

The M-layer – overview

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Ambiguity is a problem for interoperability

- SI notation has evolved beyond the 19th century Maxwell / Fourier formalism (which applied to certain types of data).
- Traditional notation
 1. assumes the kind of quantity is known
 2. assumes the (numerical) structure of data

Interoperability ⇔ legitimate conversion

“... so that we may be able at once to transform our results from one system to another”
– J C Maxwell

SI notation leads to difficulties

interpreting data:

1. Special unit names vs products of powers of base unit names
2. Multiple meanings for some unit names

$$0.555 \text{ Hz} \rightarrow 0.555 \text{ s}^{-1} \leftarrow 0.555 \text{ Bq}$$

$$1.5 \text{ Nm} \rightarrow 1.5 \text{ kg m}^2 \text{ s}^{-2} \leftarrow 1.5 \text{ J}$$

$$\begin{aligned} 12 \text{ }^\circ\text{C} &= 12 \text{ K} & (\Delta t / \text{ }^\circ\text{C} &= \Delta T / \text{K}) \\ \text{(or)} &= 285.13 \text{ K} & (T / \text{K} &= t / \text{ }^\circ\text{C} + 273.13) \end{aligned}$$

M-layer expressions have three components

(traditional) expression = { x } [x]

(M-layer) expression = { x } [[x]] $\langle x \rangle$

{ x }:value

[[x]]:scale (combines [x] with scale structure)

$\langle x \rangle$:aspect (*kind of quantity* in traditional systems)

{12} [[$^{\circ}\text{C}$], interval] $\langle T \rangle$ \Leftrightarrow {12} [[$^{\circ}\text{C}$], ratio] $\langle \Delta T \rangle$

{0.555} [[Hz], ratio] $\langle \text{frequency} \rangle$ \Leftrightarrow {0.555} [[Bq], ratio] $\langle \text{activity} \rangle$

The M-layer is register-based

- The client metadata is succinct unique digital identifiers (**UIDs**) for M-layer scales and aspects
- A **register** holds detailed information about scales and aspects, and underlying units, etc., and moderates conversion and transformation
- The UIDs index information and register services

M-layer components support interoperability

- Expression equivalence is rule-based
(may be unidirectional, conditional on aspect)

$$\begin{aligned} 1 \text{ [[Hz], ratio]} &\rightarrow 1 \text{ [[s}^{-1}\text{], ratio]} \\ 1 \text{ [[s}^{-1}\text{], ratio]} \langle \text{frequency} \rangle &\leftrightarrow 1 \text{ [[Hz], ratio]} \langle \text{frequency} \rangle \end{aligned}$$

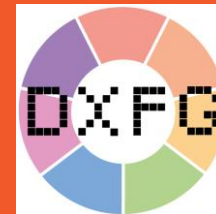
- Conversion remains possible without knowing kind of quantity (aspect)
(when appropriate – to support current practice)
- Dimensions (SI) and dimensional expressions will be supported*
- Unit / scale arithmetic will be supported*
- Scale-aspect transformations are supported (think: *change of variable* –rule-based and unidirectional, conditioned on the scale-aspect pairs)

$$\text{photon-energy: } E = h\nu = hc/\lambda = hc\bar{\nu}$$

(* where appropriate, i.e., ratio scales and recognised unit systems)

Opportunities

- **Overcomes** difficulties with SI notation
- **Smooth transition** path from current practice to digital interoperability
- **Modular** => can combine with *ad hoc* user-community notation (e.g., spectroscopy)
- Represents more **types of data** (e.g., method-defined measurands, categorical measurements, ITS-90, etc.) with a sound scientific formalism.



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