Solid Symposium

KG Usage Control Policy Framework

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KNOW GRAPHS

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Usage Control
Context

- An extension of access control
- Regulates usage of the data: permissions (prohibitions) and obligations (dispensations)
- Ensures data sovereignty
- It involves data consumers and data providers/owners
- Related to data storage, distribution, aggregation and processing
- Context of **intellectual property protection**, **privacy protection**, **compliance with regulations** and **digital rights management**

We focus on **policy-based usage control**, where we use **machine-readable policies** to express requirements for future data usage and mechanisms to enforce the respective usage policies

Usage Control
Context

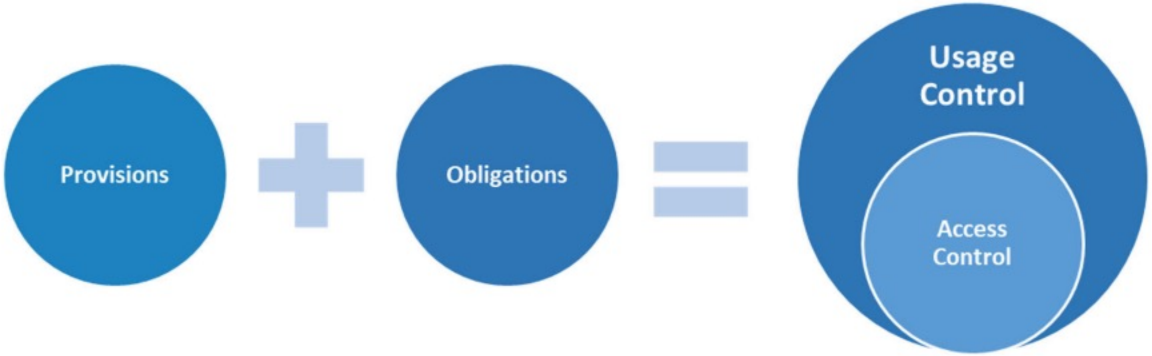

Figure taken from Usage Control in the International Data Spaces V3.0 (2021). Steinbuss et al.

Usage Control Policy Languages
Related Work

- Usage control policy frameworks/ languages
  - UCON (Park et al., 2004) and derivatives cf. (Colombo et al.,2010), (Quintero et al., 2021)
  - The Obligation Specifcation Language (Hilty et al., 2007)
  - ...
- General policy languages
  - Kaos (Uszok et al, 2003)
  - Rei (Kagal et al., 2003)
  - ...
- Tailored policy languages
  - ODRL (Iannella et al., 2018)
  - The Special Policy Language (Bonatti et al., 2020)
  - …

Use Case
Legal Requirements

The legal requirements regarding the registration process in Austria:

Rule 1. A person is obliged to register their address with one of the local authorities within three days of changing residence or having moved from abroad to Austria.

Rule 2. A person is obliged to deregister their old address within three days of changing their place of residence, or of leaving the country.

Rule 3. Tourists in Austria are exempt from registering their address.

Rule 4. If the person stays in a hotel, they are allowed to request a signature from the hotel.

Rule 5. If the person stays in with friends or family members, they are allowed to request a signature from the property owner.

Rule 6. A person is not allowed to open a bank account if they do not have a certificate of registration.

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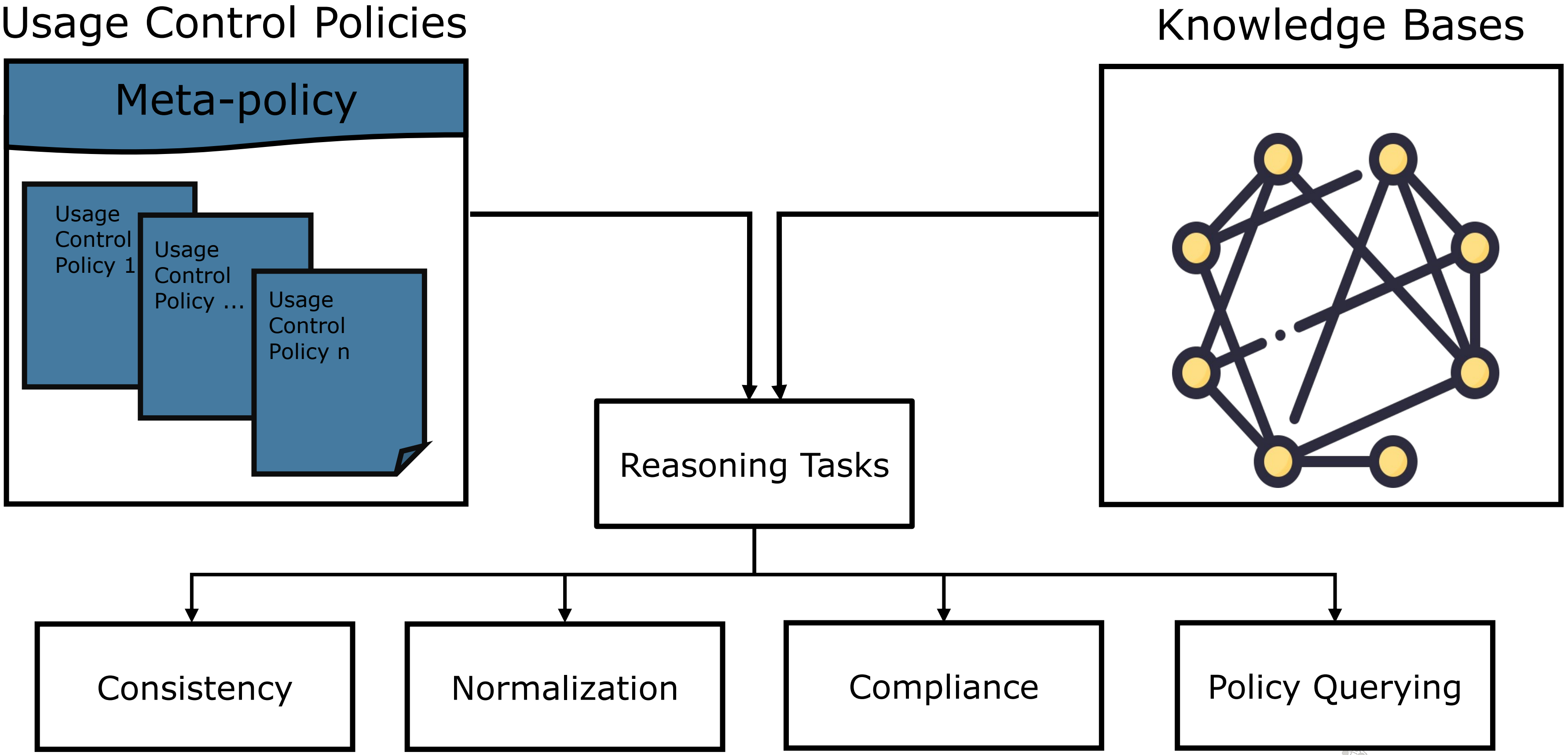
Reasoning Tasks



Usage Control Policies

Knowledge Bases

Meta-policy

Usage Control Policy 1

Usage Control Policy ...

Usage Control Policy n

Reasoning Tasks

Consistency

Normalization

Compliance

Policy Querying

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Notation

- **O, D, P, A** denote the deontic operators **Obligation**, **Dispensation**, **Prohibition**, and **Permission** (allowance)
- ***U*** and ***L*** denote the set of ***URIs*** and ***literals*** respectively.
- ***T*** denote the union of ***U*** ∪ ***L***
- ***P*** , ***A*** such that ***P*** ⊆ ***U*** **,** ***A*** ⊆ ***U***

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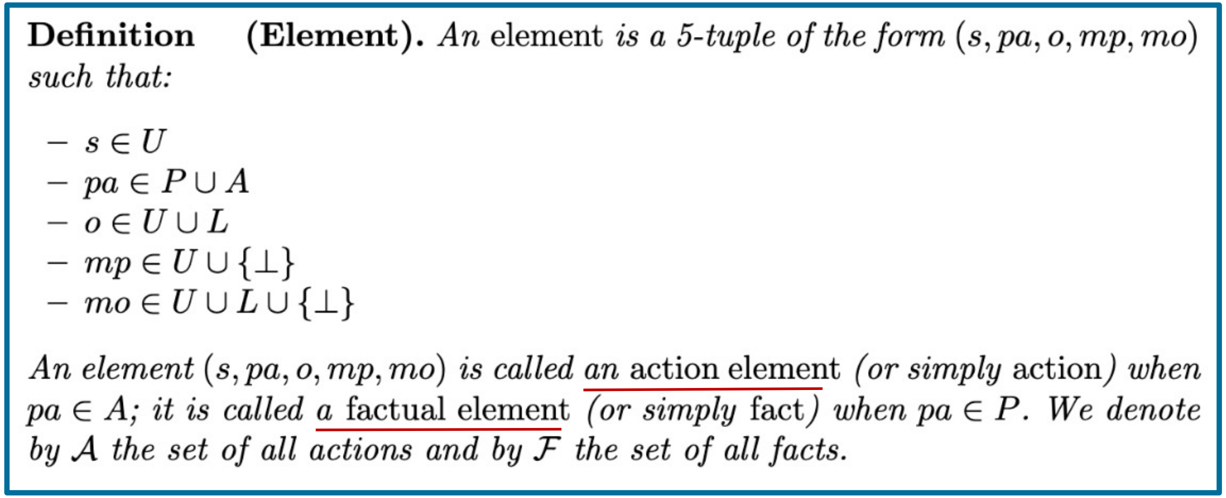
Basic Elements: Action and Factual Elements



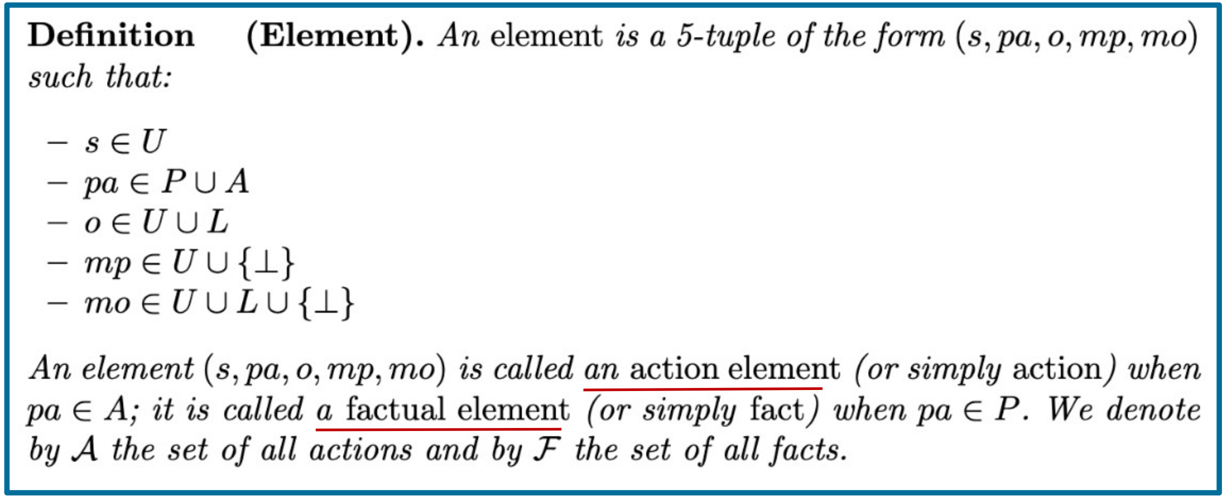
Definition (Element). *An* element *is a 5-tuple of the form* (s, pa, o, mp, mo) *such that:*

- $s \in U$
- $pa \in P \cup A$
- $o \in U \cup L$
- $mp \in U \cup \{\perp\}$
- $mo \in U \cup L \cup \{\perp\}$

An element (s, pa, o, mp, mo) *is called an* action element *(or simply* action*) when* $pa \in A$*; it is called a* factual element *(or simply* fact*) when* $pa \in P$*. We denote by* $\mathcal{A}$ *the set of all actions and by* $\mathcal{F}$ *the set of all facts.*

s, pa, o, mp, and mo denote respectively the concepts of subject, property action, object, meta-property, and metaobject.

KG Usage Control Policy Framework
Basic Elements: Action and Factual Elements



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s, pa, o, mp, and mo denote respectively the concepts of subject, property action, object, meta-property, and metaobject.

Action Element:

```
(:alice, :register, :boulevard18, :on, :21-08-2022)
```

Factual Elements:

```
(:alice, :type, :Person)
(:alice, :movedTo, :boulevard18, :on, :22-08-2022)
(:boulevard18, :type, :Address)
```

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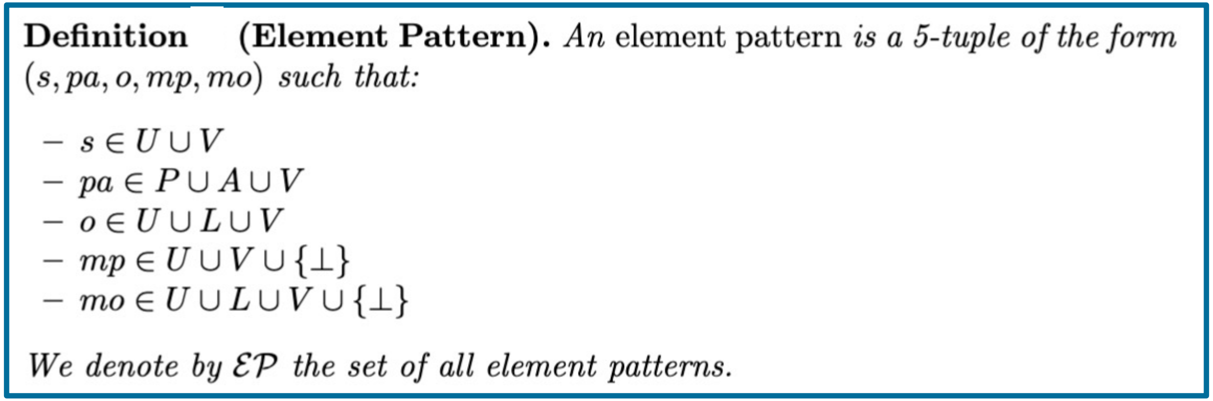
Basic Elements: Element Pattern



Definition (Element Pattern). *An* element pattern *is a 5-tuple of the form* (s, pa, o, mp, mo) *such that:*

- $s \in U \cup V$
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We denote by $\mathcal{EP}$ *the set of all element patterns.*

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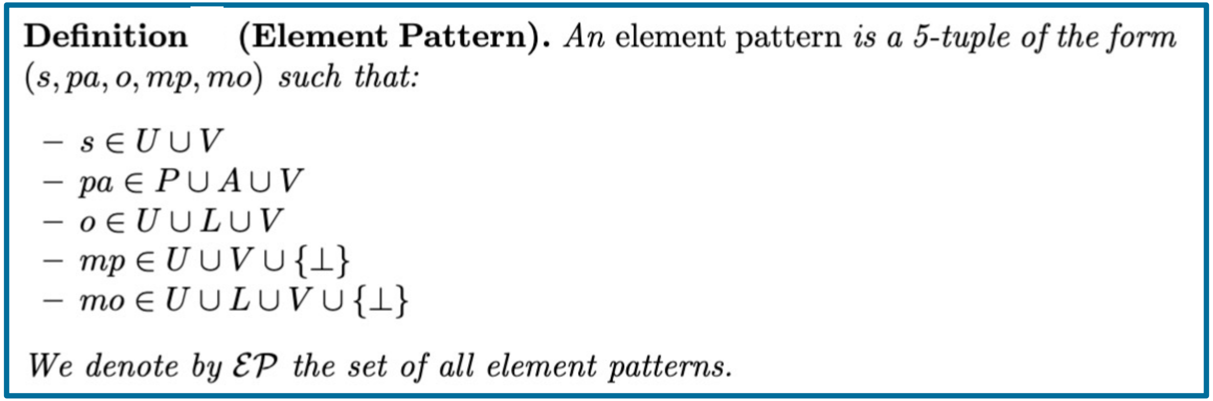
Basic Elements: Element Pattern



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We denote by $\mathcal{EP}$ *the set of all element patterns.*

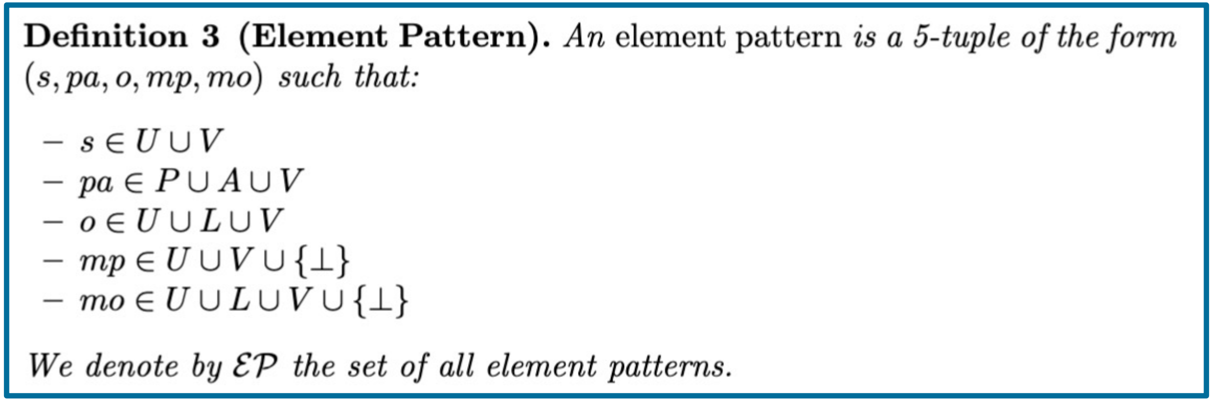
A person is obliged to register their address if they move.

Element Pattern:

```
(?x, :register, ?y, ?mp, ?mo)
```

KG Usage Control Policy Framework

Basic Elements: Element Pattern



Definition 3 (Element Pattern). *An* element pattern *is a 5-tuple of the form* (s, pa, o, mp, mo) *such that:*

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We denote by $\mathcal{EP}$ *the set of all element patterns.*

A person is obliged to register their address if they move.

Element Pattern:

```
(?x, :register, ?y, ?mp, ?mo)
```

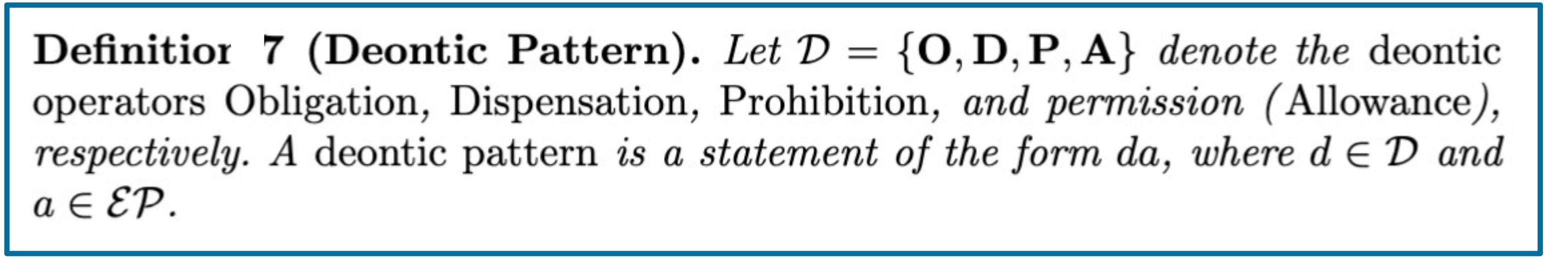
Conditions:

```
(?x, :type, :Person)
(?x, :movedTo, ?y)
(?y, :type, :Address)
```

We’ll come back to this

KG Usage Control Policy Framework

Basic Elements: Deontic Pattern



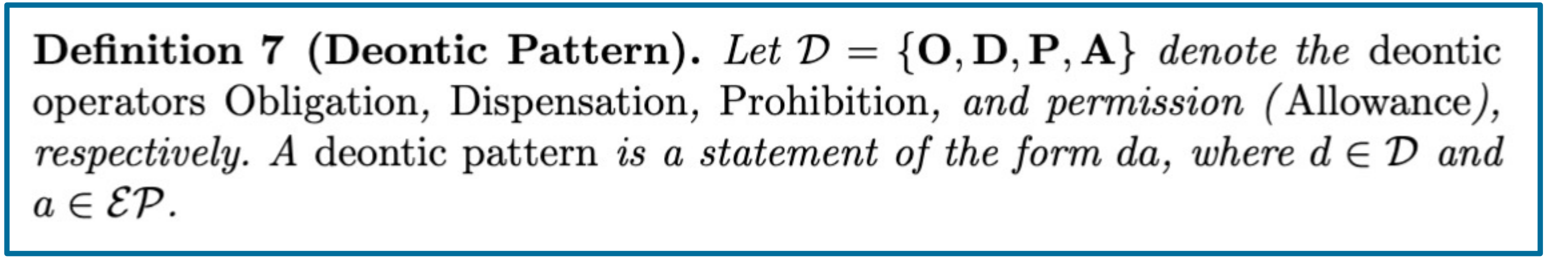
Definitior 7 (Deontic Pattern). *Let* $\mathcal{D} = \{\mathbf{O}, \mathbf{D}, \mathbf{P}, \mathbf{A}\}$ *denote the* deontic operators Obligation, Dispensation, Prohibition, *and permission (*Allowance*), respectively. A* deontic pattern *is a statement of the form da, where* $d \in \mathcal{D}$ *and* $a \in \mathcal{EP}$.

Denotic Pattern:
A person is obliged to register their address if they move.

```
O(?x, :register, ?y, ?mp, ?mo)
```

KG Usage Control Policy Framework

Basic Elements: Deontic Pattern



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(?y, :type, :Address)
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We'll look at this next

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Usage Control Policies

- A set of rules
- Each rule follows the form: IF **condition** THEN **Aa** | **Pa** | **Oa** | **Da**

A person is obliged to register their address if they move.

```
(?x, :moveTo, ?y).(?x, :type, :Person).(?y, :type, :Address)
⇝ O(?x, :register, ?y, ?mp, ?mo)
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KG Usage Control Policy Framework

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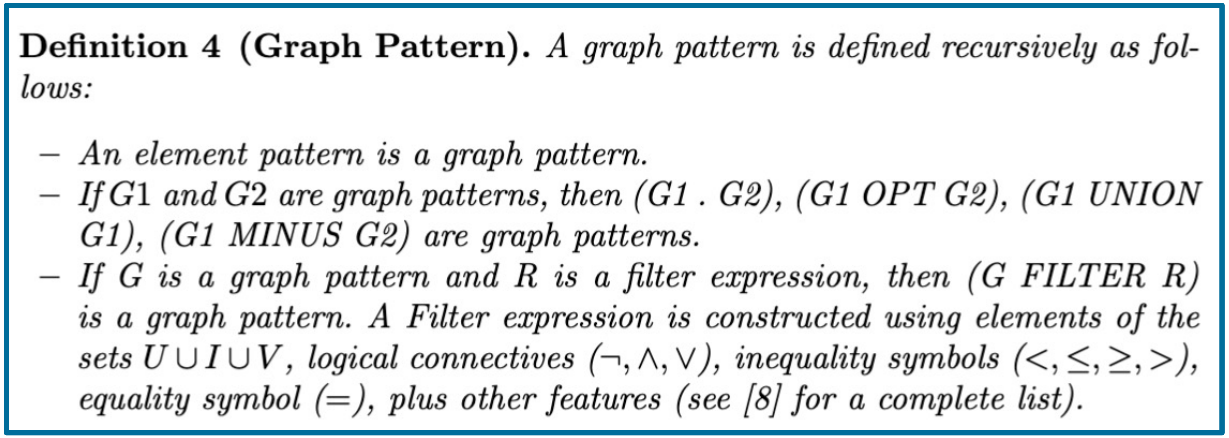

Definition 4 (Graph Pattern). *A graph pattern is defined recursively as follows:*

- *An element pattern is a graph pattern.*
- *If G1 and G2 are graph patterns, then (G1 . G2), (G1 OPT G2), (G1 UNION G1), (G1 MINUS G2) are graph patterns.*
- *If G is a graph pattern and R is a filter expression, then (G FILTER R) is a graph pattern. A Filter expression is constructed using elements of the sets $U \cup I \cup V$, logical connectives $(\neg, \wedge, \vee)$, inequality symbols $(<, \leq, \geq, >)$, equality symbol $(=)$, plus other features (see [8] for a complete list).*

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Instantiations

- Different Initiatives:
    - ODRL (*Ontology Engineering Group at Universidad Politécnica de Madrid*)
    - SHACL (*L3S research center at Leibniz Universität Hannover*)
    - RDF surfaces (*IDLab at Ghent University*)
    - Description Logics (*us*)

    - Other suggestions?

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