U.S. DEPARTMENT OF ENERGY | Office of Cybersecurity, Energy Security, and Emergency Response

Cyber Labeling Research Initiative

Presented by Animesh Pattanayak, PNNL

Why Cyber Labeling Research?

- "U.S. Cyber Trust Mark" program initiated in 2023 to be led by FCC to "help Americans more easily choose smart devices that are safer and less vulnerable to cyberattacks."[1]
- DOE initiated research to develop a proof-of-concept for cybersecurity labeling for energy products to explore the best methods to present information about security features in energy products to inform consumer decisions.
- Focused on market-facing products: solar inverters and smart meters.
- Output: final research report detailing the results of the pilot and making recommendations to an expanded OT labeling program.

Overlap with SBOM

- Emphasis on information disclosure and transparency
- Goal of promoting energy sector security
- Where else is there overlap?

Who is involved?

- Funded by President Biden's Bipartisan Infrastructure Law, via DOE CESER[2]
- Led by a collaborative team of researchers from six National Laboratories (NREL, ORNL, SNL, INL, PNNL, LLNL)[2]
- Informed by feedback from five volunteer vendor partners with inverter and smart meter products
- In its proof-of-concept phase, the project will seek feedback from broader audiences (auditors, other vendors, the "general public", you)
- Final implementation decisions will be made by the FCC. If implemented, participation would be voluntary and available to energy sector vendors.

Process so far

- Assessed 19+ standards/recognized research/legislation pertaining to labeling, privacy, and security for IoT and IIoT
  - Key takeaway: no existing standard or labeling regime adequately addresses privacy and security concerns applicable to energy sector ICS technologies such as smart meters and inverters.
- Consulted with policy and technology experts from 5 volunteer vendors, both in 1-1 interviews and group workshops
  - Key takeaway: any label for energy IIoT should be informational (displaying disclosures about security and privacy measures) rather than assessment or certification-based (displaying a rating or seal of approval), due to the context-dependent and highly variable nature of security in these environments.
- Produced an initial mockup of a label and associated data-request form, which will be used to run a pilot/proof of concept with vendor partners.

Building the Label Requirements

- For each proposed data field, lab researchers answered the following questions:
  - How do we describe this element?
  - What types of data could fill this field?
  - What function does inclusion of this element fill?
  - Is it verifiable and/or immutable?
    - How could it be verified? By whom?
    - How do we address elements that are subject to change over time?
  - Is it applicable to smart meters and inverters?
  - Does it map to commonly used standards and best practices?
  - Who does the information provide value to?

Challenges with SBOM inclusion

- Concerns about public SBOM disclosure
- Concerns about public interpretation of SBOMs
  - How to interpret relevance of vulnerability announcements, etc.
- Concerns about maintaining up-to-date, accurate information

21. Hardware Bill of Materials (HBOM)

Hardware Bill of Materials (HBOM) refers to a listing of the components (circuit boards, chips, etc.) within a hardware system.

	Yes	No
Do you maintain an HBOM for this system?	☐	☐
Is it available upon request?	☐	☐

Addt'l text box will populate if "Yes" is selected: To whom and under what conditions may an HBOM be made available?

22. Software Bill of Materials (SBOM)

Software Bill of Materials (SBOM) refers to a listing of components (e.g. applications, libraries, files and folders) within a software package.

	Yes	No
Do you maintain an SBOM for this system?	☐	☐
Is it available upon request?	☐	☐

Questions

- Can including SBOM in a cybersecurity label help promote acceptance of SBOM?
- How can we best include it?
- What challenges have you faced?
- Are there goals of SBOM that can be achieved through a cyber label or vice versa?

Thank You

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Visualizing Comparisons of Bills of Materials

February 2, 2024

Rebecca Jones

Lucas Tate

Funded by CESER

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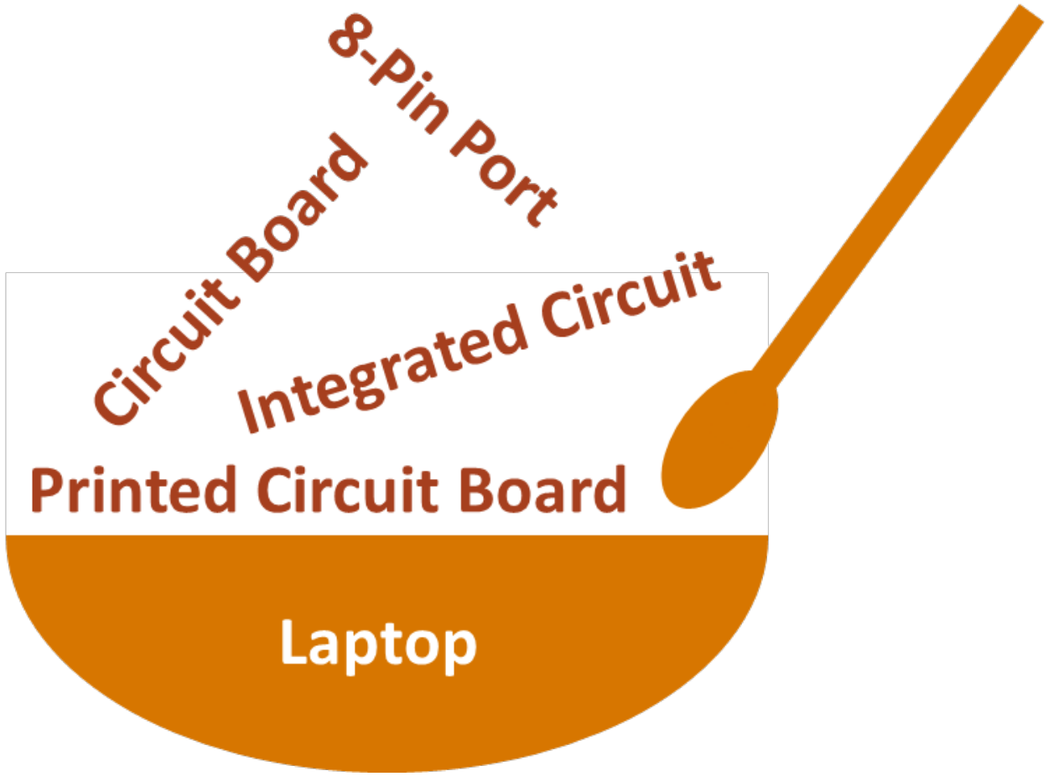
Bills of Materials (BOMs)

- What is in system?
  - All the objects for a piece of hardware or software
  - Includes how the objects are related
  - Metadata
    - ✓ Part Number
    - ✓ Vendor
    - ✓ Country of Origin
    - ✓ Version
- Required for all software sold to US Government
- No standard format



Comparing Bill of Materials

Questions to Answer

- How do different versions of a BOM compare?
- How do BOMs change over time?
- When there are multiple BOMs for a system, are they the same?
- How similar are the underlying systems of the same model and versions?
- How are classes of systems similar?
- How can we easily identify the differences between two BOMs?

Current Methods

- Set comparisons
- Spreadsheets
- Tabular comparisons
- Side by side version comparisons

The methods don't account for relationships and can be difficult with large BOMs.

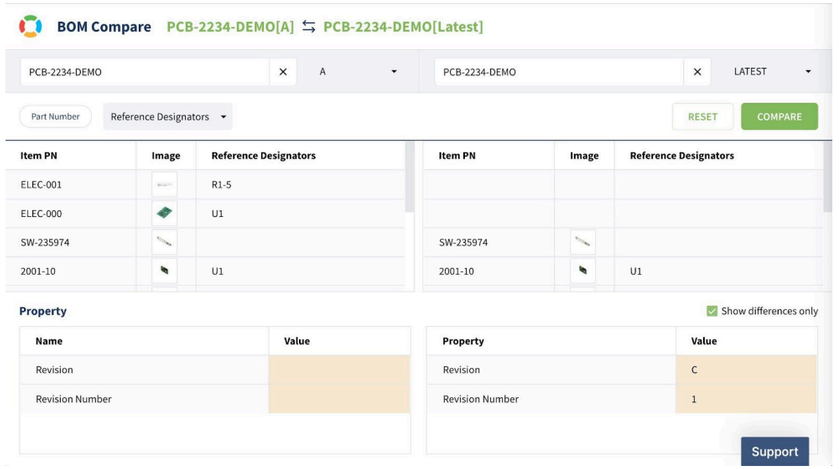


Image of OpenBOM comparison tool

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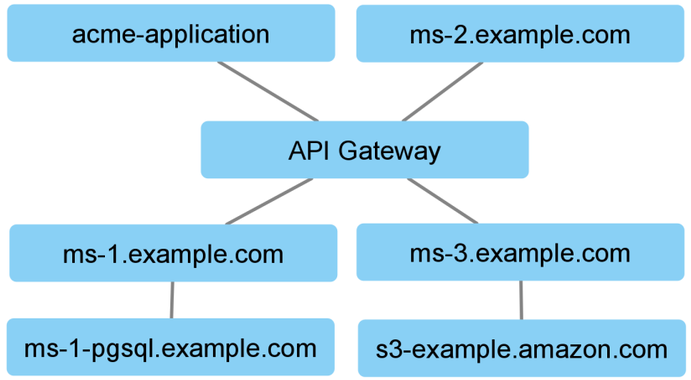
BOMs as Graphs

- Objects become nodes
- Relationships become edges
  - Physical connections
  - DLL calls
  - File structure
  - Package imports
- Metadata becomes attributes in graph



CycloneDX **SaaSBOM** example*

*https://github.com/CycloneDX/bom-examples


```
{
  "bomFormat": "CycloneDX",
  "specVersion": "1.4",
  "serialNumber": "urn:uuid:3e671687-395b-41f5-a30f-a58921a69b79",
  "version": 1,
  "metadata": {
    "component": {
      "bom-ref": "acme-application",
      "name": "Acme Cloud Example",
      "version": "2022-1"
    }
  },
  "services": [
    {
      "bom-ref": "api-gateway",
      "name": "API Gateway",
      "version": "2022-1",
      "description": "Example API Gateway",
      "data": [
        {
          "classification": "PII",
          "flow": "bi-directional"
        }
      ],
      "services": [
        {
          "bom-ref": "ms-1.example.com",
          "name": "Microservice 1",
          "version": "2022-1",
          "data": [
            {
              "classification": "PII",
              "flow": "bi-directional"
            }
          ]
        },
        {
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          "name": "Microservice 2",
          "version": "2022-1",
          "description": "Example Microservice",
          "data": [
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              "flow": "bi-directional"
            }
          ]
        }
      ]
    }
  ],
  "dependencies": [
    {
      "ref": "acme-application",
      "dependsOn": [ "api-gateway" ]
    },
    {
      "ref": "api-gateway",
      "dependsOn": [
        "ms-1.example.com",
        "ms-2.example.com",
        "ms-3.example.com"
      ]
    }
  ]
}
```

Comparing Graphs

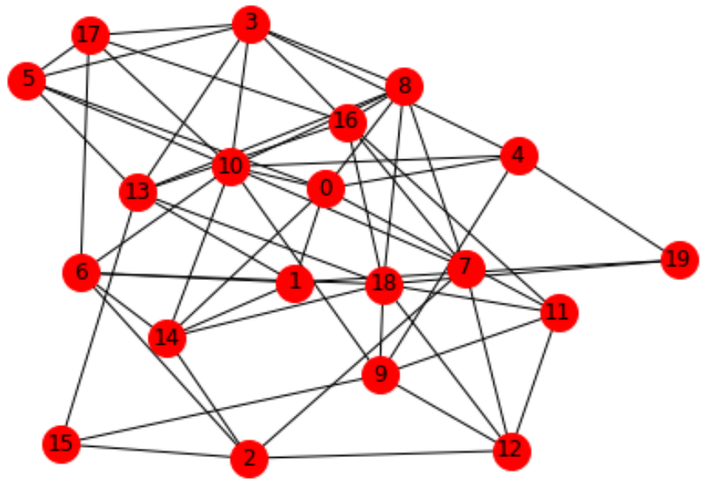
How similar are two graphs? Where are the differences?

Methods

- Distance Methods
- Spectral analysis
- Clustering Techniques
- Deep Learning
- Node Correspondence

Gaps in Current Methods

- Work on specific family of graphs
- Focus on graph structure
- Attributes
- Global solutions
- Do not predict individual possible mappings
- End-to-end solution



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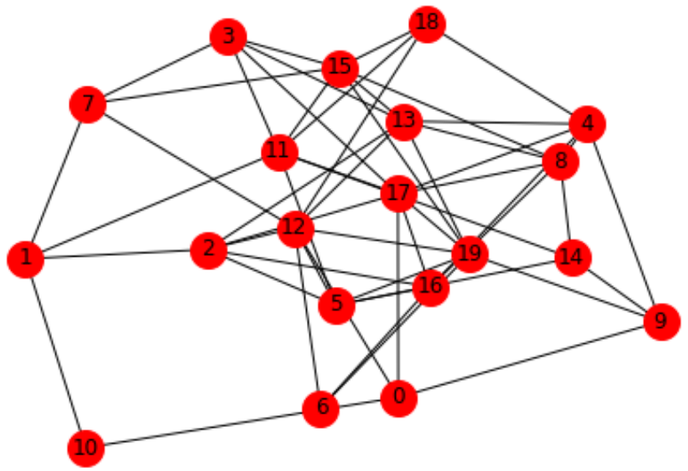

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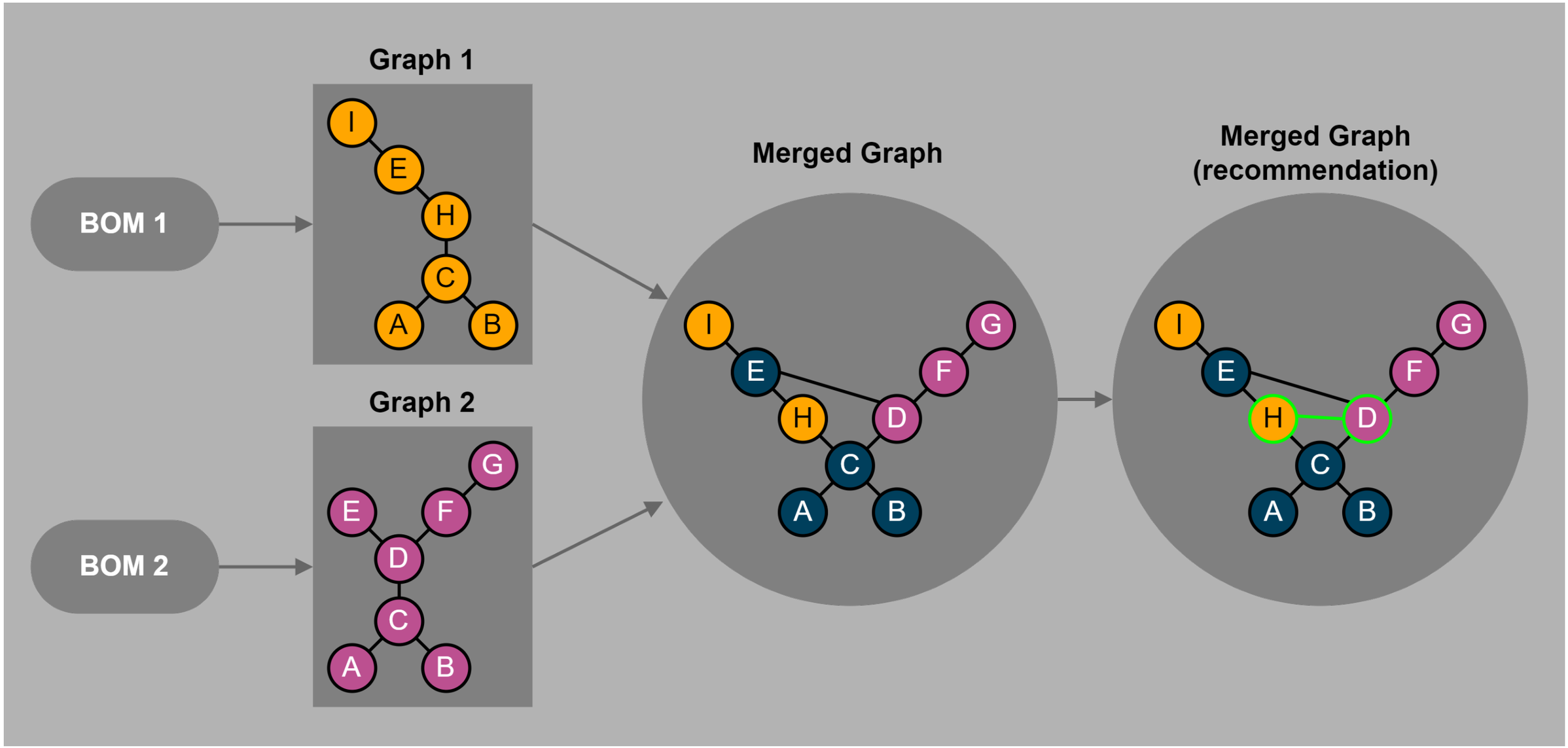
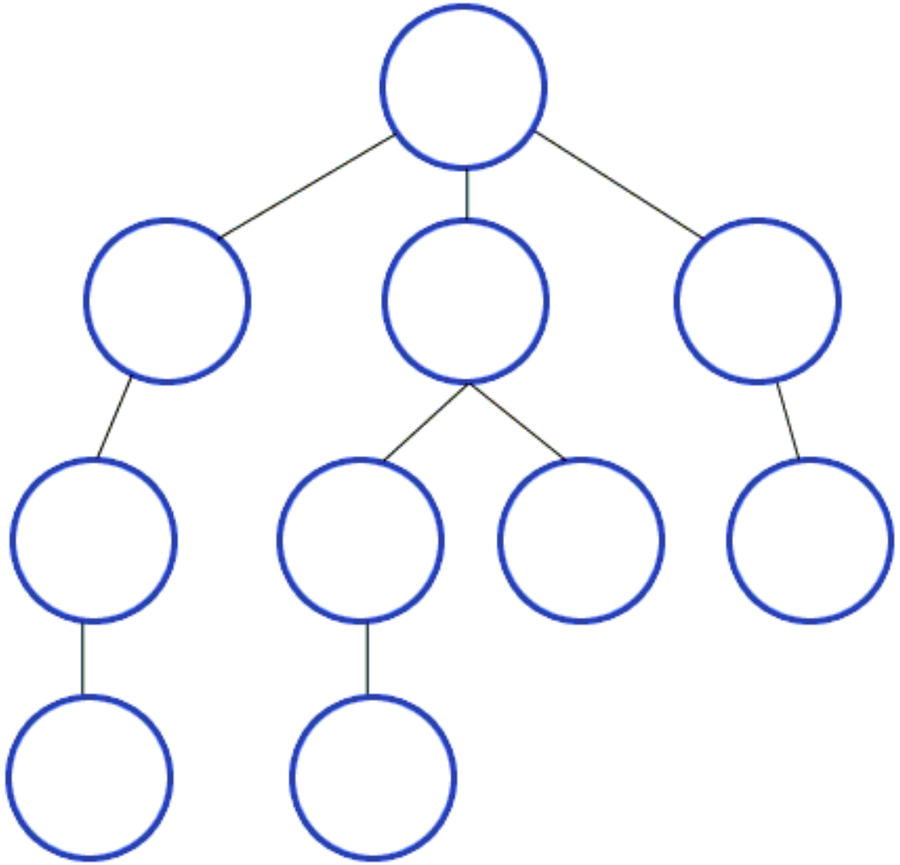
Overall Approach



Method

- Based on Depth First Search
  - Linear time graph traversal
  - Parallelized
- Considers neighbors of a node as well as multiple attributes
- Incorporates record linkage
- Can predict non-exact matches



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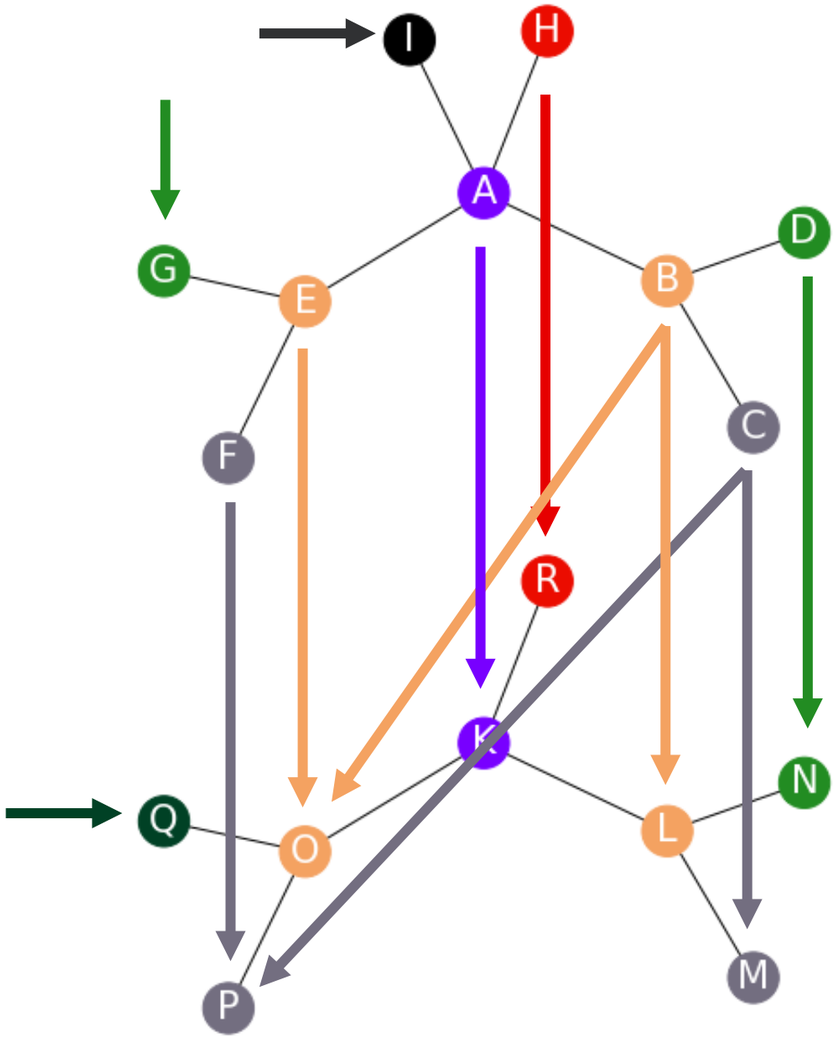
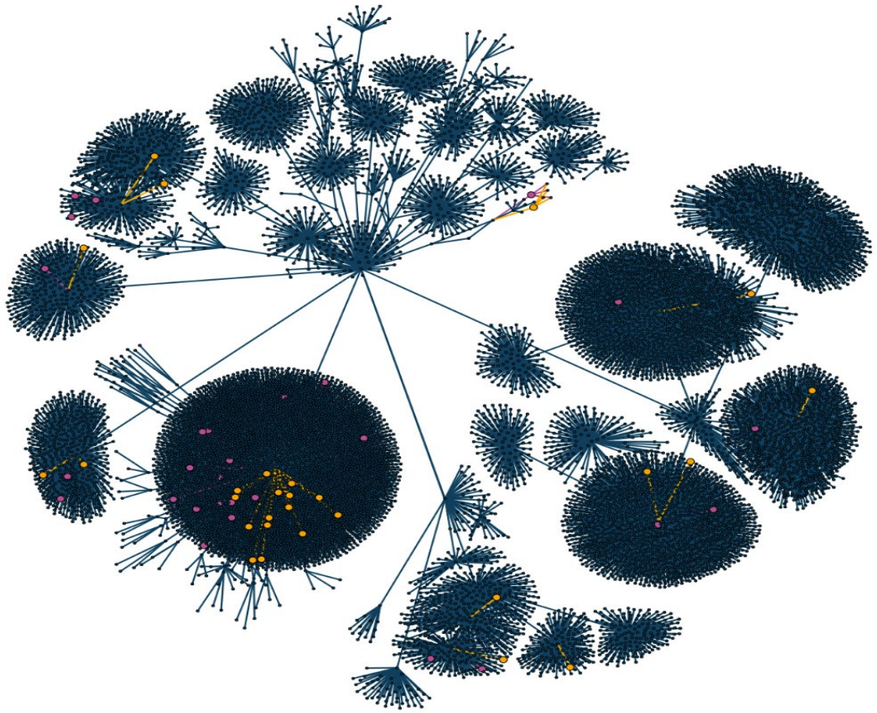
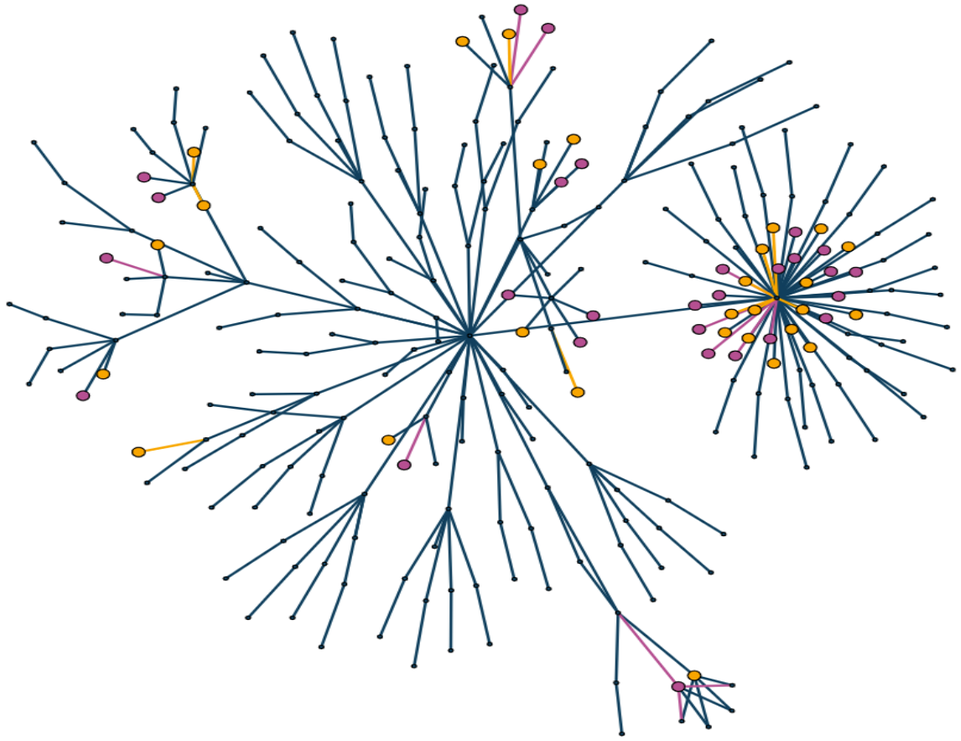
Algorithm



Supernodes

- In large graphs, can be difficult to see differences, especially with overplotting
- Collapse leaf nodes of same neighbor into supernode
- Can spot differences more easily

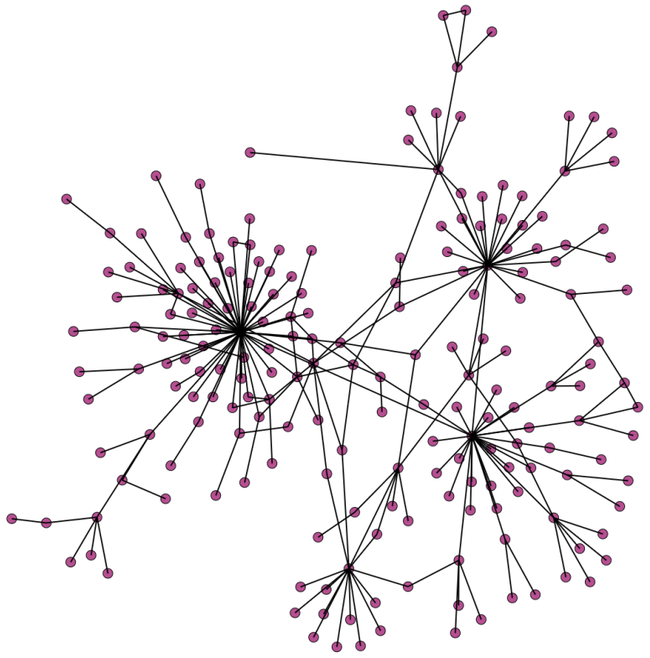




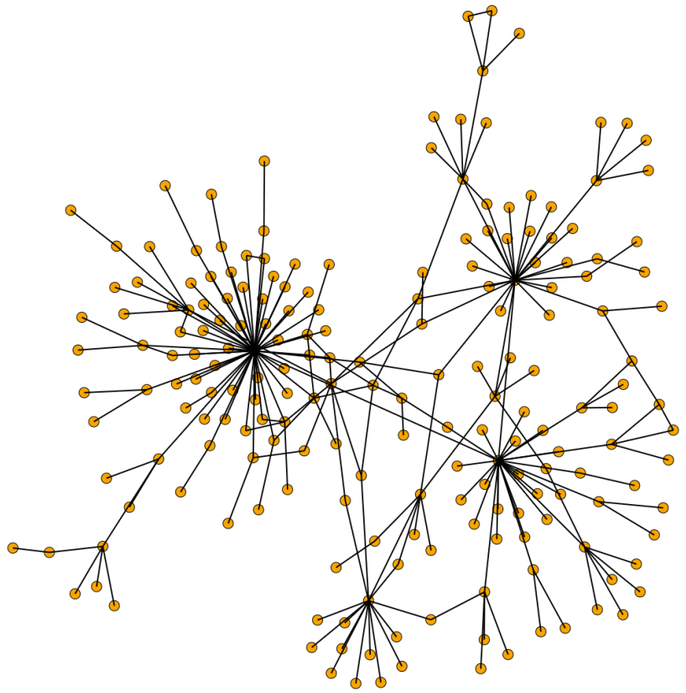
Images of large SBOM compared with manually modified copy

SBOM Graph Comparison

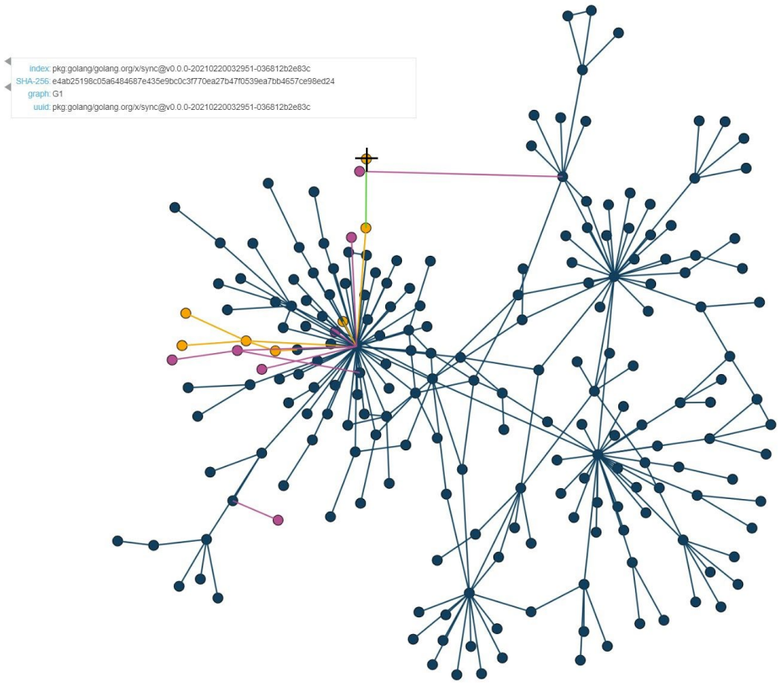
CycloneDX open source SBOMs



Proton-bridge v.1.6.3

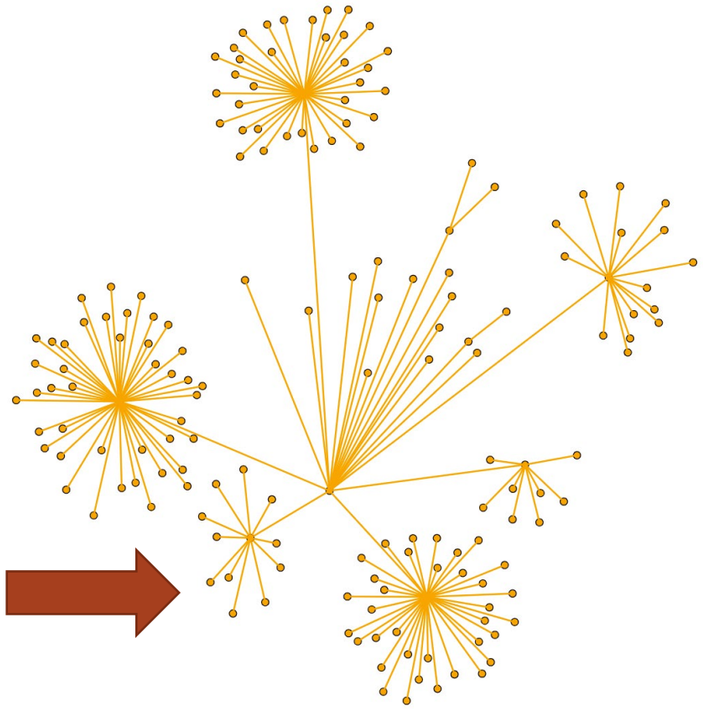


Proton-bridge v.1.8.0

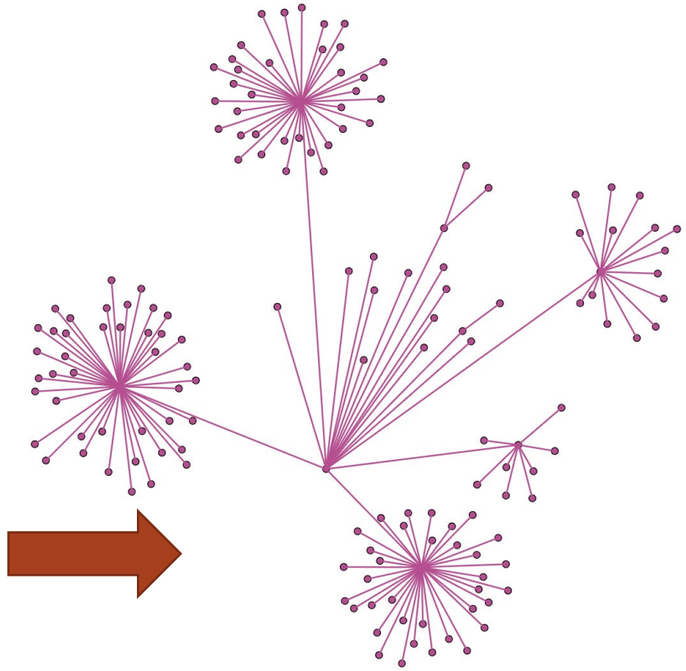


Proton-bridge Combined

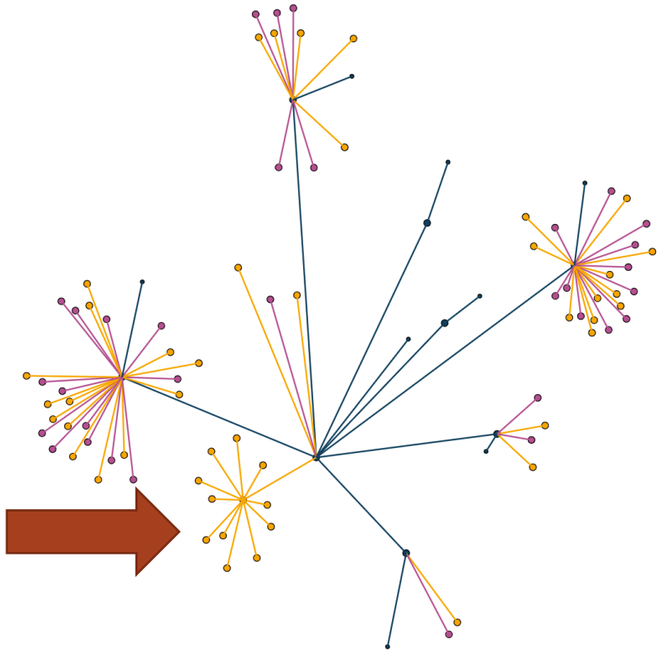
HBOM Graph Comparison



Version 1 of hardware



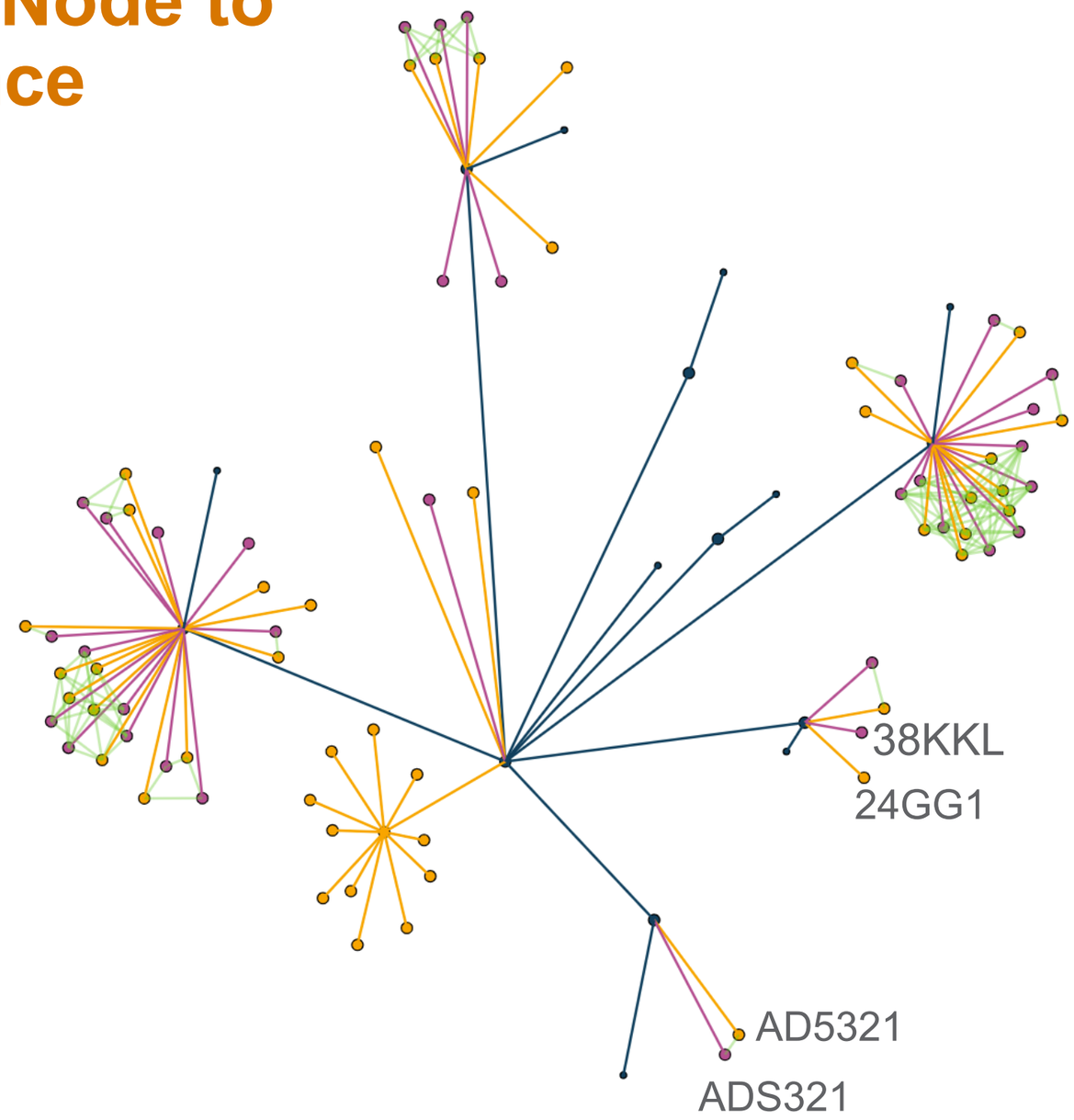
Version 2 of hardware



Merged Graph – Blue indicates nodes in both

Predicting Possible Node to Node Correspondence

- Reran algorithm on nodes that are not in both graphs using fuzzy matching (Jaro-Winkler)
- Overlay predicted edges (in green)
- Found differences that could be user error S/5



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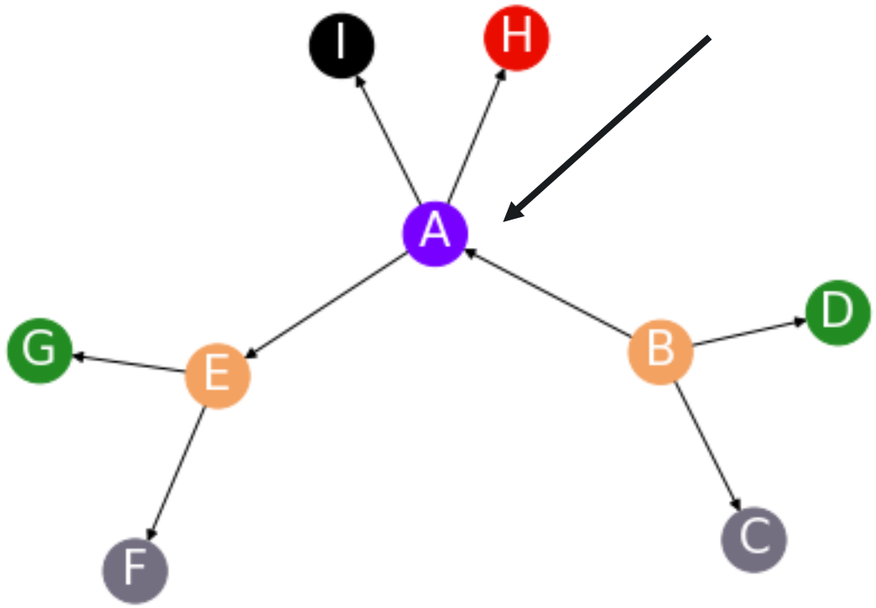
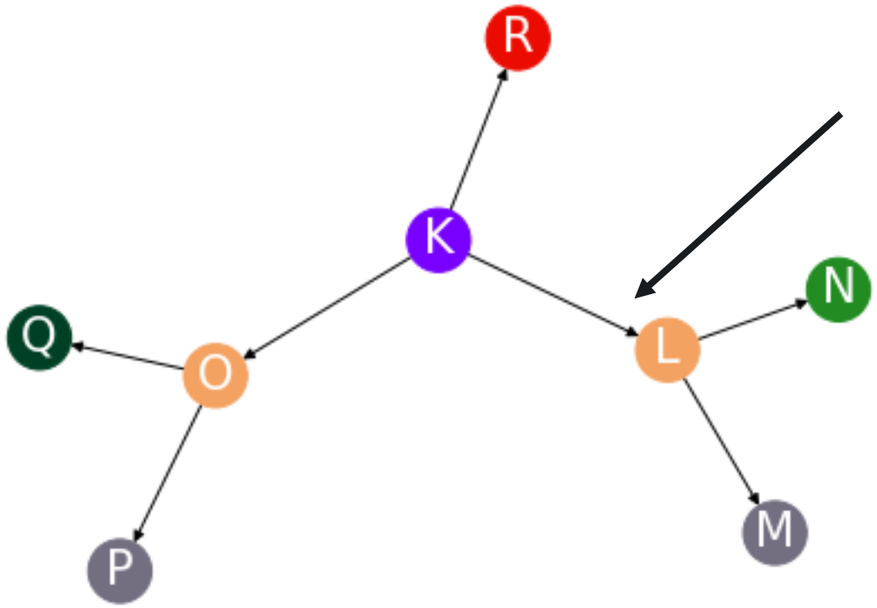
Conclusion

- Created new end-to-end system to compare Bill of Materials
- Graph representation improved analysis compared to sets and lines of code
- Quick algorithm and collapsing supernodes accommodate large BOMs
- Interactive visualization allows for differences in BOMs to be quickly identified
- Were able to find locations of discrepancies in BOMs in hardware

Future Work

- Compare multiple Bills of Materials at a time
- Consider directed graphs
- Account for types of edges/edge attributes
- Identify subgraphs of interest





Acknowledgements

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Thank you