On Blank Nodes

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How are blank nodes defined?

Blank nodes are defined in RDF

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- SPARQL
- OWL
- RDB2RDF
- RIF

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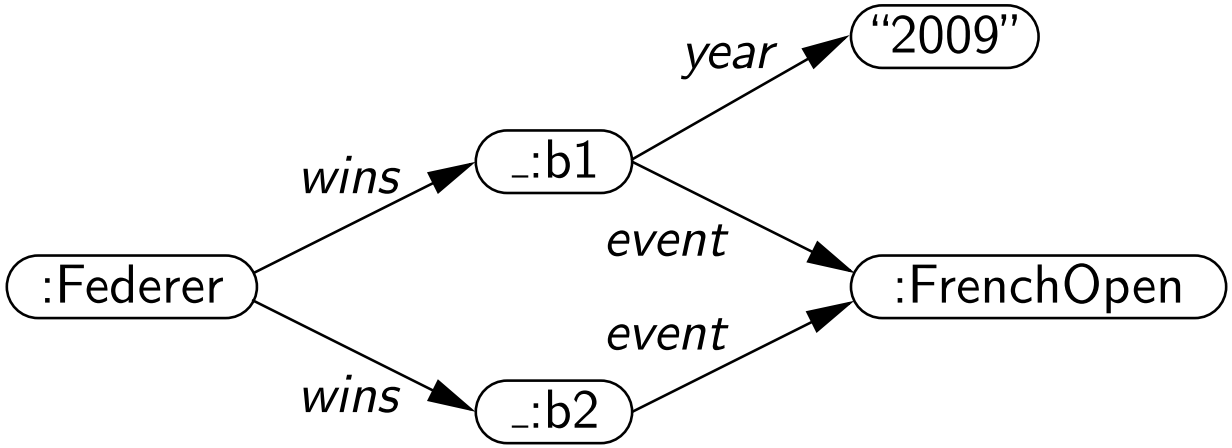
How many times has Federer won the French Open?



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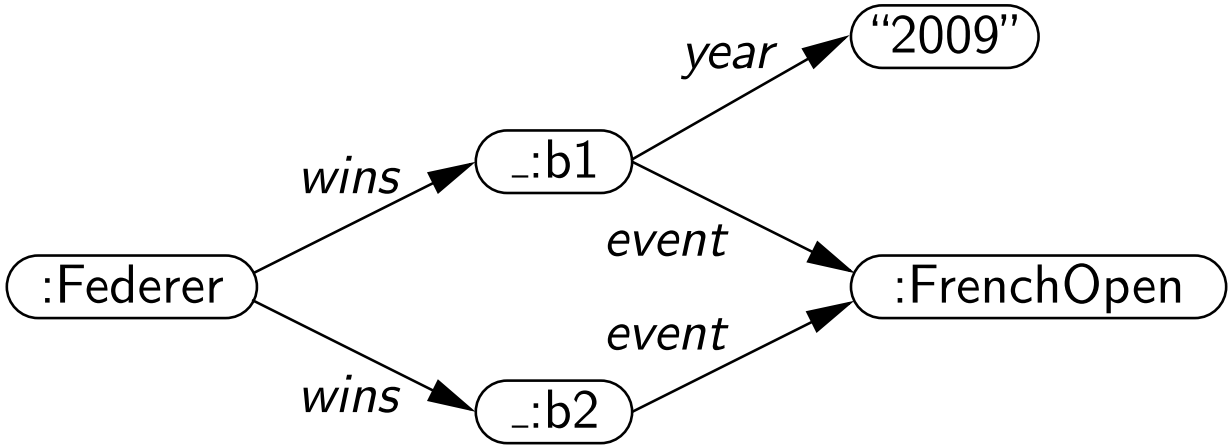


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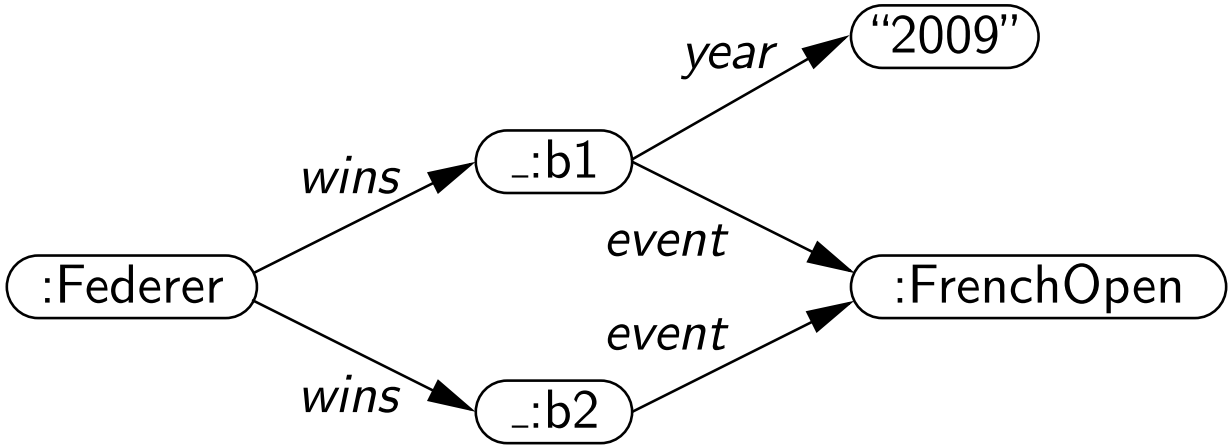


```
SELECT (COUNT(?FO) AS ?total)
WHERE {
  :Federer wins ?FO .
  ?FO event :FrenchOpen .
}
```

In RDF, blank nodes are anonymous existential variables

Blank nodes don't have names.

```
:Vader :fatherOf [ :name "Luke" ] , [ :name "Leia" ].
```

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:Vader :fatherOf [ :name "Luke" ] , [ :name "Leia" ].
```

Labels are used in (some) serializations.

```
:Vader :fatherOf _:b1 .
:Vader :fatherOf _:b2 .
_:b1 :name "Luke" .
_:b2 :name "Leia" .
```

Careful with the terminology: names, labels and the like

In different normative documents, the following words are mixed in several ways:

- Name
- Label
- Identifier

In RDF, blank nodes are anonymous existential variables

Blank nodes indicate the existence of a thing.

?

```
:John :telephone _:b1 .
```

In RDF, blank nodes are anonymous existential variables

Blank nodes indicate the existence of a thing.

"John has a telephone number."

```
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In RDF, blank nodes are anonymous existential variables

Two blank nodes *could* represent the same thing.

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In RDF, blank nodes are anonymous existential variables

A blank node is valid in a limited context.

Graph G_1

```
:Vader :fatherOf _:b1 .
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Graph G_2

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:John :telephone _:b1 .
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- Not the same blank node!

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Merge of G_1 and G_2

```
:Vader :fatherOf _:x .
:John :telephone _:y .
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Graph G_2

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- Not the same blank node!

Merge of G_1 and G_2

```
:Vader :fatherOf [] .
:John :telephone [] .
```

Blank nodes are not used as NULLs

An SQL table

name	telephone
John	888-8888
Jane	NULL

Is this graph equivalent, *in some sense*?

```
_:b1 :name "John" ;
     :telephone "888-8888" .
_:b2 :name "Jane" ;
     :telephone _:b3 .
```

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* Recently discussed by the RDB2RDF Working Group.

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What about RDF2RDB?

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Is this an equivalent SQL table? No!

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In practice, blank nodes are used as constants. . .

. . . *different* constants.

"John has two telephone numbers"

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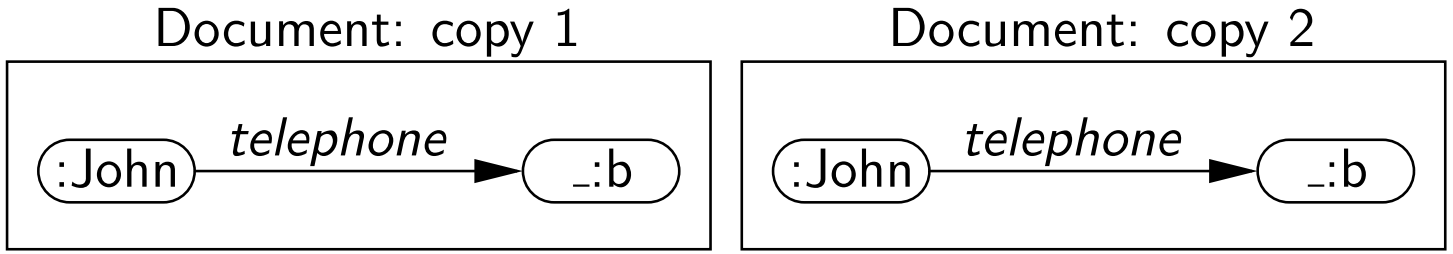

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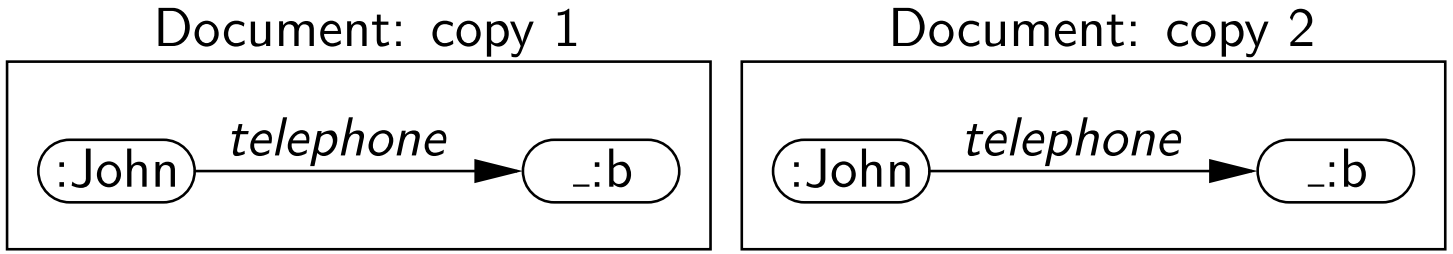

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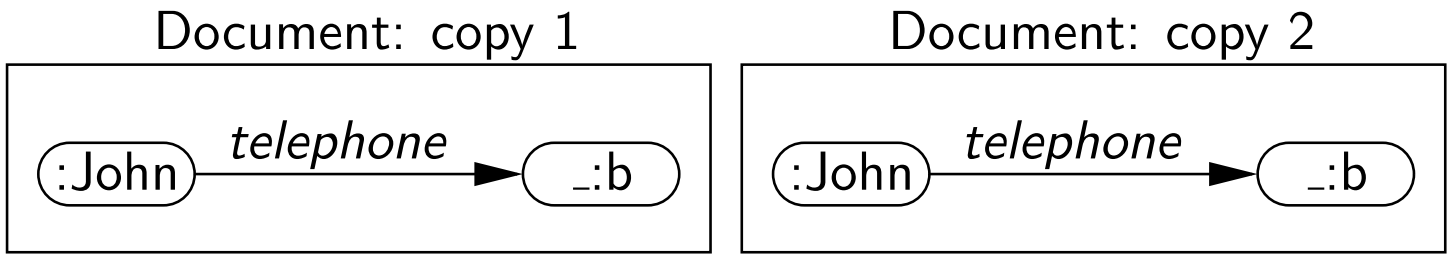

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- Still two telephone numbers?

. . . as local/structural constructs in data structures. . .

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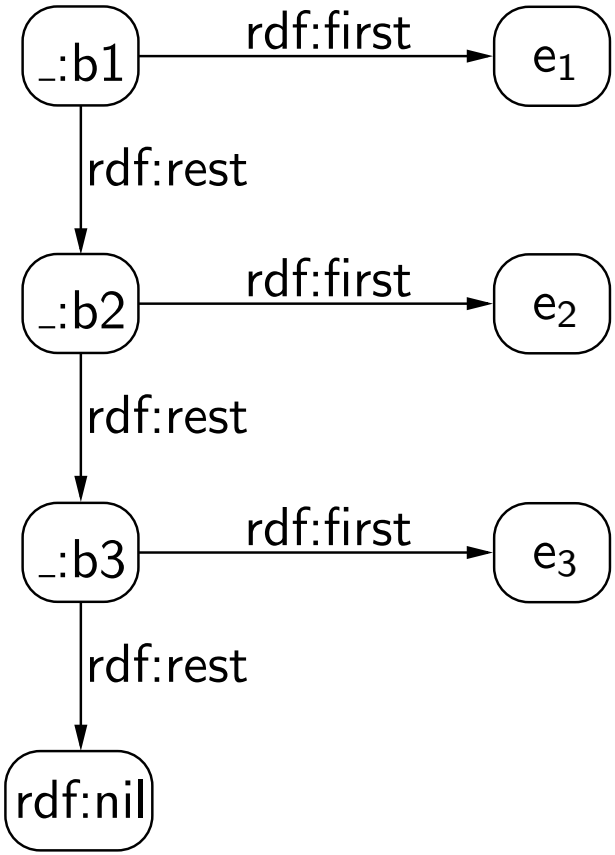

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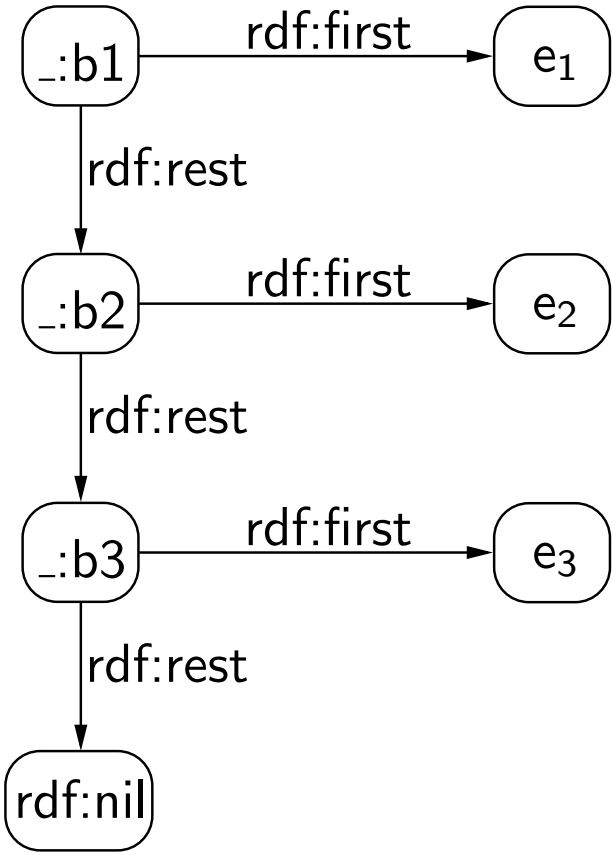

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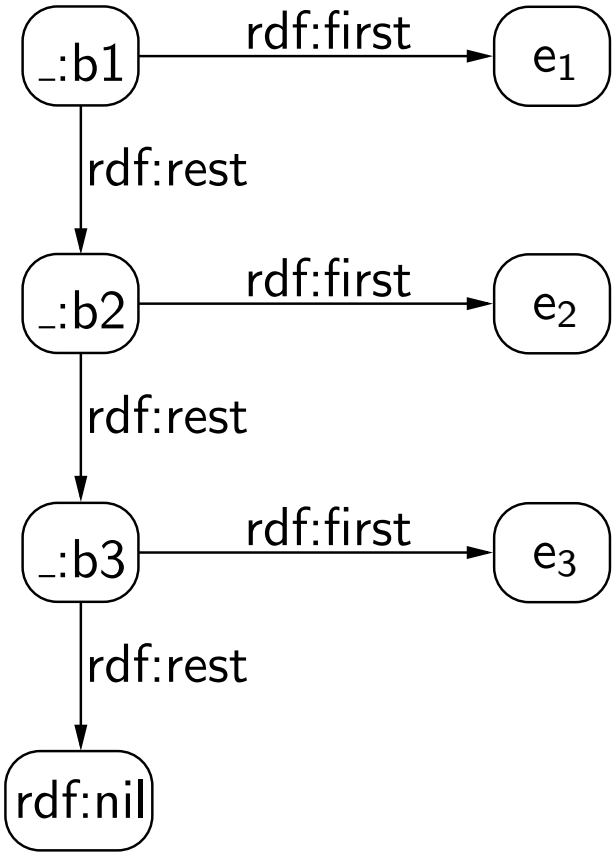

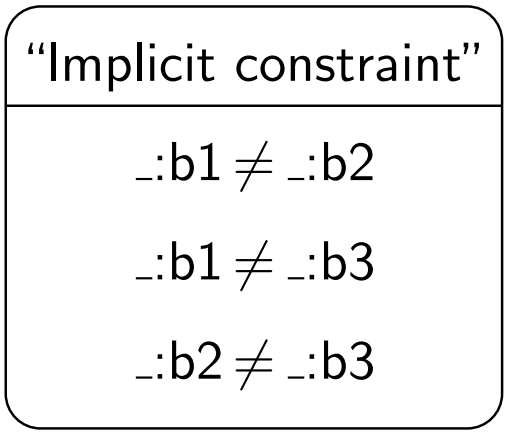

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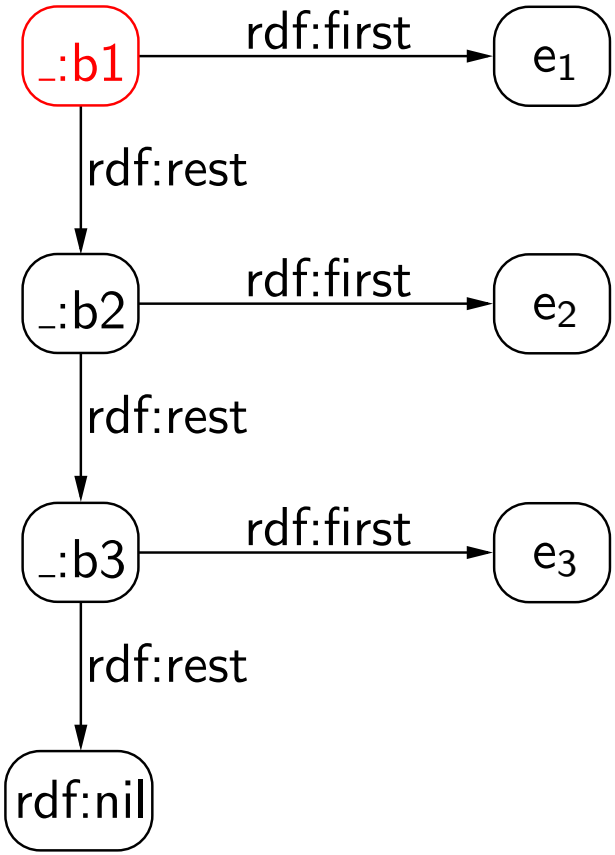

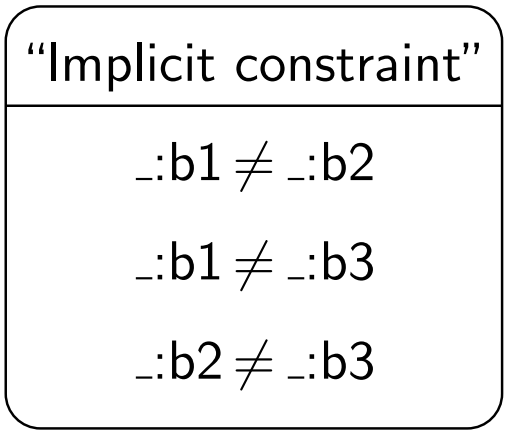

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. . . as default names

. . . instead of URIs that I *should* generate:

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Meaning depends on the publisher's intention (if any).

Not all the normative uses are common in practice

We already asked:

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- $\sim$90 responses (thanks!).
- `http://bit.ly/bnodes`

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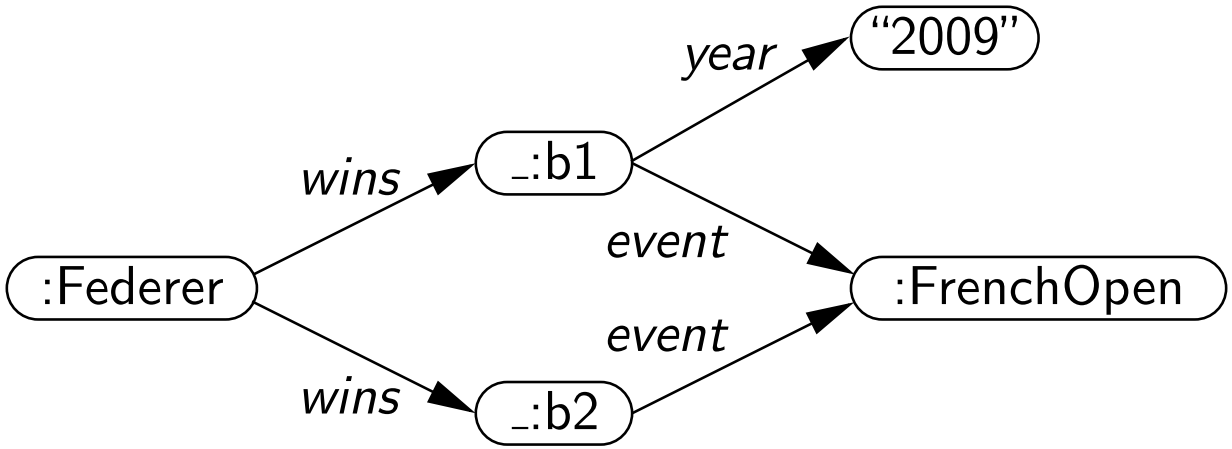
One clear conclusion: blank nodes are divisive.

SPARQL considers blank nodes as different constants

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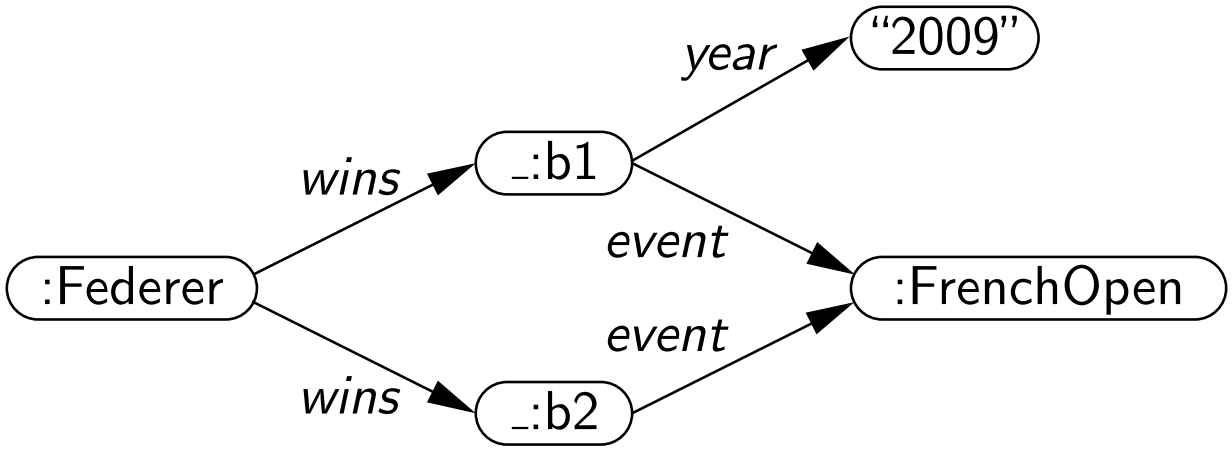


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?FO
_:b1
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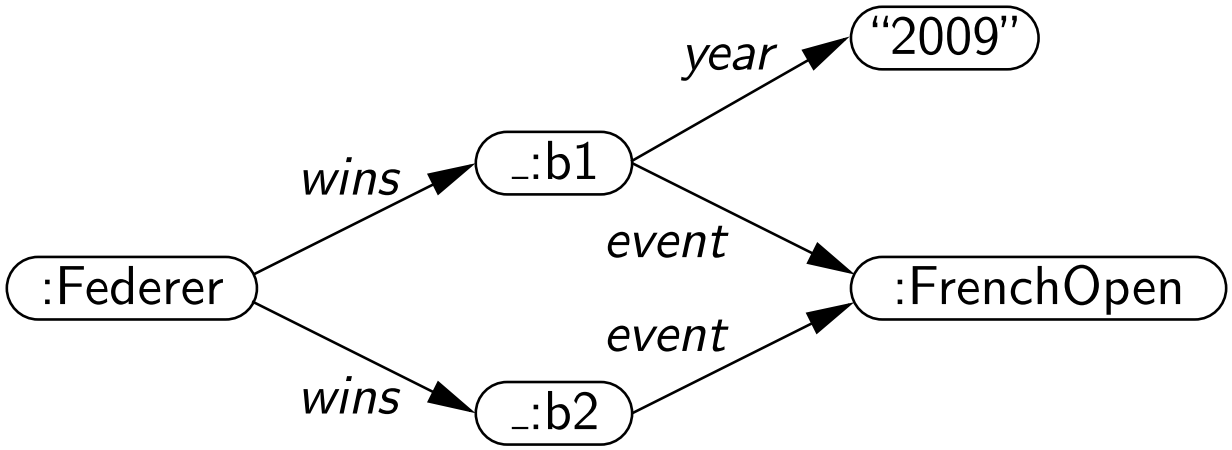


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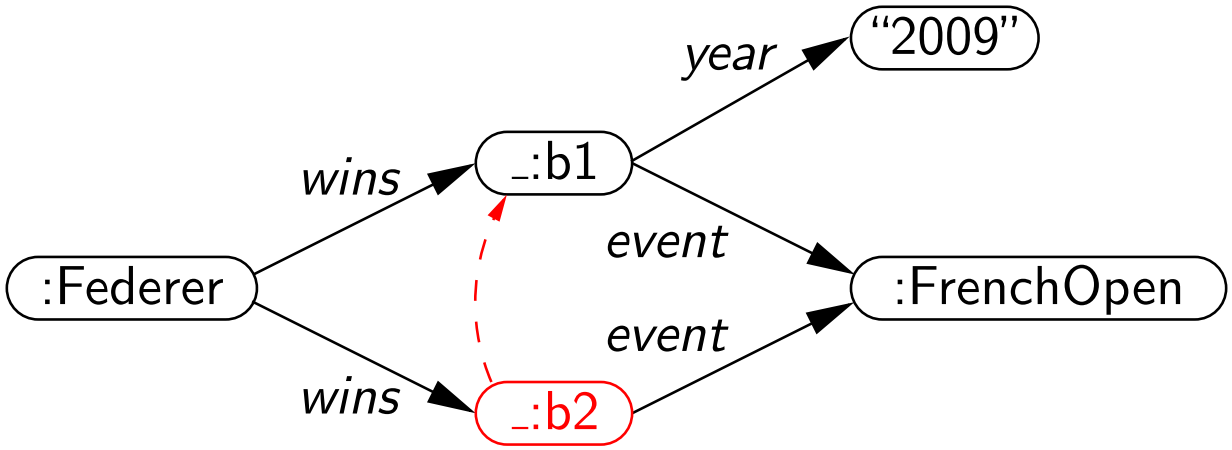


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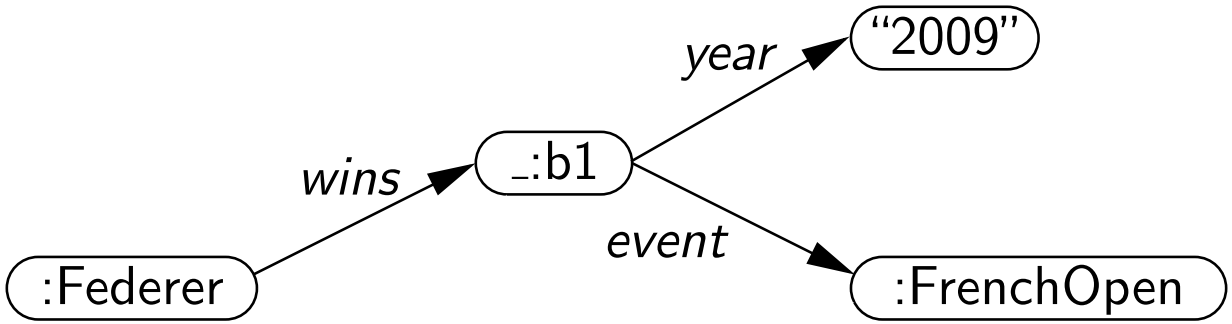


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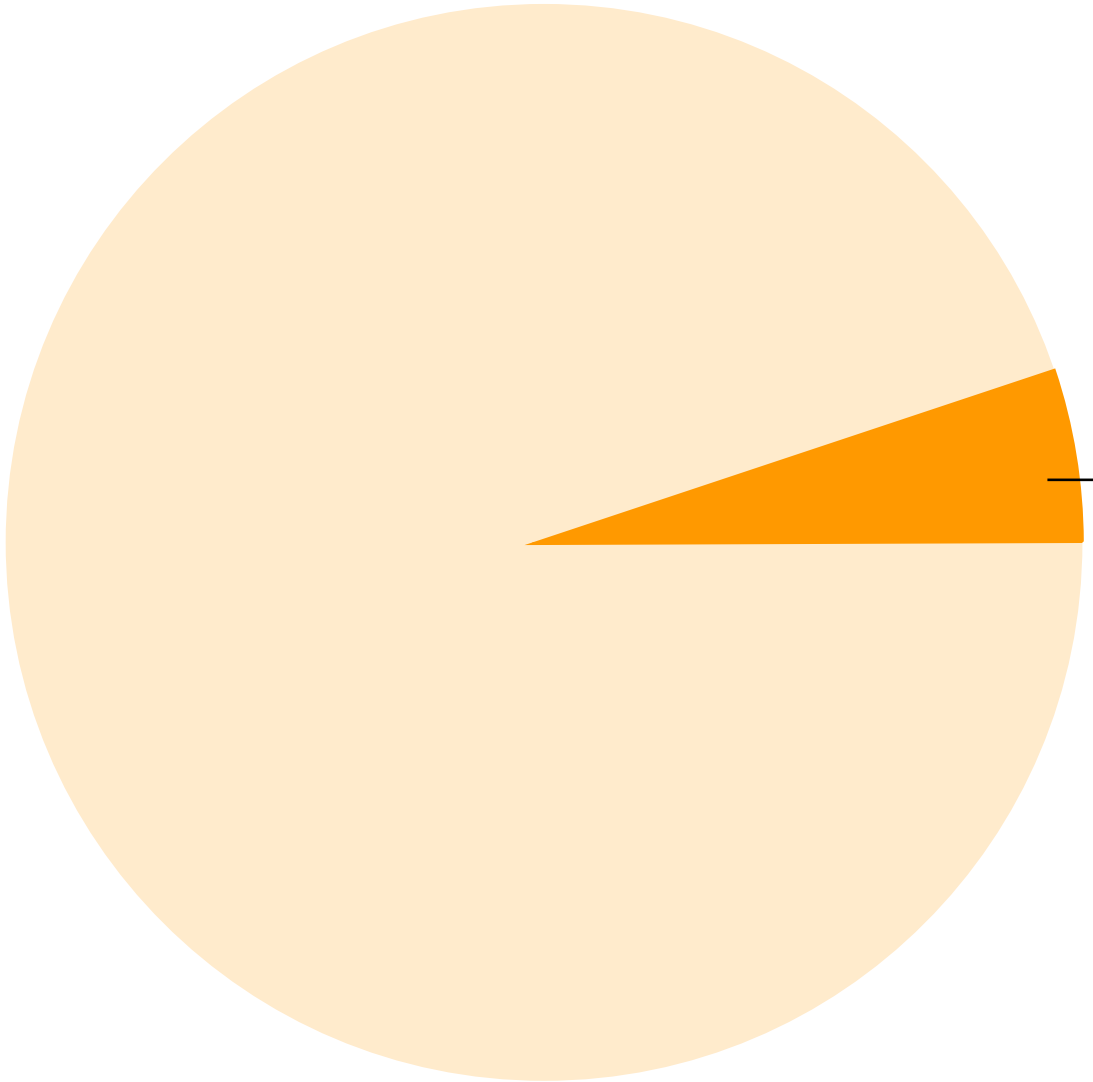
```

?FO
_:b1

Blank nodes in The Wild: size

From the corpus of study in Aidan Hogan's PhD thesis:



783 domains

4M documents

965M triples

avg. 7.5% bnodes per domain

44% of domains did not publish any blank nodes

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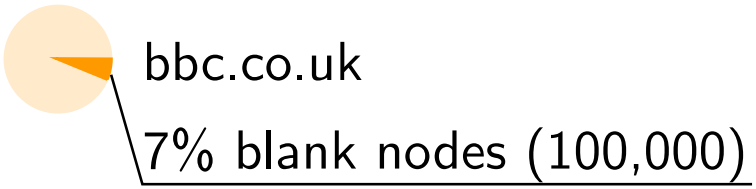

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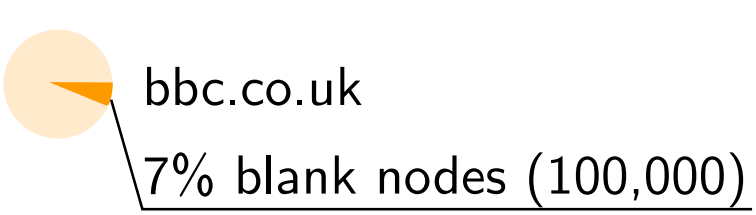

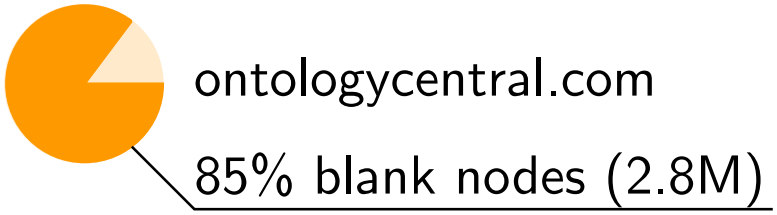

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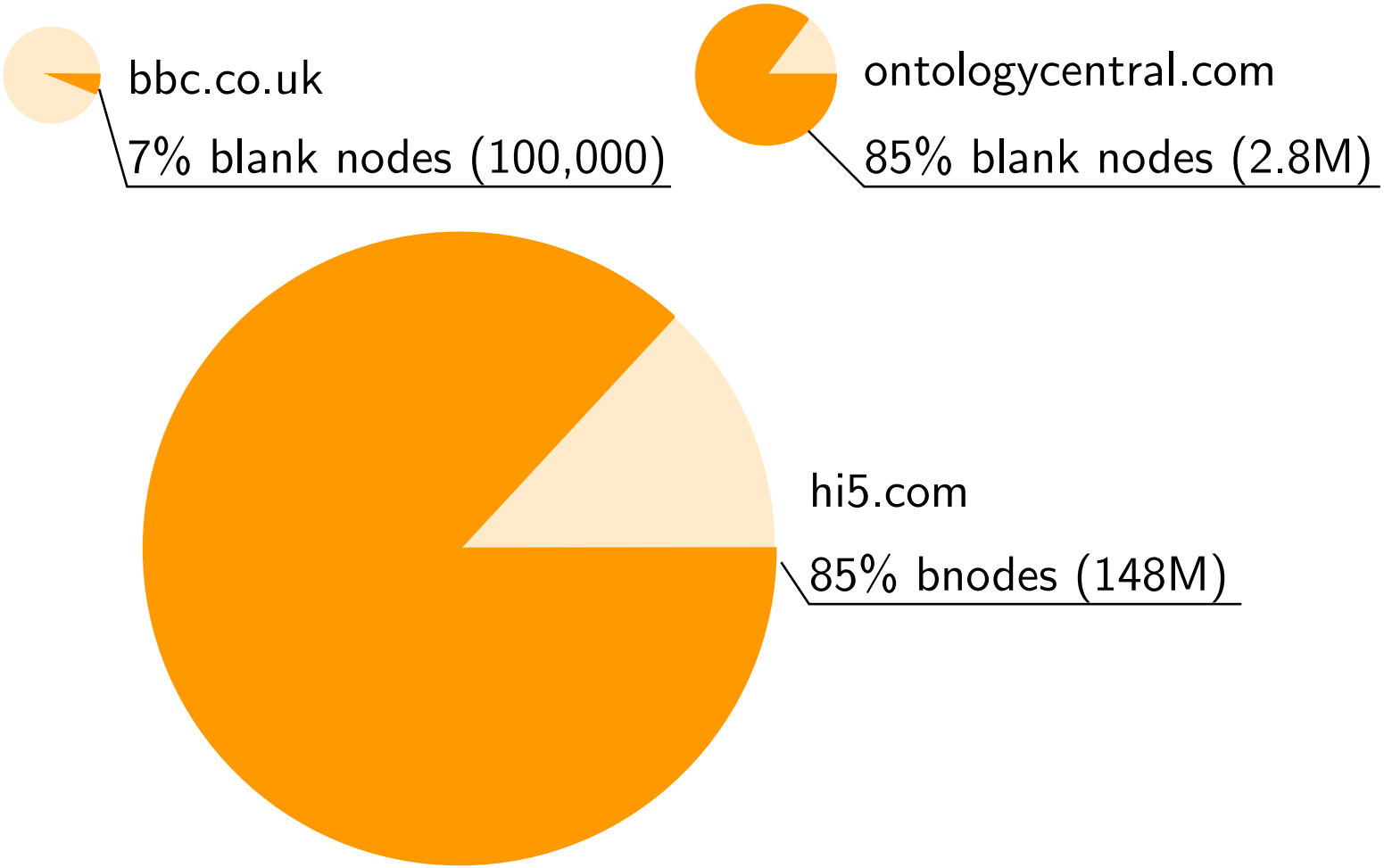
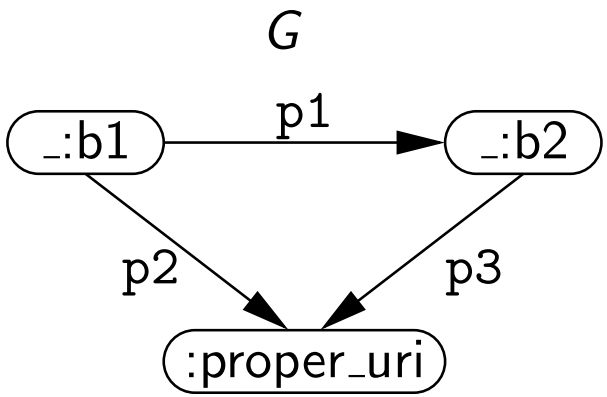


Blank nodes: structure

For an RDF graph G, blank(G) is the largest subgraph of G consisting only of blank nodes, seen as an undirected graph.



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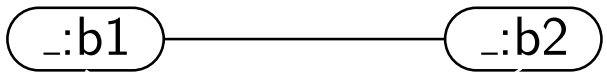

Blank nodes: structure

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- The higher the treewidth of blank(G), the harder entailment becomes [Pichler et al. 2008].

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- Polynomial algorithm for *bounded treewidth:* $O(n^k)$, with k proportional to the treewidth of blank(G)

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Why do we need this notion?

- The higher the treewidth of blank(G), the harder entailment becomes [Pichler et al. 2008].
- Polynomial algorithm for *bounded treewidth:* $O(n^k)$, with k proportional to the treewidth of blank(G); NP-complete in general.

Blank nodes: structure

We studied the blank-node structure of the graphs in our corpus, looking to find trees of blank nodes.

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Why trees? Trees behave nicely.

- Entailment is efficient—low treewidth.
- Merging trees produces more trees.

Blank nodes in The Wild: plenty of "good" graphs

Good news #1

Not many graphs have complex blank node structure.

treewidth	# graphs
1	518,831
2	8,134
3	208
4	99
5	23
6	–
7	1

Treewidth in our corpus

The outlier: a graph with "blank treewidth" of 7

Found in
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- You should be impressed ☺

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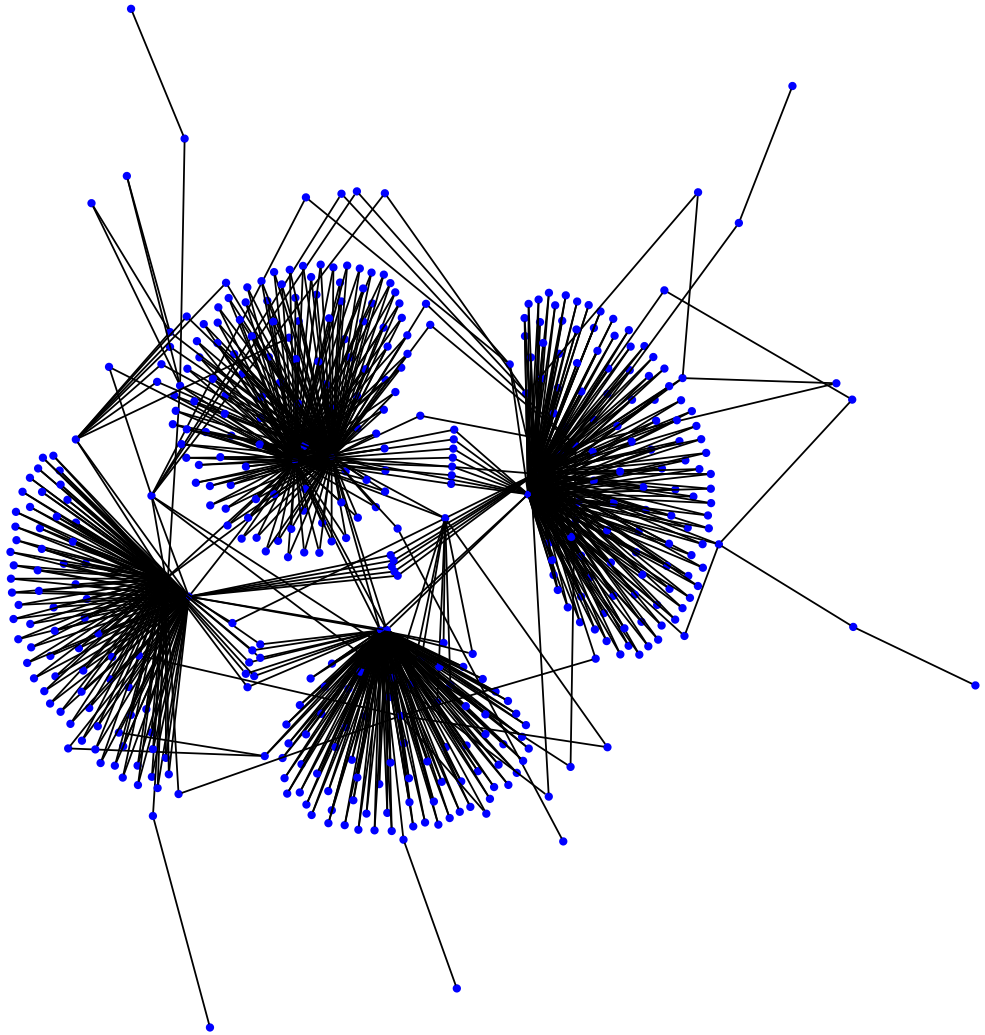

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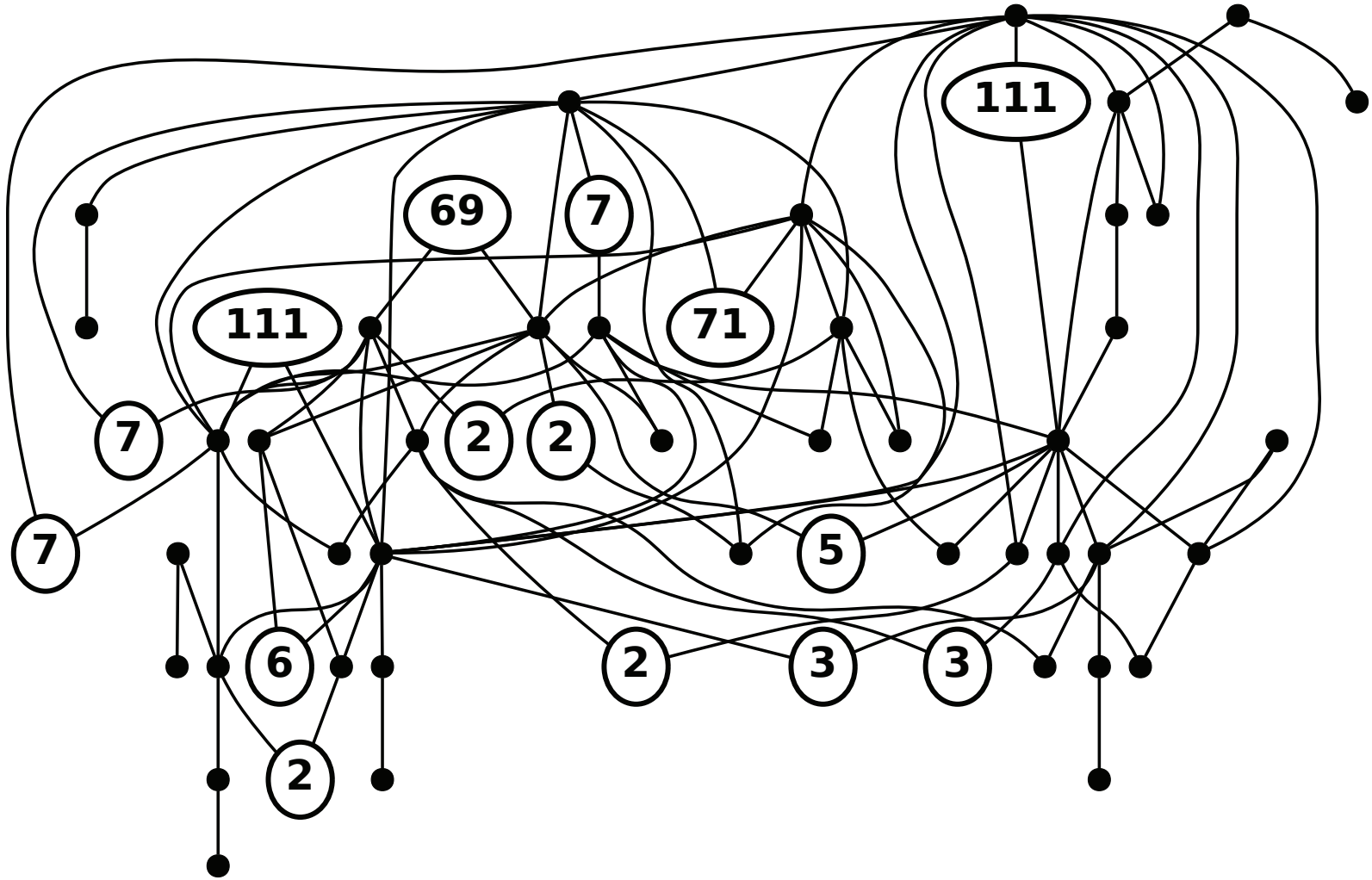

The outlier: a graph with “blank treewidth” of 7

Questions you might have right now:

- “What does this mean?”
- “Should I panic?”
- “How do I avoid this mess in my datasets?”

How to guarantee a tree-structure for blank nodes

Good news #2

When blank nodes are not labeled, we have trees.

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- Bracket syntax in Turtle

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How to guarantee a tree-structure for blank nodes

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- RDF/XML without `nodeID`

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:ex="http://example.org/">
  <rdf:Description rdf:about="http://example.org/Vader">
    <ex:fatherOf rdf:parseType="Resource">
      <ex:name>Luke</ex:name>
    </ex:fatherOf>
  </rdf:Description>
</rdf:RDF>
```

What if I want to get rid of blank nodes?

Good news #3: Skolemization

Process to replace blank nodes with fresh constants.

Original graph

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:John :telephone _:b1 .
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Skolemized graph

```
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`newConstant` is a name that has not been used before, anywhere.

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Standardizing the process with a Skolemization scheme

"So. . . how (on earth) do I generate these constants?"

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- Defines a standard syntax for *Skolem constants*.
- It is recommended as "best practice".
- It doesn't require changes in the semantics of RDF.

Towards a Skolemization scheme

Currently under discussion by the RDF Working Group:

Use well-known URIs (RFC 5785)

`http://my.domain/.well-known/bnode/abc123xyz789`

- Fixed string in well-known URIs
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  - Other options: `genid`, `skolem`
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