Supporting failure analysis with discoverable, annotated log datasets

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“Why was my job 30% slower today than usual?”

- Network congestion caused by whatever else happened to run at that time?
- How do we find out?
  - Browse the logs?
  - Are we collecting HSN counters?

Why is this hard?

- Volume
- Access
  - It's on SMW
  - It's in someone else's $HOME
- Variety
  - Formats, storage
- Expertise
  - What do all those messages actually mean?

Spoiler alert

- "We can solve any problem by introducing an extra level of indirection"
- Machine-readable metadata
  - Decouple publication and discovery from storage and access
  - Deal with a tractable volume of data before diving deeper
  - Solve the solvable now, and let local solutions address local constraints

What are the requirements?

- Volume
- Variety
- Access
- Expertise

What are the requirements?

- Format-agnostic, storage-agnostic
  - Work with what we have
- No dependence on a priori knowledge of data
  - "Ann is collecting that" is fine .. If you know Ann, and what she is collecting (and if she's available today)
- Decentralized
  - If you have everything in one place – great! (But you probably don't)

What are the requirements?

- Low effort, low risk to publish data
  - “select something non-sensitive to publish” vs. “redact all the sensitive bits”
- Make contributing expertise easy
- Deal in tractable volumes
  - Don’t download the internet
- Understand connected/related components
  - The fault might start somewhere else

A metadata solution

- Format-agnostic, storage-agnostic
- No dependence on a priori knowledge of data
- Decentralized
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With metadata we can:

- Decouple publication and discovery from storage and access
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- Link different data together
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A metadata solution

- RDF vocabulary for describing log data collections and finding relevant logs
  - Machine readable, searchable, decentralized, global graph
- Schema for annotating data within logs and exploring a reduced set of relevant log entries

Linked Data and RDF

Linked Data and RDF

- Triples: subject, predicate, object
  - CUG2018 is a Conference
  - Conference has Research Presentations
  - Stockholm is hosting CUG2018
- We can infer that this talk is happening, here, now

Linked Data and RDF

- **Everything* is a URI**
- **Convention:**

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
rdfs:type
```

- **Means:**

```
<http://www.w3.org/2000/01/rdf-schema#type>
```

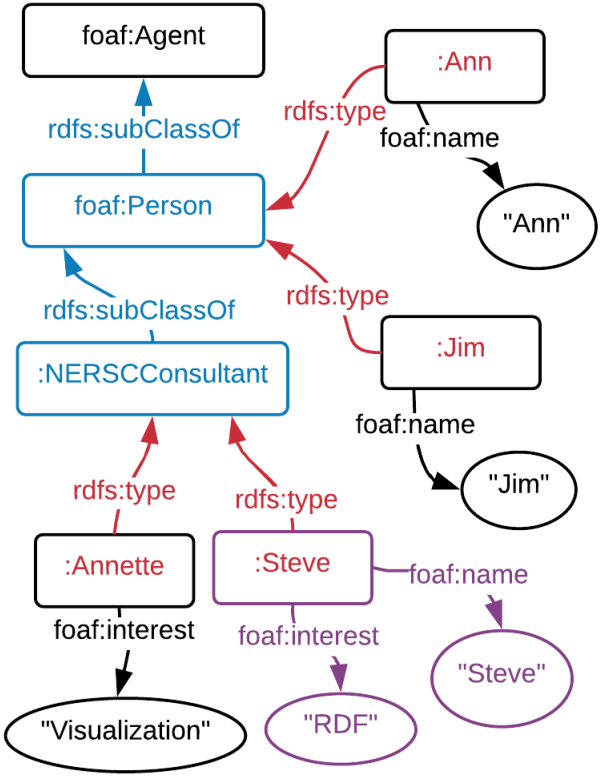
```
@prefix nersc: <http://nersc.gov/project/hmdr/nersc#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
nersc:nersc rdfs:type foaf:Organization .
```

* Almost everything (some things are literal strings, etc)

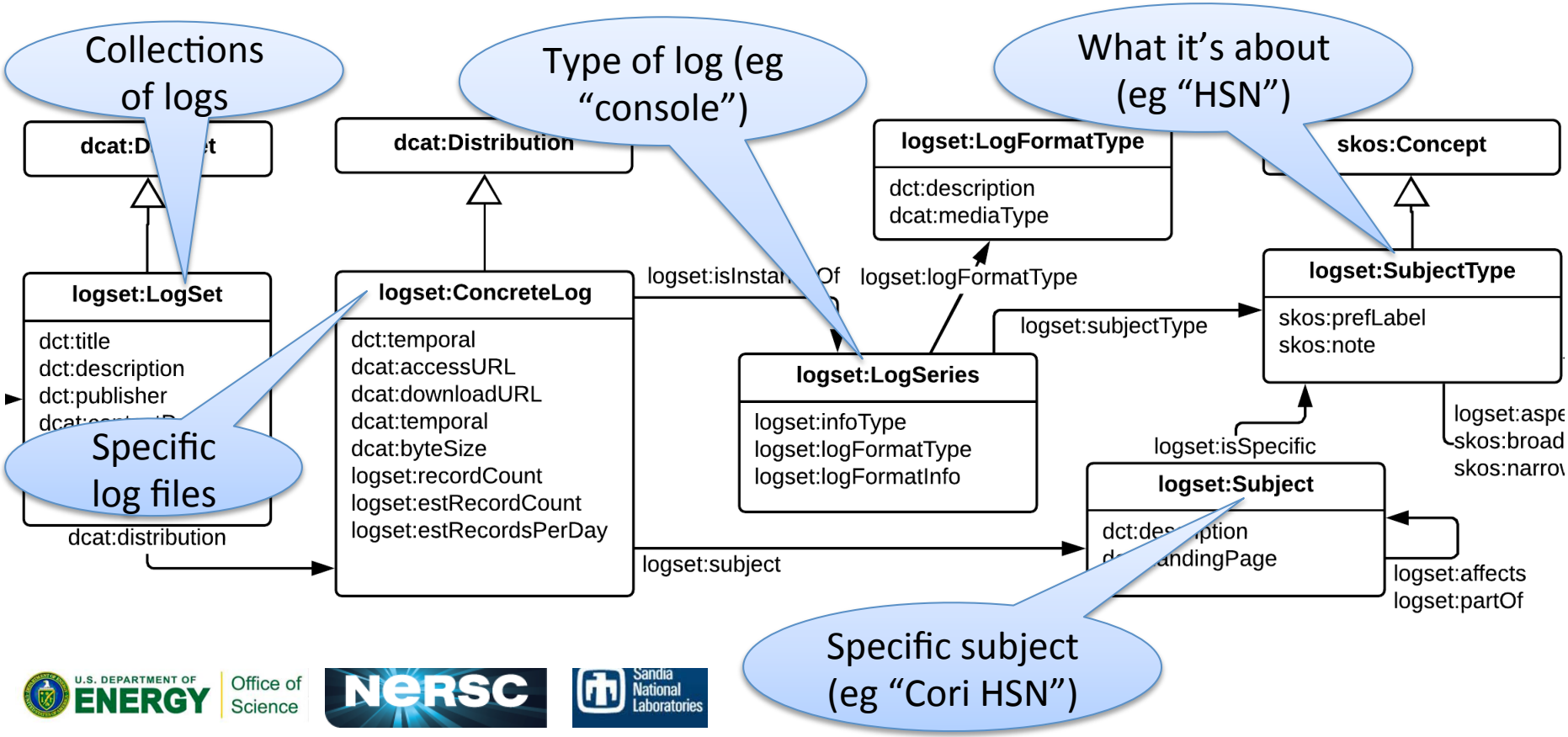
Querying a graph (SPARQL)

```
SELECT ?name ?interest
WHERE {
  ?type rdfs:subClassOf* foaf:Agent .
  ?uri rdfs:type ?type .
  ?uri foaf:name ?name .
  ?uri foaf:interest ?interest .
}
```

- Returns “Steve”, “RDF”



RDF Vocabulary for log data



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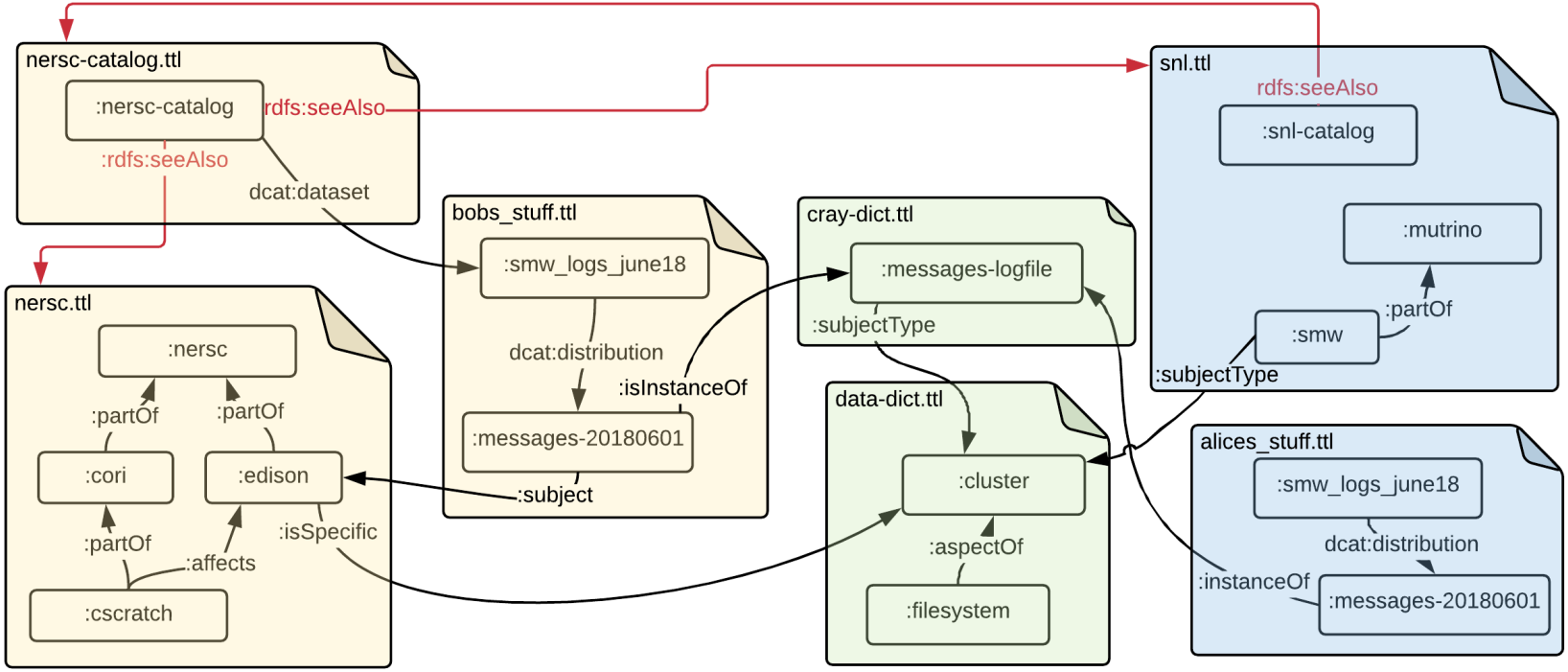
Global graph, Catalogs form hubs



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What does this get us?

- Format-agnostic, storage-agnostic
- **No dependence on a priori knowledge of data**
- **Decentralized**
- Low effort, low risk to publish data
- Make contributing expertise easy
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- **Understand connected/related components**

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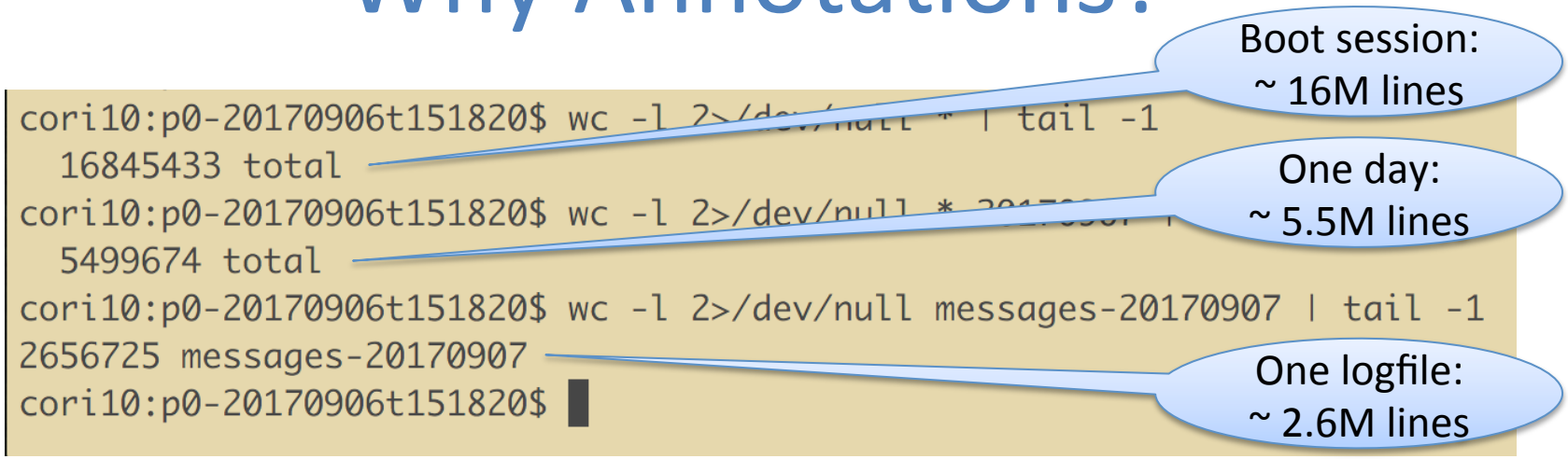
A metadata solution

- RDF vocabulary
  - Discovery ***of*** data
- Schema for annotating data within logs and exploring a reduced set of relevant log entries
  - Discovery ***in*** data

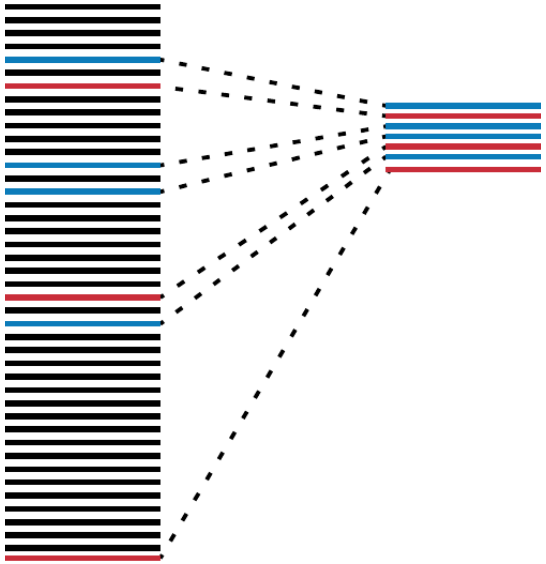
Why Annotations?



- That's a lot to search through!

Annotations

- Human-provided commentary
  - "I swapped a DIMM in node nid00123"
  - "These messages are due to a fault injection experiment"
- Machine–generated annotations
  - Eg subset of entries matching significant Baler patterns, with timestamps, components called out



An annotation schema

```
CREATE TABLE 'annotations' (
        id              integer,
        authorid        char(3) NOT NULL,
        description     text NOT NULL,
        -- timespan of the action or event:
        starttime       datetime NOT NULL,
        endtime         datetime NOT NULL,
        -- impact of the action or event:
        startstate      text,
        endstate        text,
        systemdown      boolean,
        system          text,
        components      text,
        -- was the event manually induced?
        manual          boolean,
        -- subject type and annotation context:
        LDcategory      text,
        LDtag           text,
        balerpatternid integer,
        -- event source:
        logfiles        text,
        PRIMARY KEY('id','authorid')
         );
```

Summary, who to ask

When?

What?

Where?

Why?

Categorization

Pointer back to full, raw data

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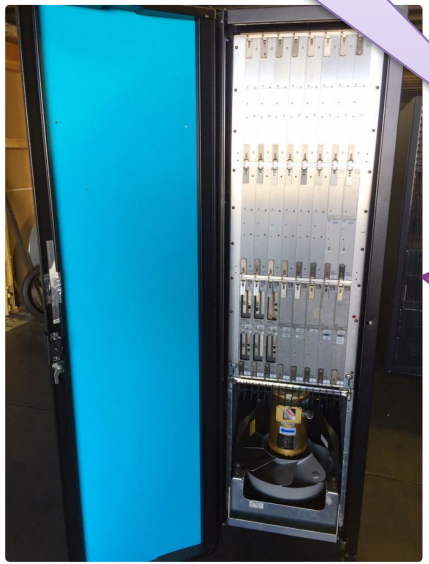
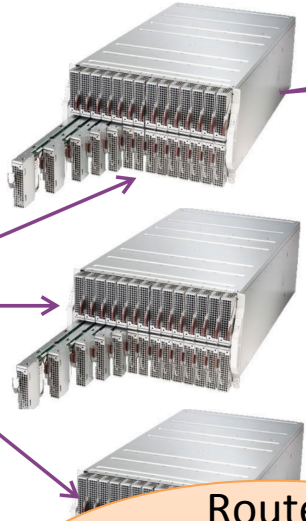
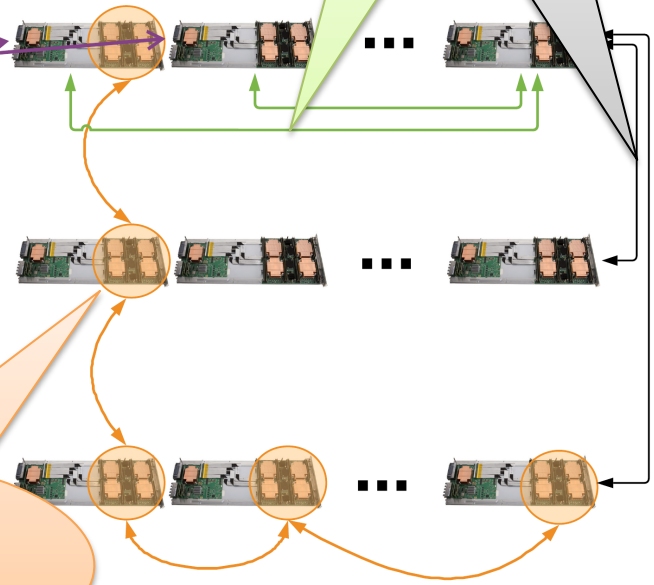
Architectures

Physical architecture: parent:child





Link architecture: peer:peer



Router architecture: parent:child, peer:peer

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  - ~~Browse the logs?~~ Search a set of annotations

Testing it out

- Some prototype tools:
  - Construct a graph from RDF files on web (or locally)
  - Scan a directory of logfiles and generate RDF to describe them
    - Asks some questions, basic inspection of file characteristics, infers most metadata from the answers and graph
  - Populate an annotation database from a subset of log entries identified via Baler, and some admin notes
    - Baler: finds patterns in log files, weights by presence of listed keywords, filter by highest-weighted patterns
  - Search the annotation database for things of interest

Are applications interfering with each other via HSN congestion?

```
elds (e.g., description, LDcategory) contain the word 'congest'

            description                                                  logfiles  LDc
):15:44  System computing and listing congestion candidate applications  nlrd    NE
):15:44  System computing and listing congestion candidate nodes         nlrd    NE

                                                  idate applications     nlrd    NE
                                                 e nodes                 nlrd    NE
```

"What applications did it find?" (fetch that part of nlrd file)

- … none at all!
- What else happened? Search annotations for the half-hour leading up to this one

Are applications interfering with each other via HSN congestion?

- The last half hour:
  - 300 annotated events, 7 distinct
  - 192 were:

    ```
    c0-0c1s8a0n0 Correctable memory error.  This may
    result in degraded performance.
    ```

  - 47 were:

    ```
    c0-0c1s8a0n0 Component failed
    ```

- Lets look at that component more closely…

Are applications interfering with each other via HSN congestion?

- `c0-0c1s8a0n0` "Component failed" and "Correctable memory error"
- Issues started a few weeks earlier and stopped a few days later (.. Why did it *stop*?)
  - Start coincided with deliberately induced faults for system testing – difficult to ascertain
  - Why did it stop? Search a bit wider, over a couple of levels of physical architecture
    - Found at a couple of levels up that the blade was reseated on that day. Constraining the search to around the time the errors stopped, can see entries documenting a warm swap, after which the errors stopped

What did we learn?

- Our intuition was wrong – we expected to find a communication-heavy application but instead found a component issue
- Searching a database of annotated log entries reduced the search space from 150000+ lines to a few hundred

Where are we now?

- RDF vocabulary defined
- Annotation schema defined
- Prototype tools
  - (further development in progress)
- Finding: this can make exploration more tractable, and lead to interesting insights

Making log data discoverable and tractable – machine readable metadata

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Q&A