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Applications of Network Methods for Supply Chain Analysis

Zedekiah P. Fashena

April 2023

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DATAWorks 2023:
Applications of Network Methods for Supply Chain Analysis

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Deficiencies and Bottlenecks in the Defense Industrial Base Directly Impact DoD Capabilities

Pentagon

The US is running out of bombs — and it may soon struggle to make more

By Aaron Mehta

May 22, 2018

Key suppliers for weapons such as the AIM-120 advanced medium-range air-to-air missile are fleeing the defense-industrial base, which could have an impact on the ability of America to wage war in the future. (R. Nial Bradshaw/U.S. Air Force)

From Rockets to Ball Bearings, Pentagon Struggles to Feed War Machine

The flow of arms to Ukraine has exposed a worrisome lack of production capacity in the United States that has its roots in the end of the Cold War.

Congress

The US is heavily reliant on China and Russia for its ammo supply chain. Congress wants to fix that.

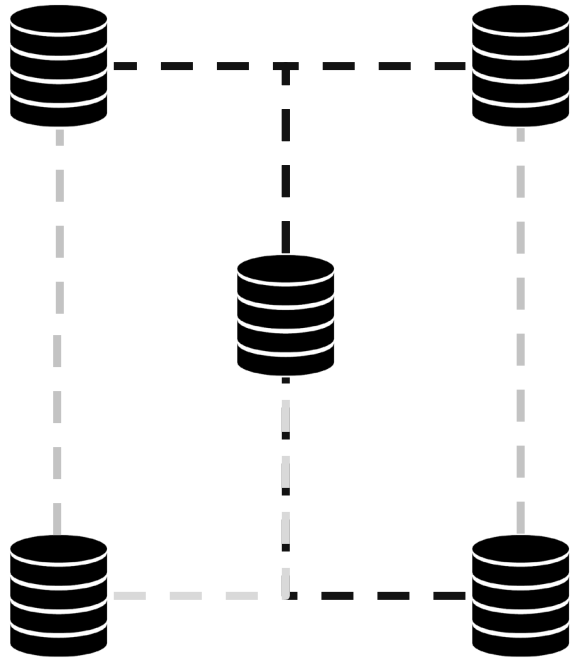
By Bryant Harris

Jun 8, 2022

Bullets are seen in front of an American-made F-16V fighter during a military exercise in Taiwan on Jan. 15, 2020. (Chiang Ying-ying/AP)

No Single Entity in the DoD or DIB Has a Complete Picture of the Supply Chain for Military Critical Components

- Government authoritative sources are often stove-piped, and organizations are reluctant to share data.
- When data sharing is possible, limited documentation and incompatible schemas often make analysis difficult.
- Unclassified, open source, publicly available data can fill in gaps and identify vulnerabilities.



Open Source Data Is Often Undervalued Compared to Government Authoritative Sources

- Contracts and Subcontracts
- Sanction and Entity Lists
- SEC Filings
- Board/Personnel Activity
- Ownership/Investment Transactions
- Joint Ventures, VC, Angel, Post IPOs
- Patents
- Grants
- Commercial Earning Calls
- Business Locations
- M&A Activity
- Legal Filings/ Bankruptcy
- Budget Exhibits
- Contract Acquisition Management Packages
- Manufacturing Facilities

Open Source Data Considerations

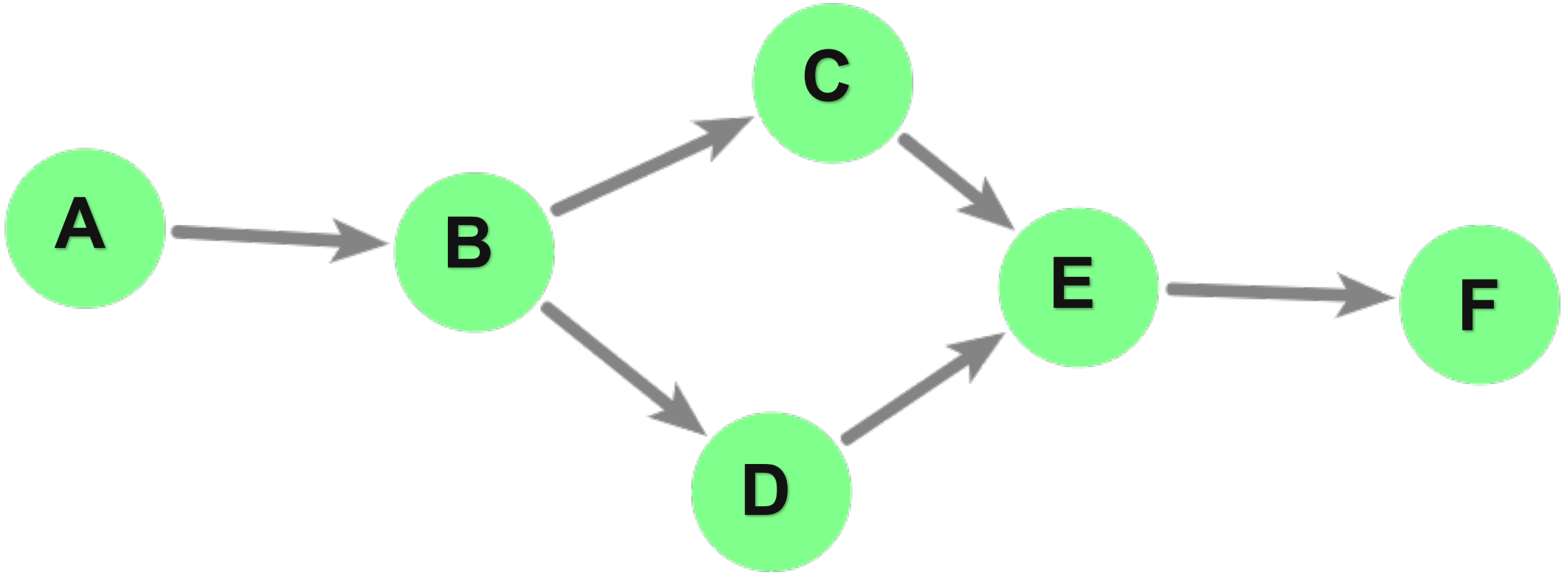
- Refresh is easy, data is more likely to be regularly updated.
- Schema/Documentation is more available, but connecting data sources is challenging.
- Data sources are often not designed to support defense analysis, so flexibility is key.
- Pivot and adapt to use the same or related data to answer multiple questions of interest.

Reproducibility Is Key in Supporting Adaptable Analyses

Methods such as version control and markdown are commonly used to enhance the reproducibility of analyses.

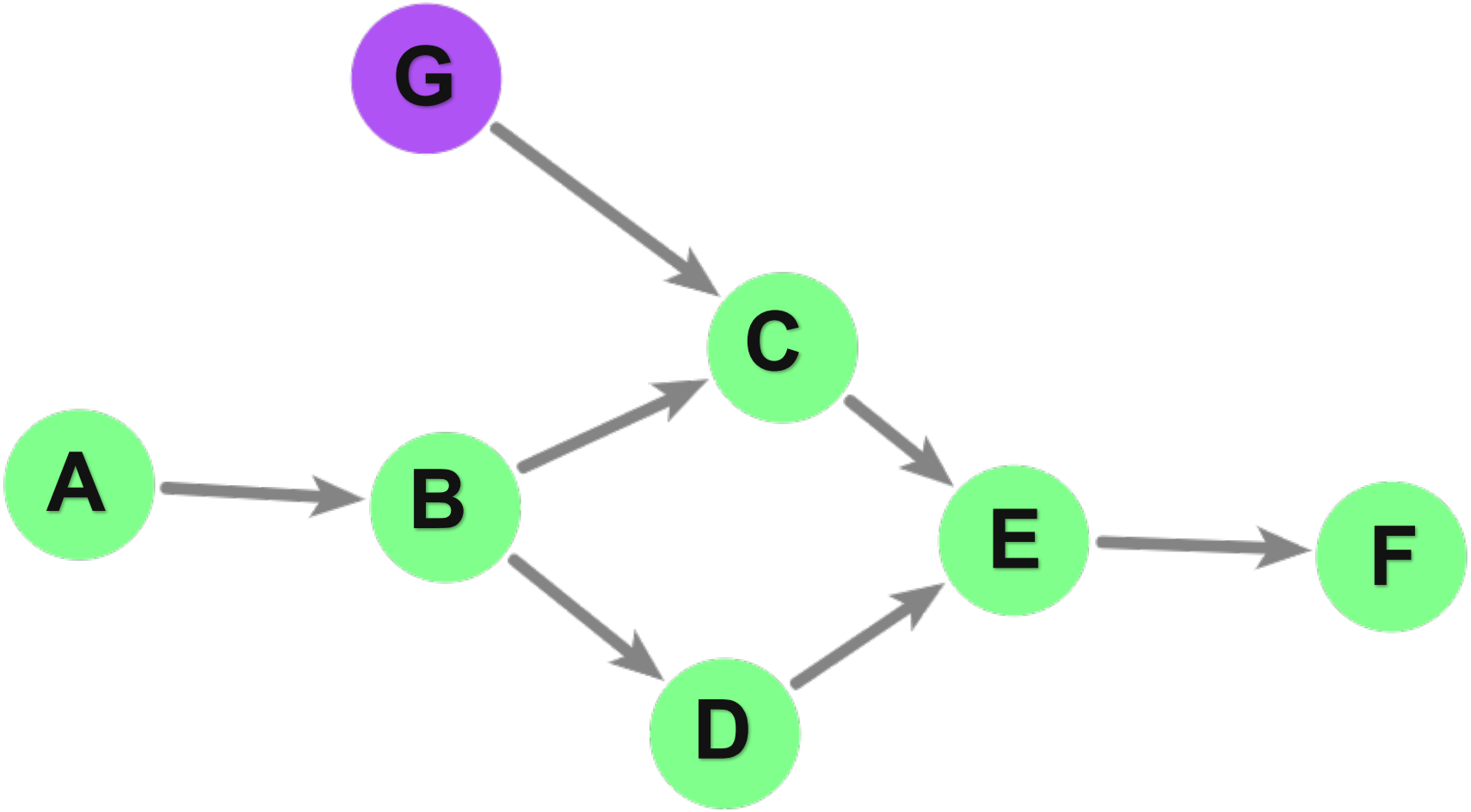
However, reproducibility alone is not enough to allow for adaptability. We must also be able to incorporate new data and transformations to rapidly and effectively respond to senior leader needs.

Data Pipeline: Directed Acyclic Graph



Each node represents an action or transformation performed on the data in a particular order, taking into account dependencies

Data Pipeline: Directed Acyclic Graph



The pipeline can be transparently modified to include an additional data source or transformation.

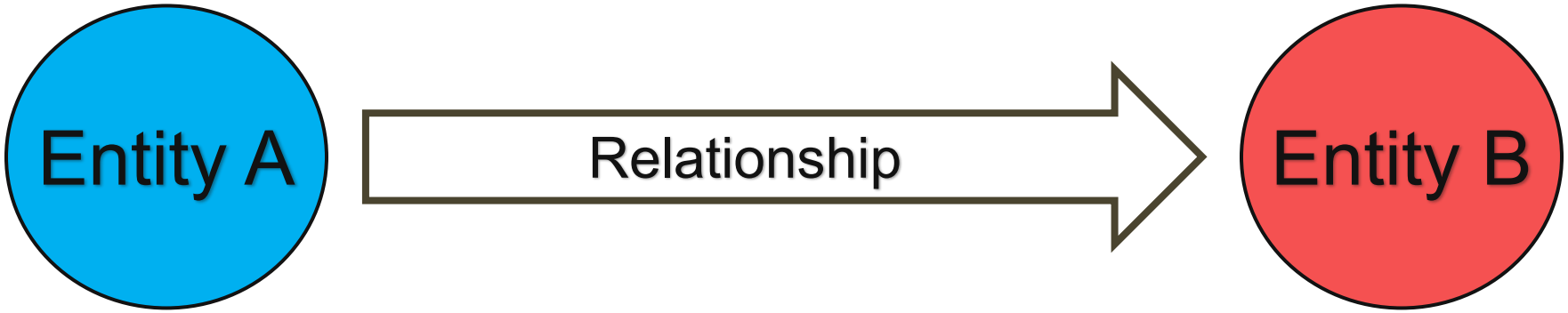
A Data Pipeline Is a Capability, Not a Tool

Many software options exist – remaining tool-agnostic prevents platform lock-in, since different solutions may be more appropriate for different problems.

Apache Airflow

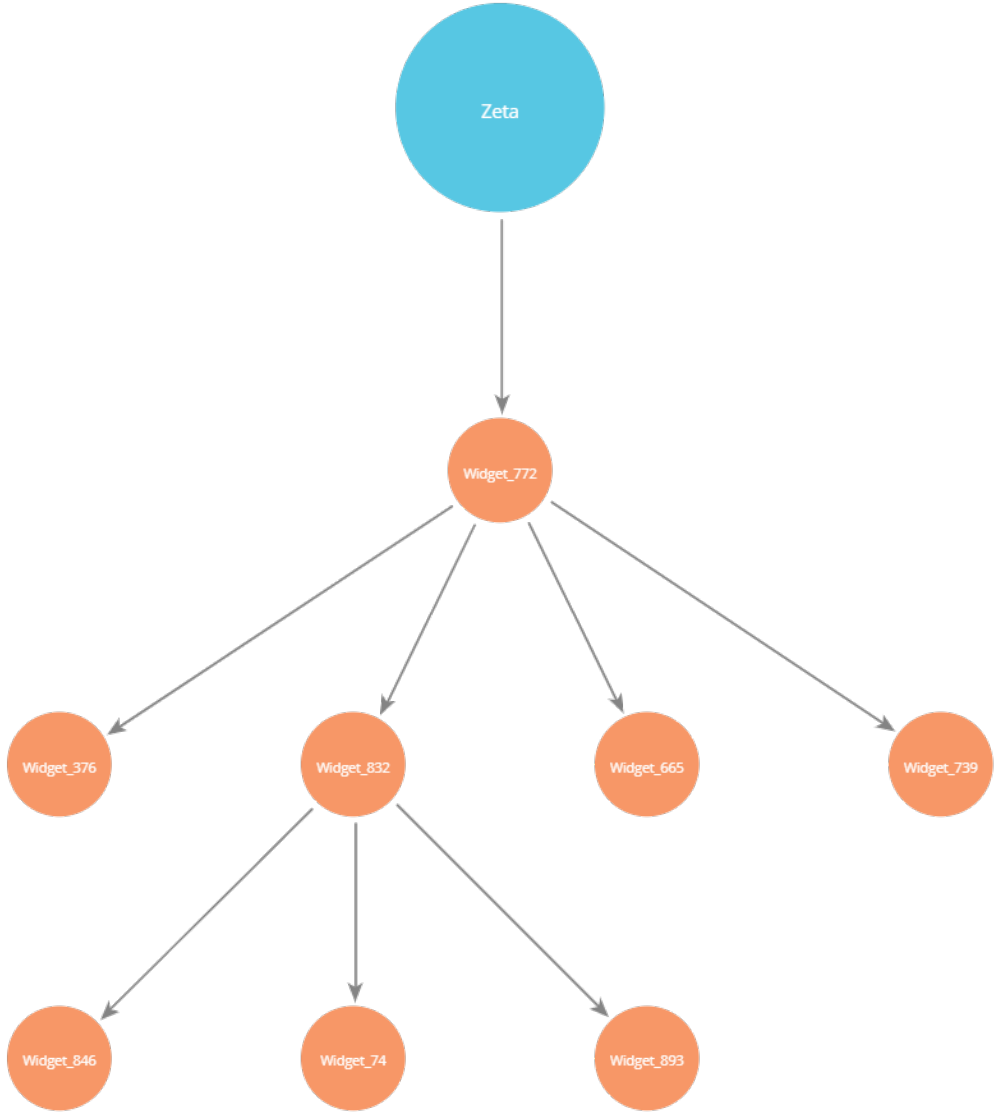
Luigi Pipeline Example Dependency Graph

Many Forms of Data Are Naturally Graphical and Can Be Described with Relationships and Entities

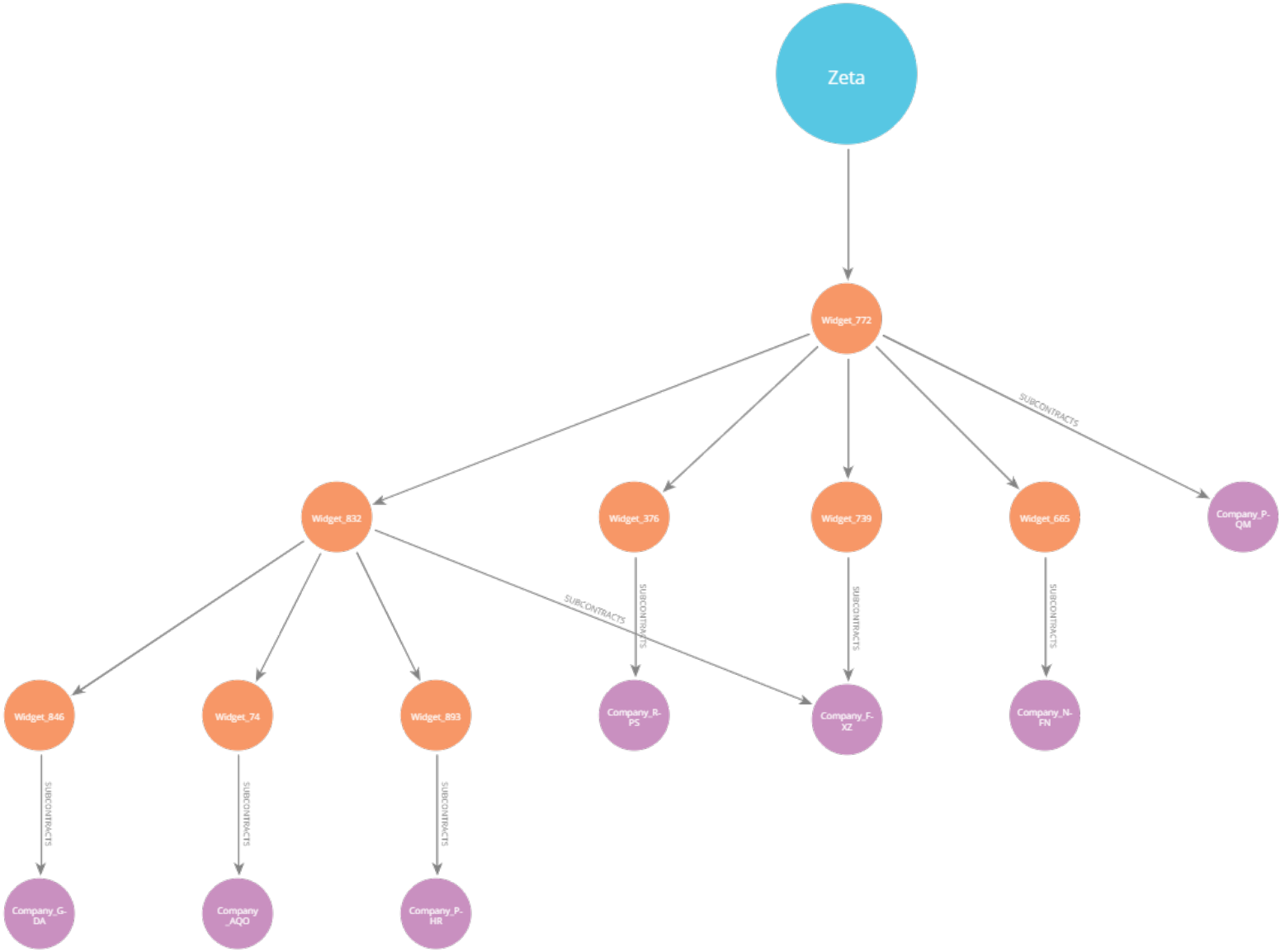


Storing data graph-natively rather than in a SQL-like relational database allows for easier network-style queries.

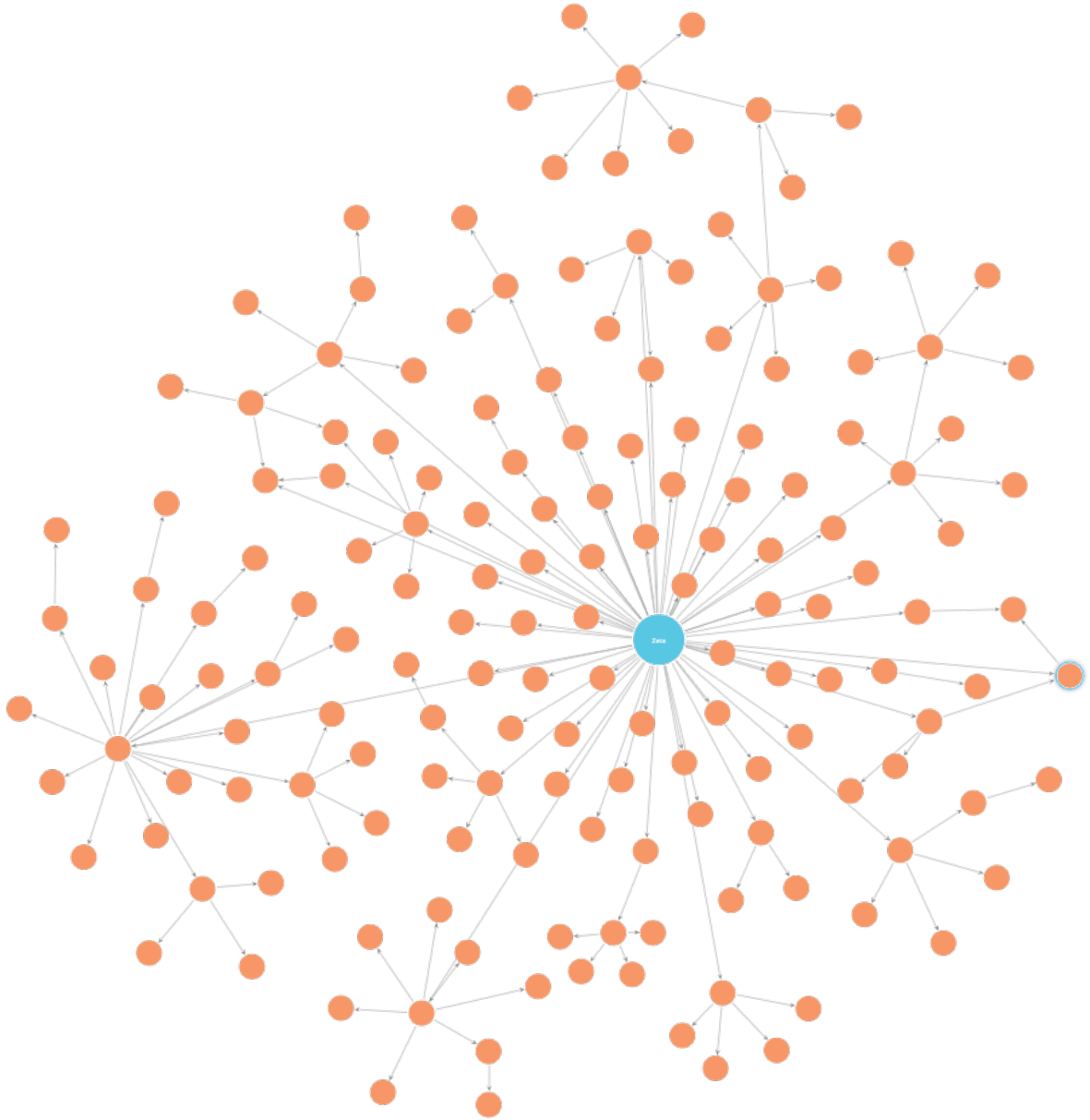
Components and Subcomponents Are Hierarchically Structured and Tied to a System of Interest



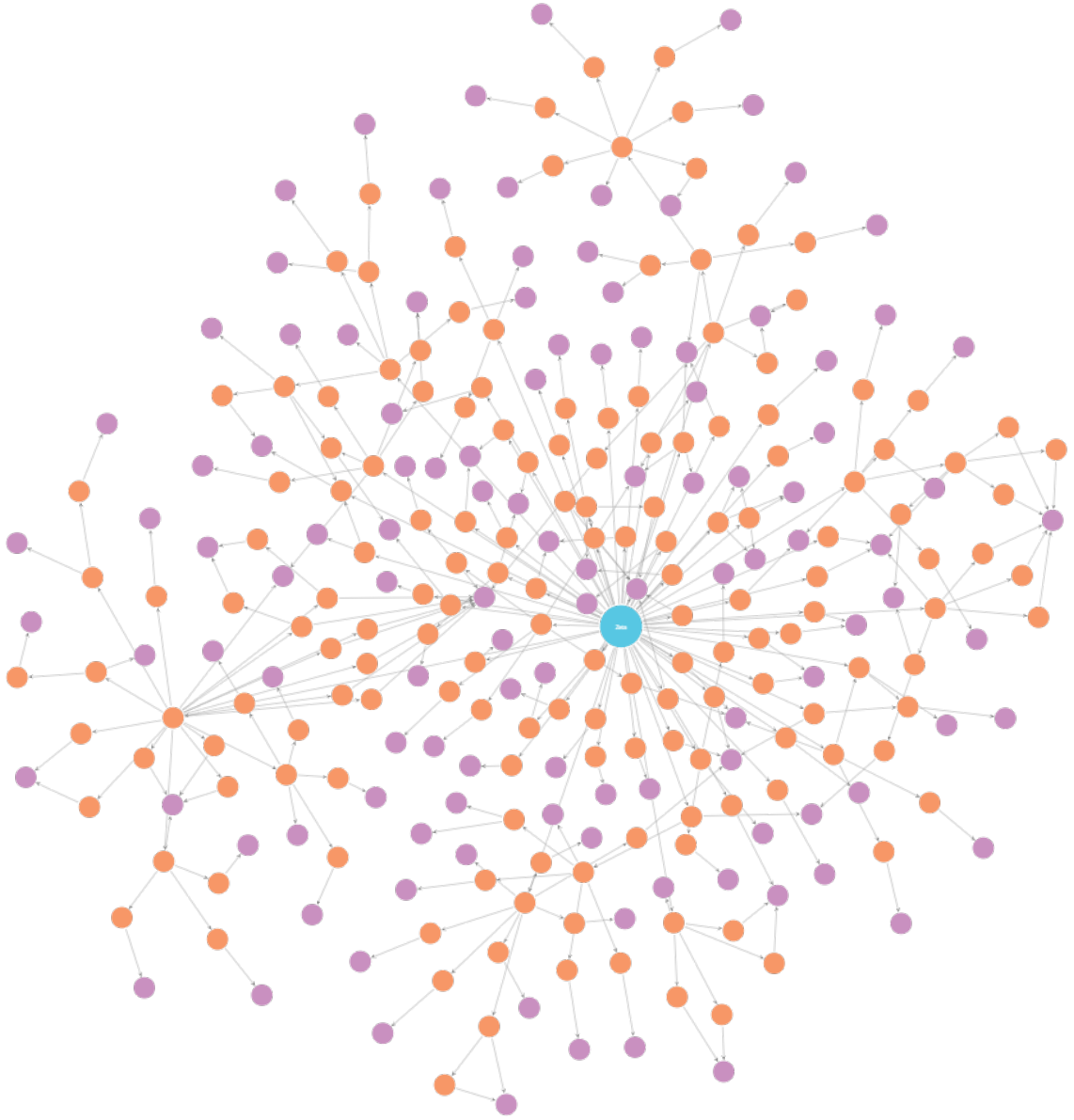
Components and Subcomponents Are Linked to Their Respective Suppliers



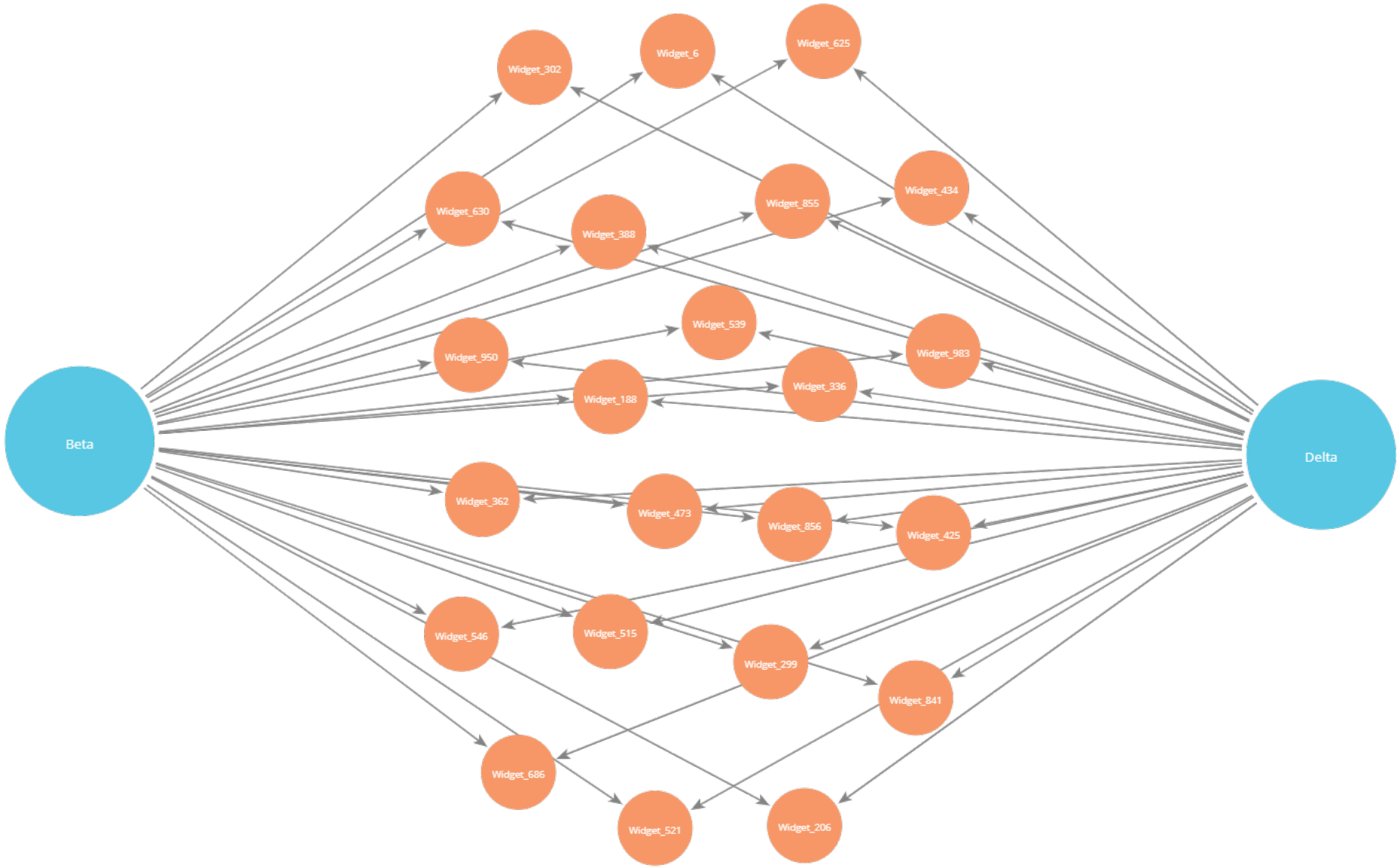
Expansion of the Components and Subcomponents for a System of Interest



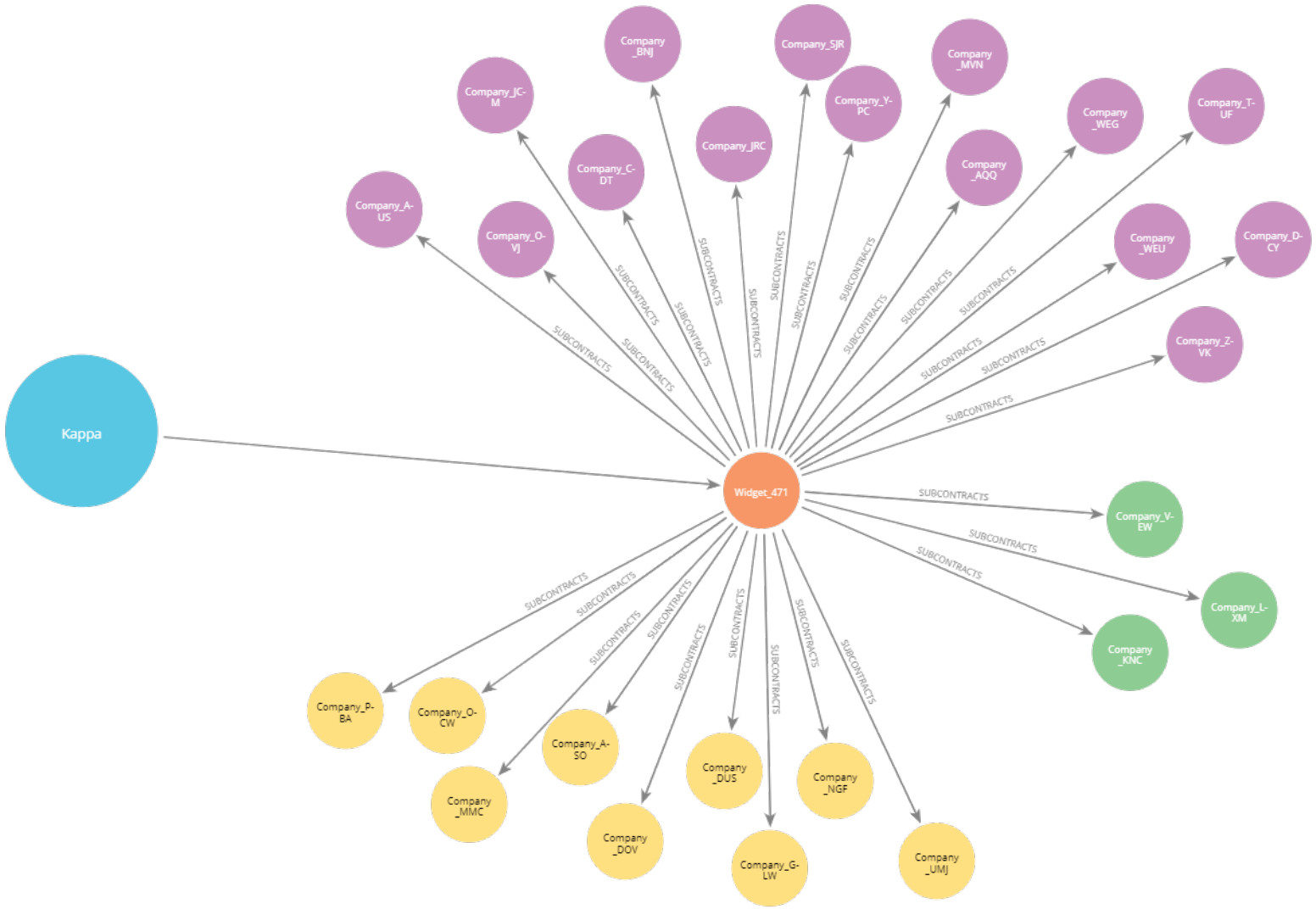
Expansion of the Components, Subcomponents, and Suppliers for a System of Interest



Components Shared Between Multiple Systems of Interest



Suppliers Are Categorized Using Contract Period of Performance Metadata

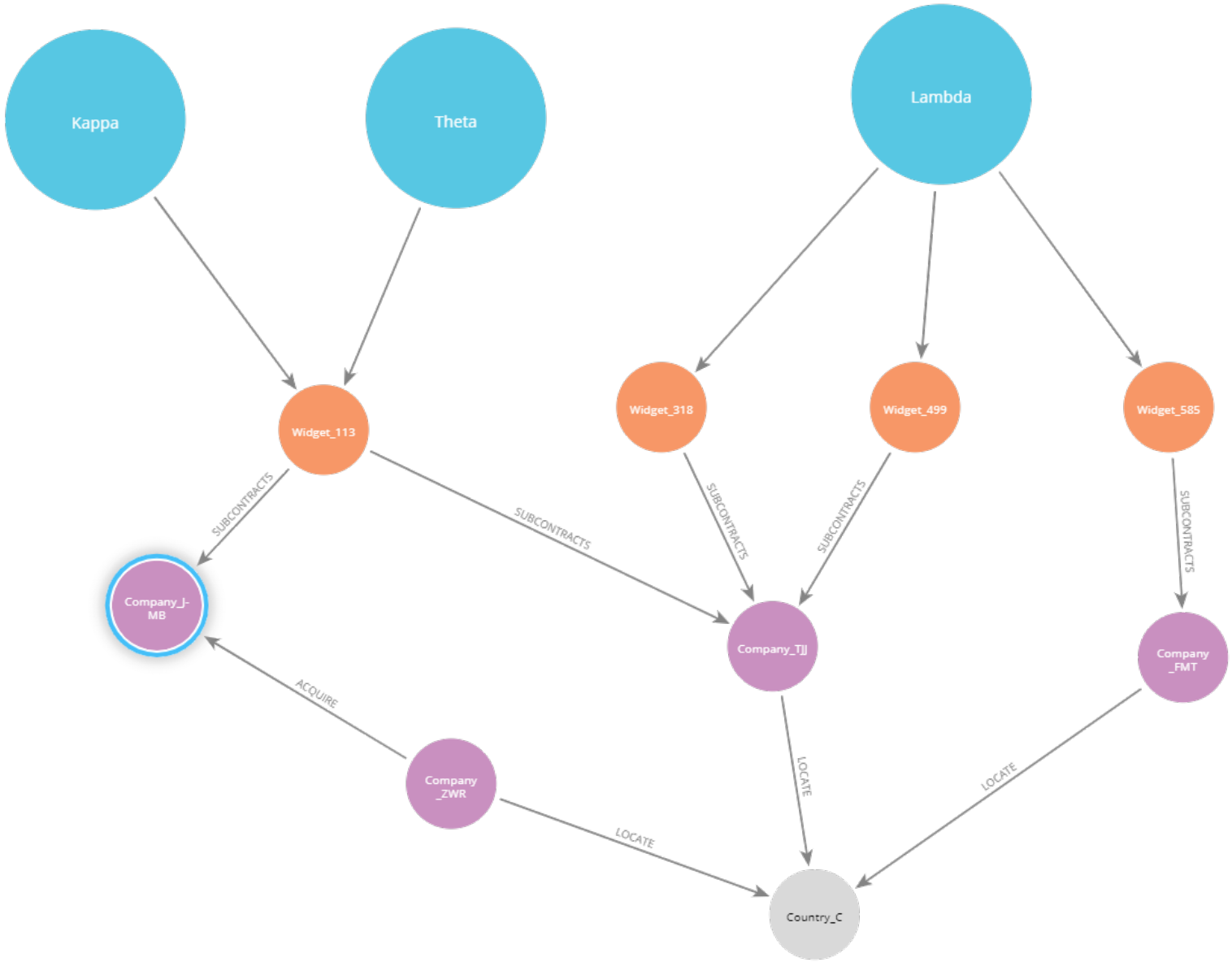


Block I: 2007-2011

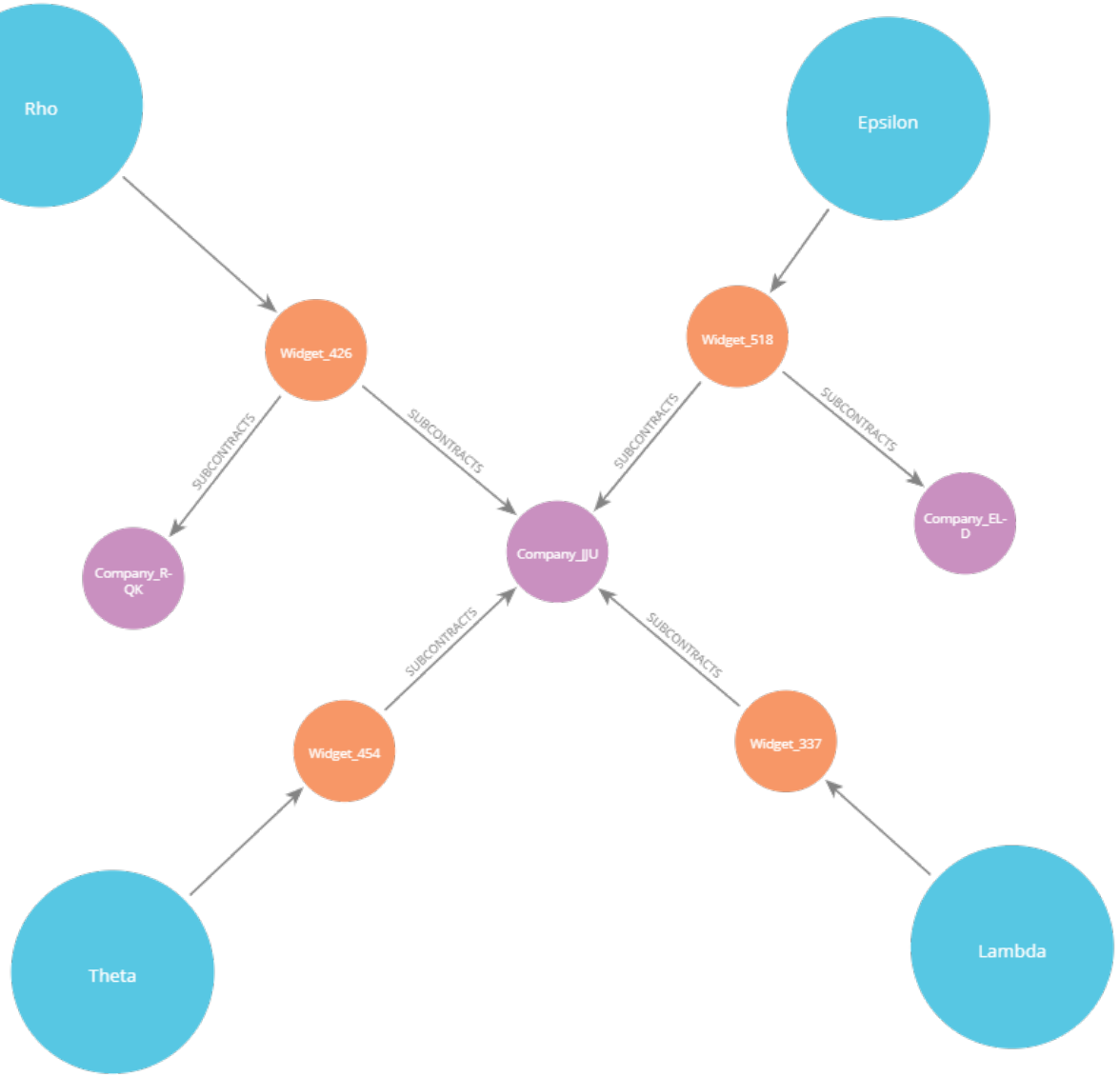
Block I and Block II

Block II: 2013-2017

Merger and Acquisition Activity in the Set of Suppliers



Shared Suppliers Between Multiple Programs of Interest



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Project Leader: Zedekiah P. Fashena

14. ABSTRACT

The DoD maintains a broad array of systems, each one sustained by an often complex supply chain of components and suppliers. The ways that these supply chains are interlinked can have major implications for the resilience of the defense industrial base as a whole and the readiness of multiple weapon systems. Finding opportunities to improve overall resilience requires gaining visibility of potential weak links in the chain, which requires integrating data across multiple disparate sources. By using open-source data pipeline software to enhance reproducibility, as well as flexible network analysis methods, multiple stovepiped data sources can be brought together to develop a more complete picture of the supply chain across systems.

15. SUBJECT TERMS

Supply chain, graph, network, data pipeline

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