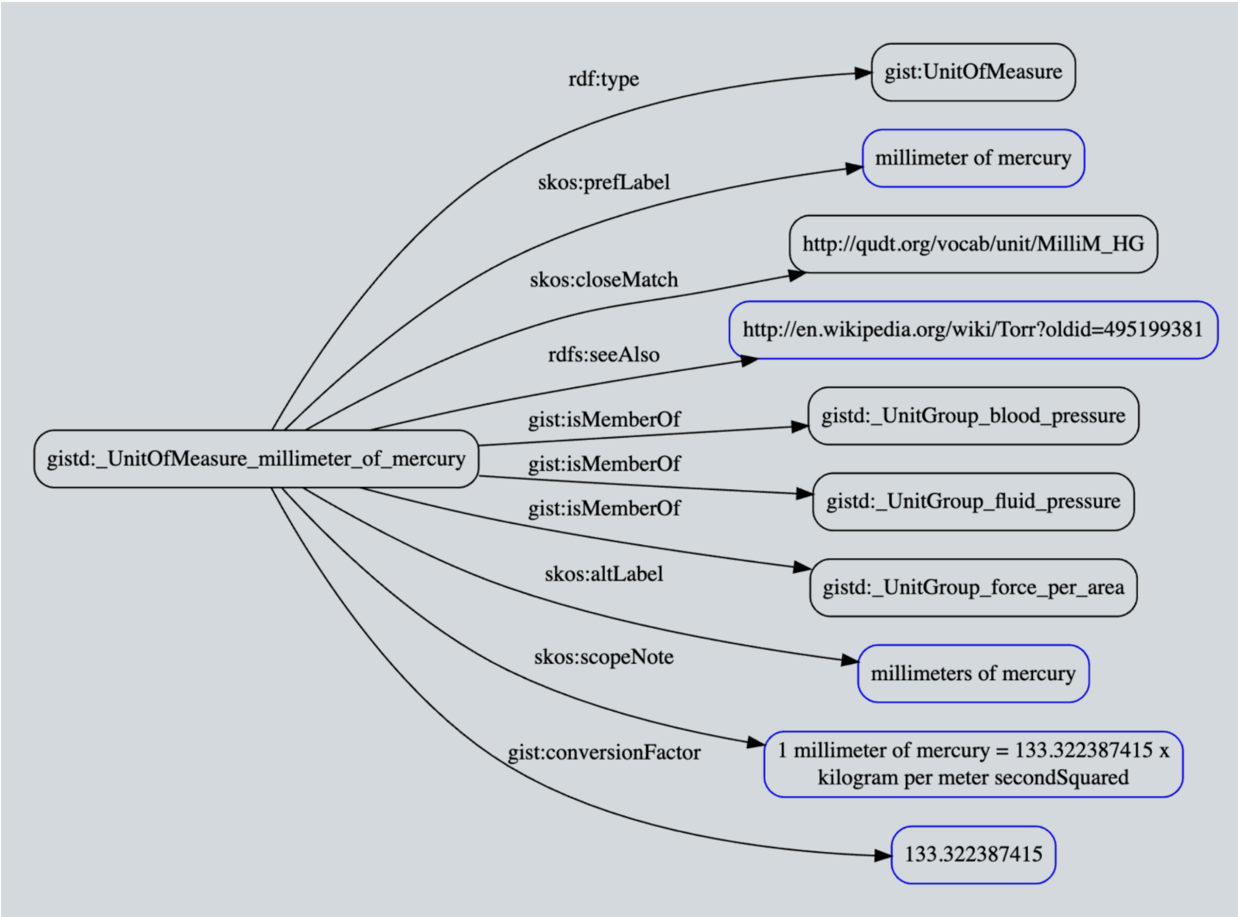
We'll end with a concrete example, *diastolic blood pressure*.



The unit group for blood pressure is a collection of units that measure blood pressure. The unit group is related to the exponents of base units of the International System of Units:



Finally, one member of the unit group for blood pressure is *millimeter of mercury*. The scope note gives an equation relating the unit of measure to the base units (in this case, kilogram, meter, and second).



The diagrams above were generated using a visualization tool. The text version of the diagrams is:

```
prefix gist:  <https://w3id.org/semanticarts/ns/ontology/gist/>
prefix gistd: <https://w3id.org/semanticarts/ns/data/gist/>
prefix owl:   <http://www.w3.org/2002/07/owl#>
prefix rdf:   <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
prefix rdfs:  <http://www.w3.org/2000/01/rdf-schema#>
prefix skos:  <http://www.w3.org/2004/02/skos/core#>
prefix xsd:   <http://www.w3.org/2001/XMLSchema#>

gistd:_Discipline_medicine rdf:type gist:Discipline .
gistd:_Discipline_biology  rdf:type gist:Discipline .


###### diastolic blood pressure ######################
gistd:_Aspect_diastolic_blood_pressure

  rdf:type gist:Aspect ;
  skos:prefLabel "diastolic blood pressure" ;

  skos:definition "from QUDT: The pressure of blood in the arteries which rises to a
maximum as blood is pumped out by the left ventricle (systole) and drops to a minimum
in diastole. The systolic/diastolic pressure is normally ~120/80 mmHg in a young
adult." ;

  skos:closeMatch <http://qudt.org/vocab/quantitykind/DiastolicBloodPressure> ;
  rdfs:seeAlso
"http://www.oxfordreference.com/view/10.1093/acref/9780199549351.001.0001/acref-
9780199549351-e-1162"^^xsd:anyURI ;
  gist:isCategorizedBy gistd:_Discipline_biology, gistd:_Discipline_medicine ;
  gist:hasUnitGroup gistd:_UnitGroup_blood_pressure ;
  .


###### kilopascal ######################
gistd:_UnitOfMeasure_kilopascal

  gist:isMemberOf gistd:_UnitGroup_blood_pressure,
                  gistd:_UnitGroup_fluid_pressure,
                  gistd:_UnitGroup_force_per_area ;

  rdf:type gist:UnitOfMeasure ;
  skos:prefLabel "kilopascal" ;
  skos:altLabel "kilopascals" ;
  skos:closeMatch <http://qudt.org/vocab/unit/KiloPA> ;

  skos:scopeNote "1 kilopascal = 1000.0 x kilogram per meter secondSquared" ;
  gist:conversionFactor 1000.0 ;
  .


###### millimeter of mercury ######################
gistd:_UnitOfMeasure_millimeter_of_mercury

  gist:isMemberOf gistd:_UnitGroup_blood_pressure,
                  gistd:_UnitGroup_fluid_pressure,
                  gistd:_UnitGroup_force_per_area ;

  rdf:type gist:UnitOfMeasure ;
  skos:prefLabel "millimeter of mercury" ;
  skos:altLabel "millimeters of mercury" ;
  rdfs:seeAlso "http://en.wikipedia.org/wiki/Torr?oldid=495199381"^^xsd:anyURI ;
  skos:closeMatch <http://qudt.org/vocab/unit/MilliM_HG> ;

  skos:scopeNote "1 millimeter of mercury = 133.322387415 x kilogram per meter
secondSquared" ;
  gist:conversionFactor 133.322387415 ;
```



```
###### unit group for blood pressure ######################
gistd:_UnitGroup_blood_pressure

  rdf:type gist:UnitGroup ;
  skos:definition "Units that measure blood pressure."^^xsd:string ;
  skos:prefLabel "units that measure blood pressure"^^xsd:string ;
  skos:scopeNote "kilogram per meter secondSquared" ;

  gist:exponentOfAmpere    "0.0"^^xsd:decimal ;
  gist:exponentOfBit       "0.0"^^xsd:decimal ;
  gist:exponentOfCandela   "0.0"^^xsd:decimal ;
  gist:exponentOfKelvin    "0.0"^^xsd:decimal ;
  gist:exponentOfKilogram  "1.0"^^xsd:decimal ;
  gist:exponentOfMeter    "-1.0"^^xsd:decimal ;
  gist:exponentOfMole      "0.0"^^xsd:decimal ;
  gist:exponentOfNumber    "0.0"^^xsd:decimal ;
  gist:exponentOfOther     "0.0"^^xsd:decimal ;
  gist:exponentOfRadian    "0.0"^^xsd:decimal ;
  gist:exponentOfSecond   "-2.0"^^xsd:decimal ;
  gist:exponentOfSteradian "0.0"^^xsd:decimal ;
  gist:exponentOfUSDollar  "0.0"^^xsd:decimal ;
  .
```

For more examples and some basic queries, visit the gitHub site gistReferenceData.

In closing, we would like to acknowledge the re-use of concepts from QUDT, namely:

- every magnitude has an aspect, via the new gist property hasAspect
- aspects are individuals instead of categories or subclasses of Magnitude as in gist 12
- exponents are represented explicitly, enabling calculations