Development of a Part Criticality Index in Inventory Management

Clint Saidy, Liudas Panavas, Ramy Harik, Abdel Bayoumi, Joseph

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INTRODUCTION

Clint Saidy
PhD Student

Ramy Harik
Assistant Professor

Liudas Panavas

- University of South Carolina McNair aerospace center
- Sophomore undergraduate
- Mechanical engineering

- Talk about what we are going to talk about – outline of presentation

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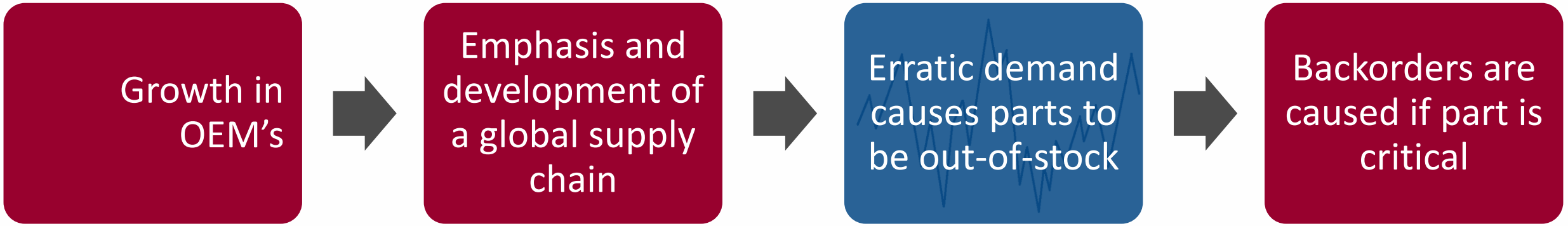
INTRODUCTION



Solution

Optimize restocking process using the concept of part criticality

OBJECTIVES

Determine

- the **parameters** that are the most important in **determining part criticality**.
- the most critical part in order to monitor its **availability in the inventory.**

Ensure

- that inventory is **dynamically evolving**
- a high level of **customer satisfaction**
- the solution is **cost effective**.

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ECONOMIC IMPACT

- Bullwhip Effect
- Backlogs
- Costs

- Cooperation between supplier and manufacturer
- Customer satisfaction

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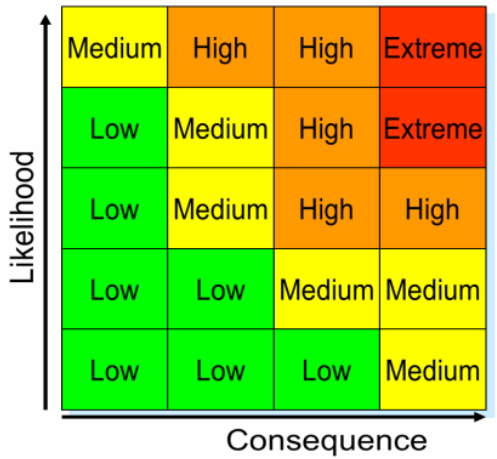
BACKGROUND/LITERATURE

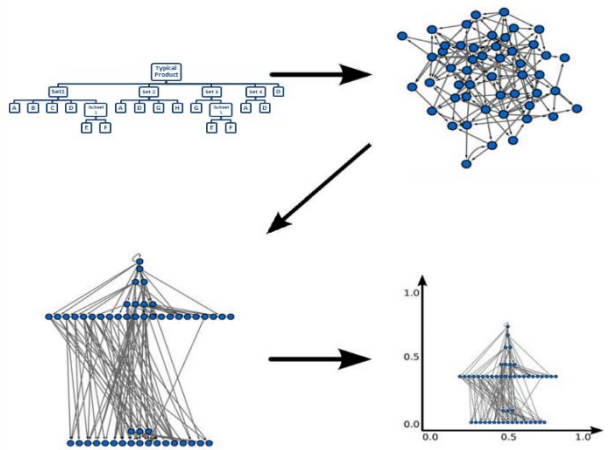
Spare Part Criticality

- Classification of criticalness of parts using **likelihood of failure and consequence of failure**



Hierarchy in complex relationship

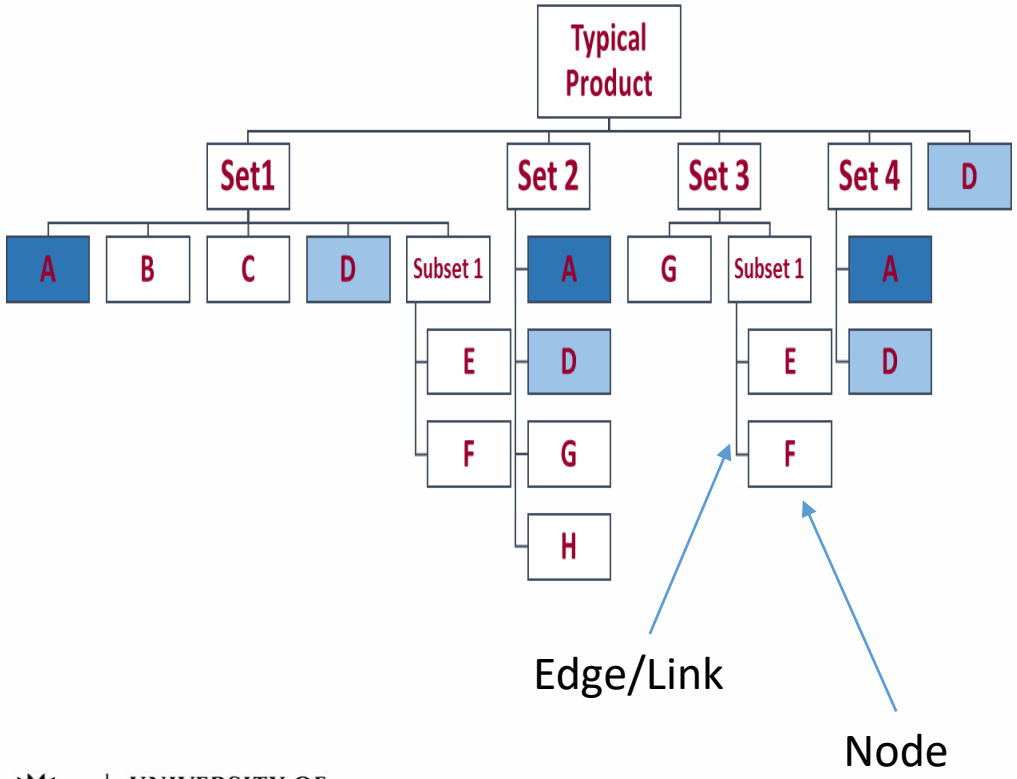
- Mones et al. uses nodes and edges to describe **fundamental features of complex systems**



Gap

No system in place to identify criticalness of parts in the complex system of a product

METHODOLOGY



1 Local Influence

LI(i) is the proportion of all nodes in the graph that can be reached from node i via incoming edges to i:

$$LI(i) = \frac{\#\ of\ direct\ child\ links}{Total\ \#\ of\ links}$$

2 Max Local Influence

We designate LI^{max} as the highest Local Influence:

$$LI^{max} = \max_{i \le N-1} LI(i)$$

3 Part to Part Influence

Thus, we can calculate the part to product influence (PPI):

$$PPI = \frac{\sum_{i \in V(j)} [LI^{max} - LI(i)]}{N-1}$$

(V(j) denotes the set of nodes in the network composing Product j)

4 Global Influence

The global influence of a part in a product can be calculated as follows:

$$GI(i) = \sum_{V(j)} [LI(i)]$$

5 Product Influence

PD(j) and BH(j) are the weighted average of demand and backlog over a 40 week horizon for product j respectively.

Then, the product influence PI is calculated:

$$PI = PD * BH * PPI$$

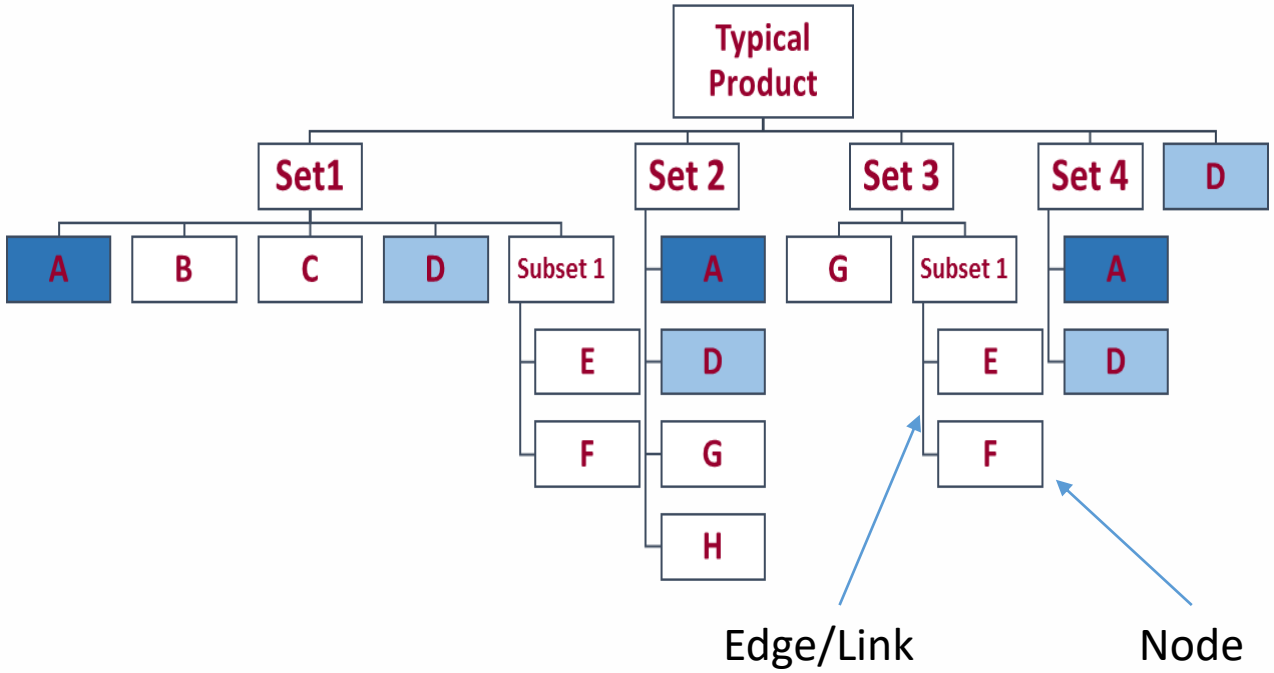
6 Comp. Global Influence

Finally calculate the compound global index for each part:

$$CGI(i) = \sum_{j} GI(i) * PI(j)$$

The most critical part has the highest CGI.

METHODOLOGY



1 Local Influence

LI(i) is the proportion of all nodes in the graph that can be reached from node i via incoming edges to i:

$$LI(i) = \frac{\#\ of\ direct\ child\ links}{Total\ \#\ of\ links}$$

- # of direct child links is 1 for all parts in our product
- Calculates relative importance of each individual part

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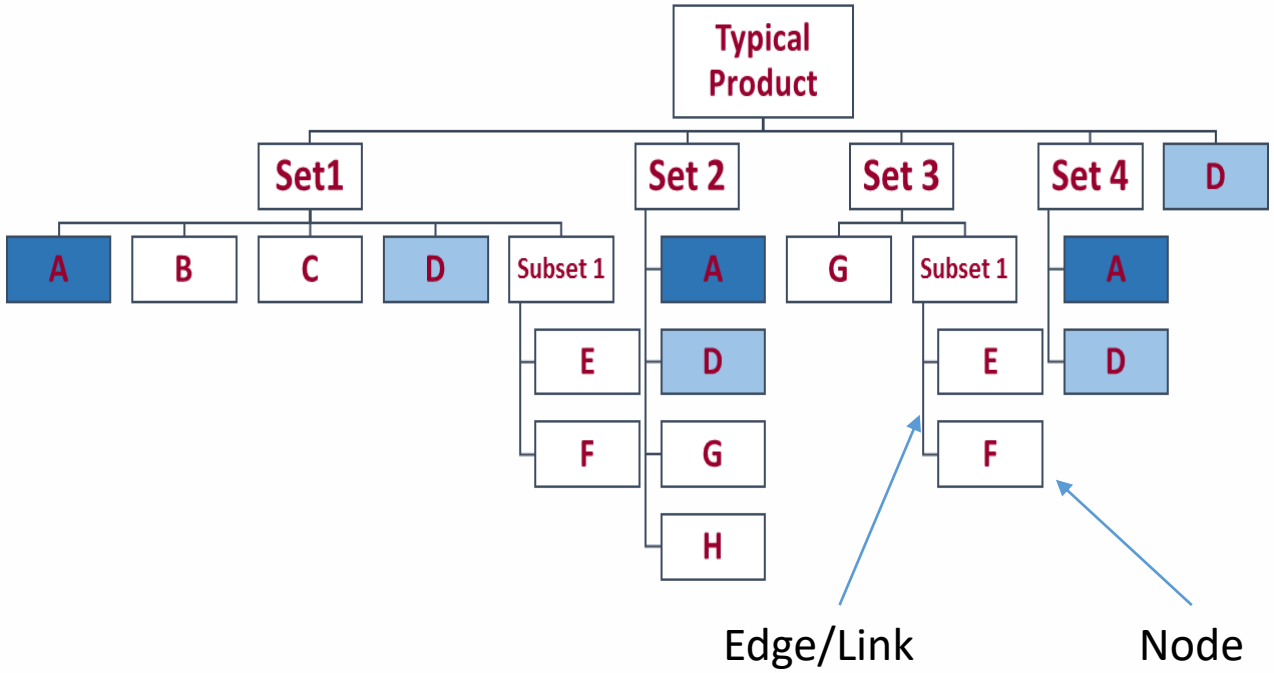
METHODOLOGY



2 Max Local Influence

We designate LI^{max} as the highest Local Influence:

$$LI^{max} = \max_{i \leq N-1} LI(i)$$

- Calculates which part has the largest local influence
- Will be used to normalize results when comparing different products

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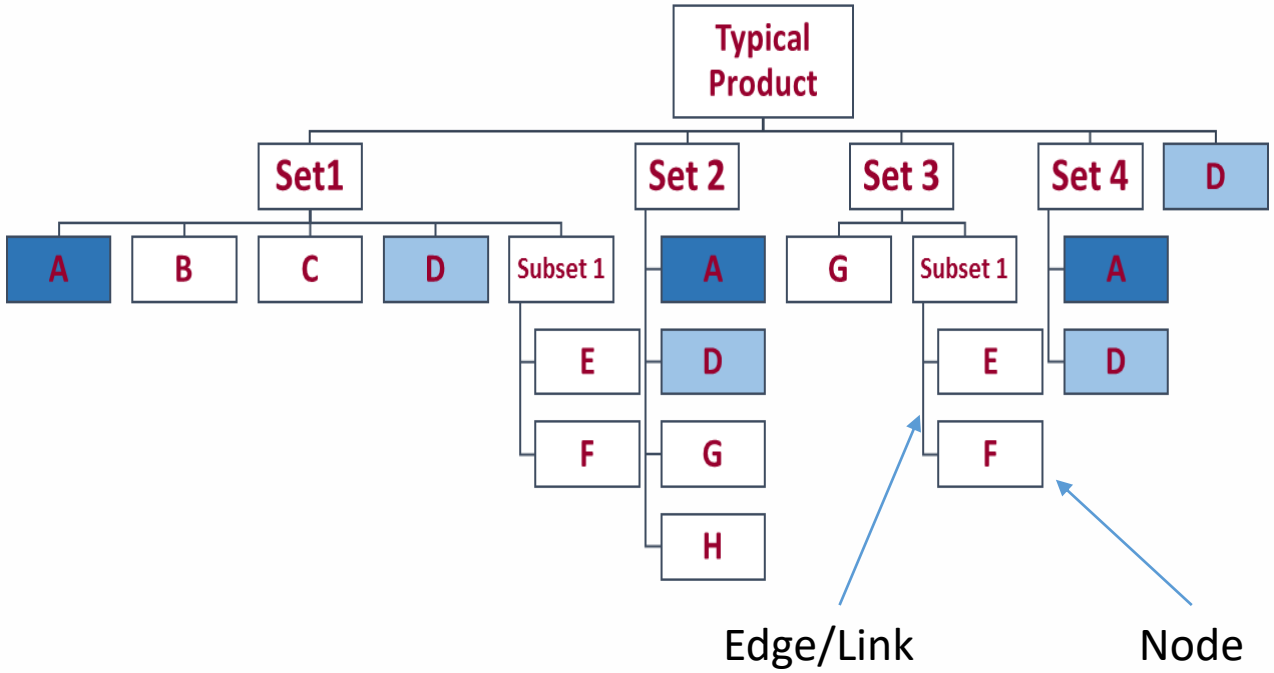


3 Part to Part Influence

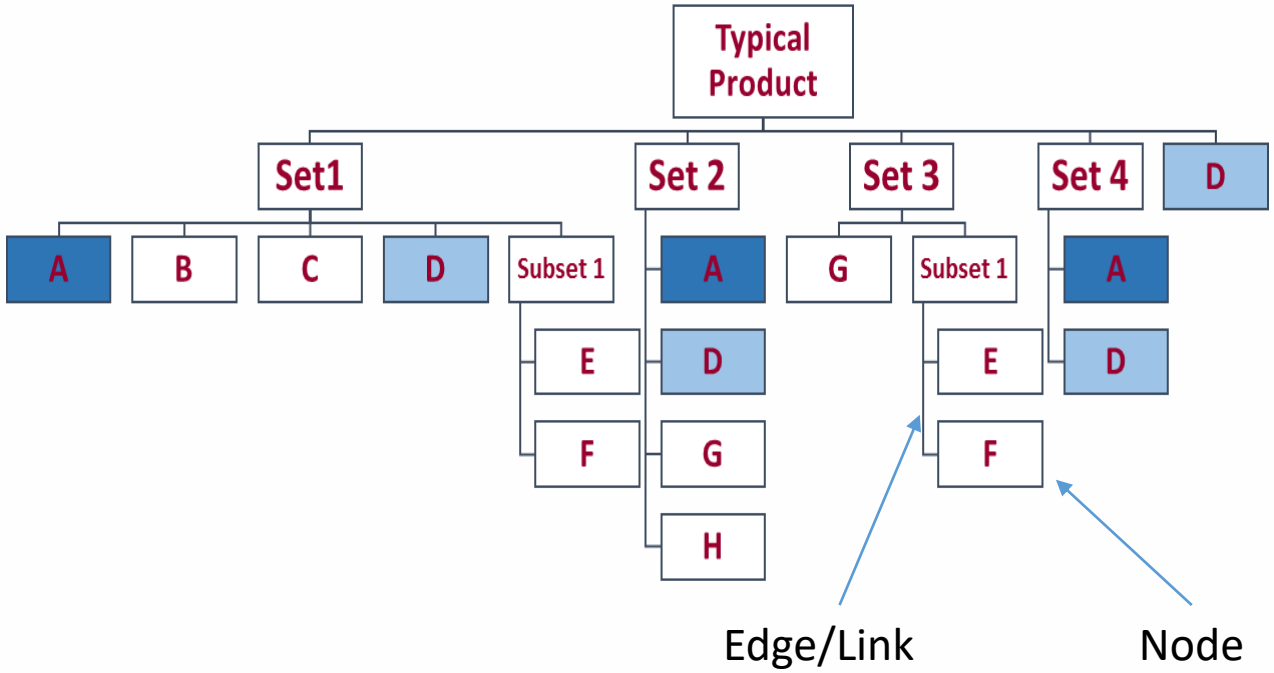
Thus, we can calculate the part to product influence (PPI):

$$PPI = \frac{\sum_{i \in V(j)} [LI^{max} - LI(i)]}{N - 1}$$

(V(j) denotes the set of nodes in the network composing Product j)

- Allows for the comparison of the same part in different products

METHODOLOGY



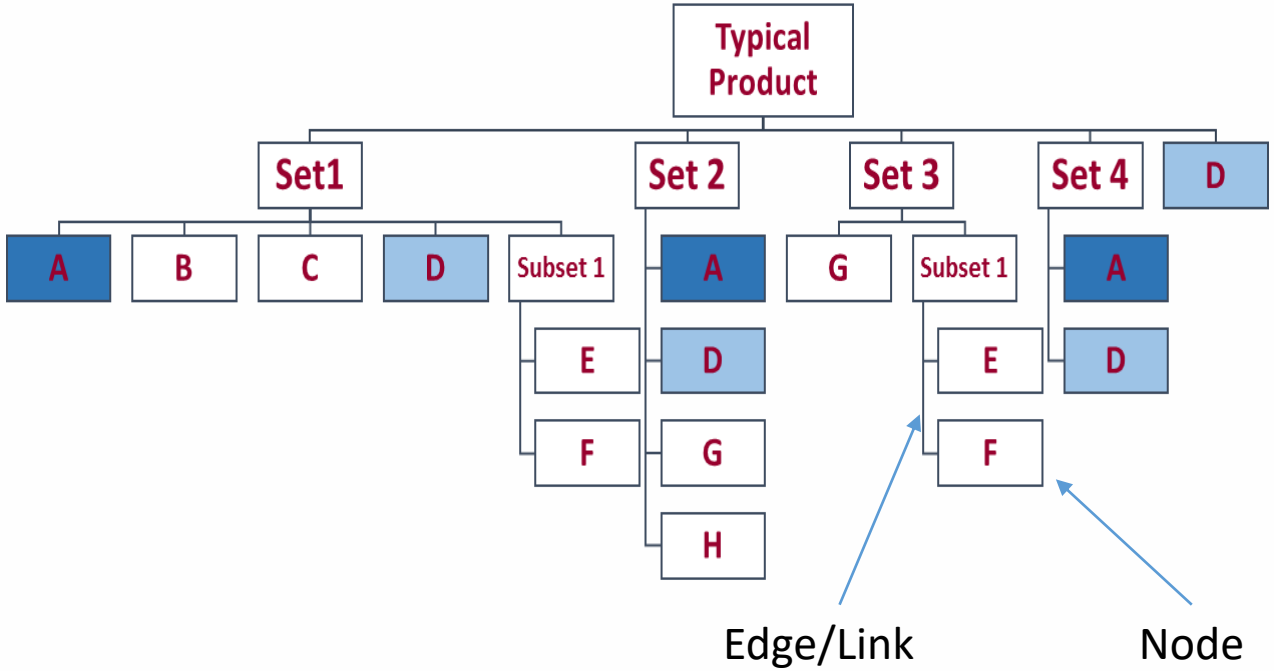
4 Global Influence

The global influence of a part in a product can be calculated as follows:

$$GI(i) = \sum_{V(j)} [LI(i)]$$

- Calculates the cumulative importance of each part in a product

METHODOLOGY



Week	Demand	Supply	Inventory	Backlog
1	10	9	0	1
2	9	10	0	0
3	10	9	0	1
4	10	12	1	0
5	11	10	0	0
6	9	8	0	1
7	10	12	1	0
8	9	12	4	0

5 Product Influence

PD(j) and BH(j) are the weighted average of demand and backlog over a 40 week horizon for product j respectively.

Then, the product influence PI is calculated:

$$PI = PD * BH * PPI$$

- Demand and supply constant stochastic values
- Determines which products are most critical by examining product demand, backlog, and part to part influence

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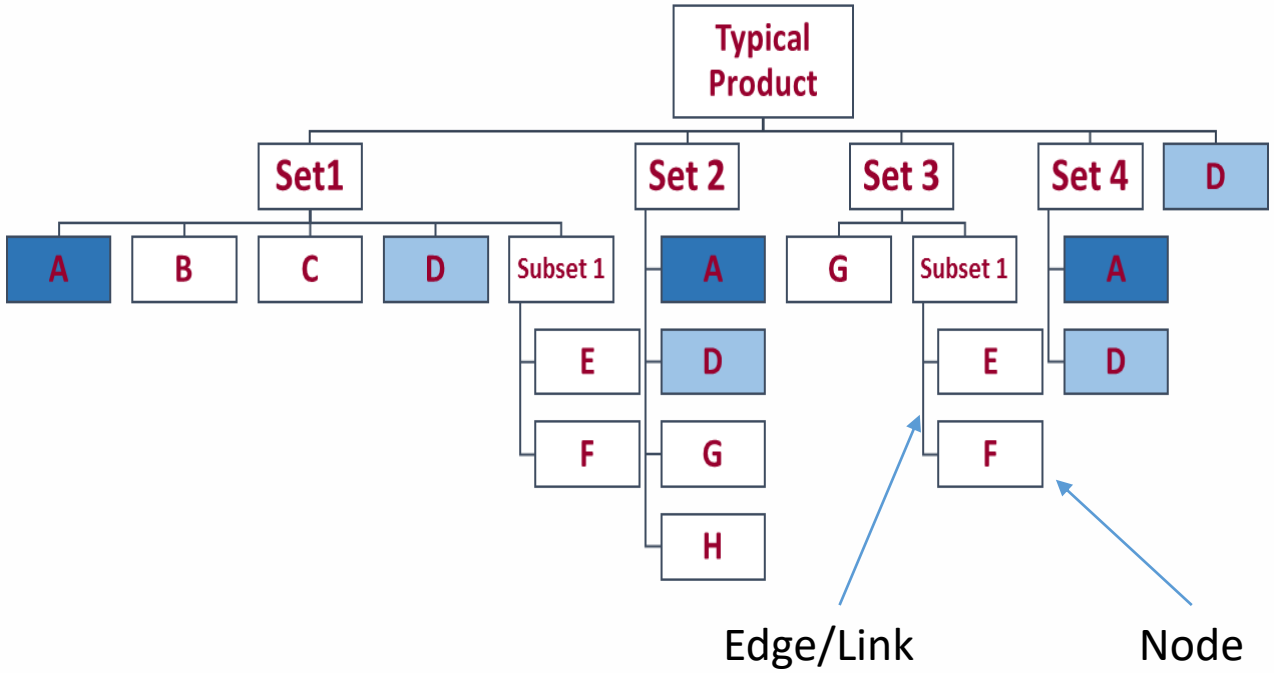

6 Comp. Global Influence

Finally calculate the compound global index for each part:

$$CGI(i) = \sum_j GI(i) * PI(j)$$

The most critical part has the highest CGI.

- Connects part criticality to product criticality
- Identifies most important part across all products

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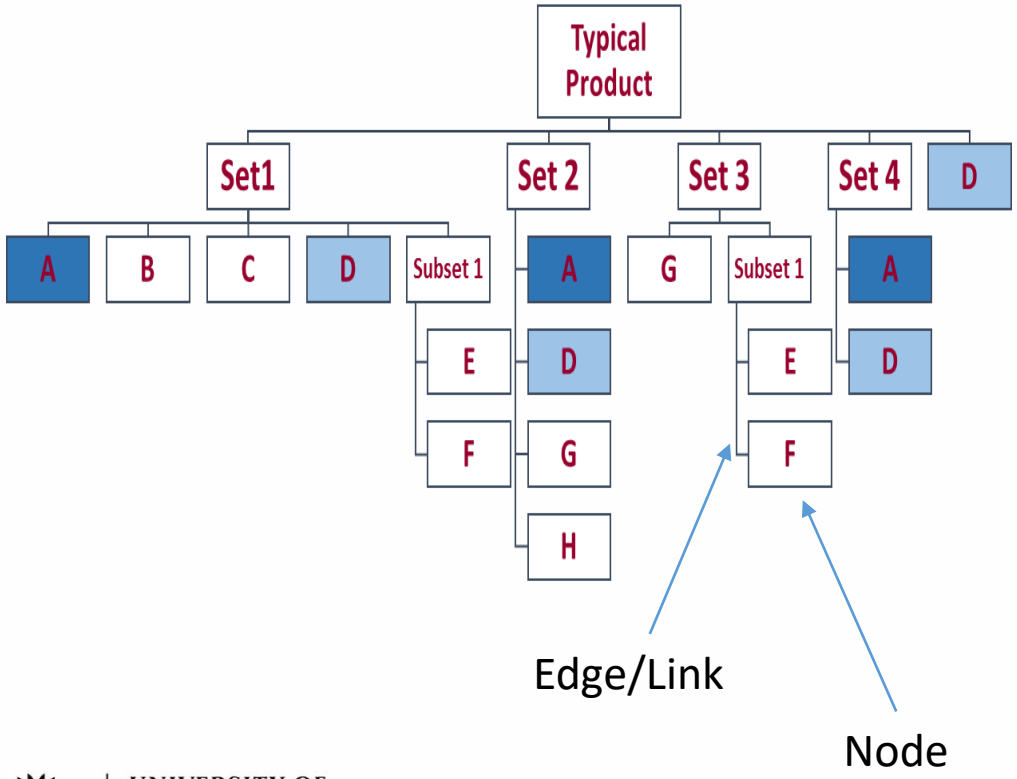

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The most critical part has the highest CGI.

RESULTS

- Short run - The highest Compound Global influence **varies depending on run**

Part	Run 1	Run 2	Run 3	Run 4	Run 5	Long Run
Set 1	0.0037707 5	0.0155130 6	0.0027851 3	0.0126266 4	0.0097451 7	0.00762882
Set 2	0.0147669 1	0.0087029 2	0.0063884 3	0.0101218 3	0.0136005 1	0.01741808
Set 6	0.0147669	0.0004902	0.0036951 4	0	0.0118145 8	0.00638000
Set 7	0.0147669	0.0004902	0.0036951 4	0	0.0118145 8	0.00638000
Subset 1	0.0037707	0.0155130	0.0054784 2	0.0147391 8	0.0106516 7	0.01095505
A	0.0336402	0.0340810	0.0217905 7	0.0330991 6	0.0372055 5	0.04400146
B	0.0037707	0.0237257	0.0027851 3	0.0206359 3	0.0106245 8	0.01534066
D	0.0223084	0.0479417	0.0146519 8	0.0454969 5	0.0348767 8	0.04371381
E	0.0037707	0.0155130	0.0054784 2	0.0147391 8	0.0106516 7	0.01095505
F	0.0076533	0.0314087	0.0076360 5	0.0253295 6	0.0195767 9	0.01576854
G	0.0147669	0.0087029	0.0090817 2	0.0122343 8	0.0145070 2	0.02074432
H	0.0148787	0.0090855	0.0084542 1	0.0101981 2	0.0136869 6	0.01792899
J	0.0147669	0.0087029	0.0036951 4	0.0080092 9	0.0126940 0	0.01409185
L	0.0148787	0.0008728	0.0057609 2	7.63E-05	0.0119010 4	0.00689090
M	0.0334164	0.0168612	0.0095479 1	0.0105903	0.0325542	0.01757349
N	0.0443007	0.0014706	0.0110854 3	0	0.0354437 6	0.01914000 8
O	0.0223084	0.0315163 6	0.0038788 3	0.0210281 9	0.0294919 1	0.01498517

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RESULTS

- Short run - The highest Compound Global influence **varies depending on run**
  - Demand and supply are random variables
- No definitive results for most important part

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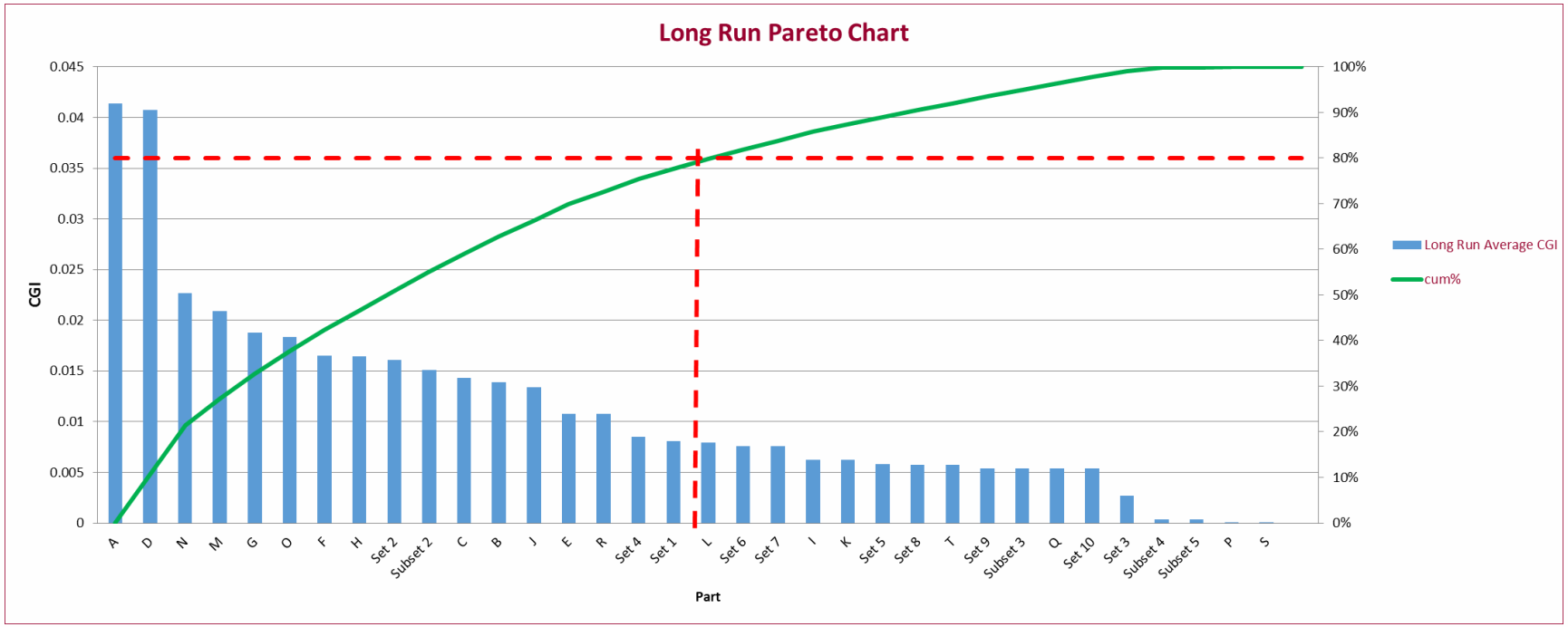
RESULTS

- Long run – **One part** consistently has the **highest criticality**
  - Random variables associated with supply and demand are normalized
- Pareto chart helps display cumulative importance of parts
  - Disobeys the 80/20 rule



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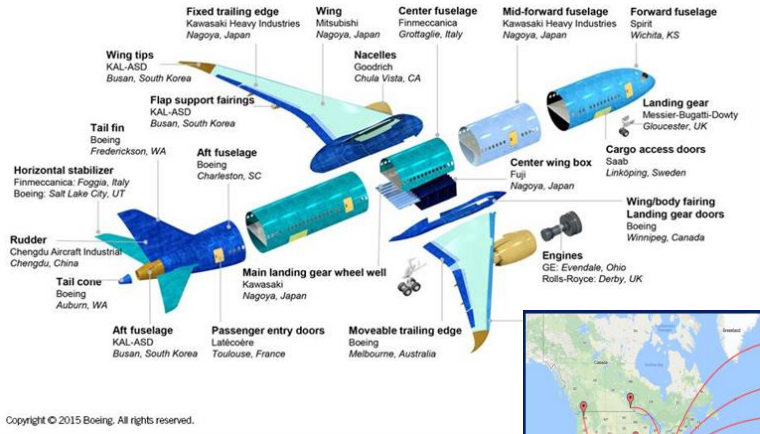
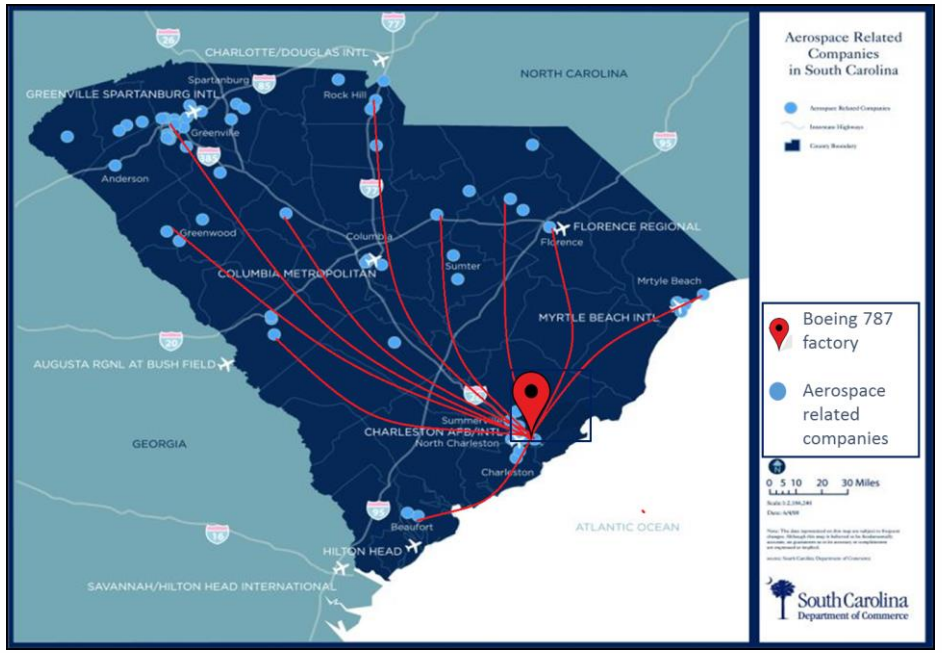
INDUSTRY SIGNIFICANCE

- Companies such as Boeing have to ship parts from **all over the world** to create a product
- Missing part can cause **long delays** in the assembly process



- Having a local manufacturer would **reduce time it takes to receive parts**
- **Symbiotic relationship** helping OEM and local manufacturers



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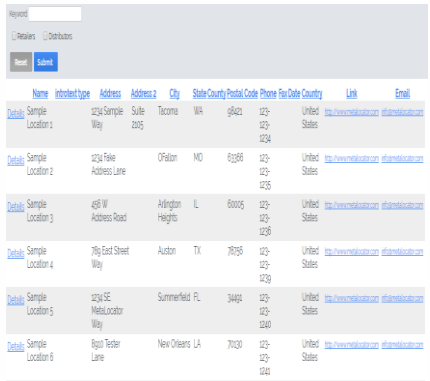
BIG PICTURE



Local part manufacturer database

Algorithm finds critical parts

Relationship is built with manufacturer that can supply critical parts

Critical part missing on assembly line

Order placed for part

Part delivered quickly and assembly can continue

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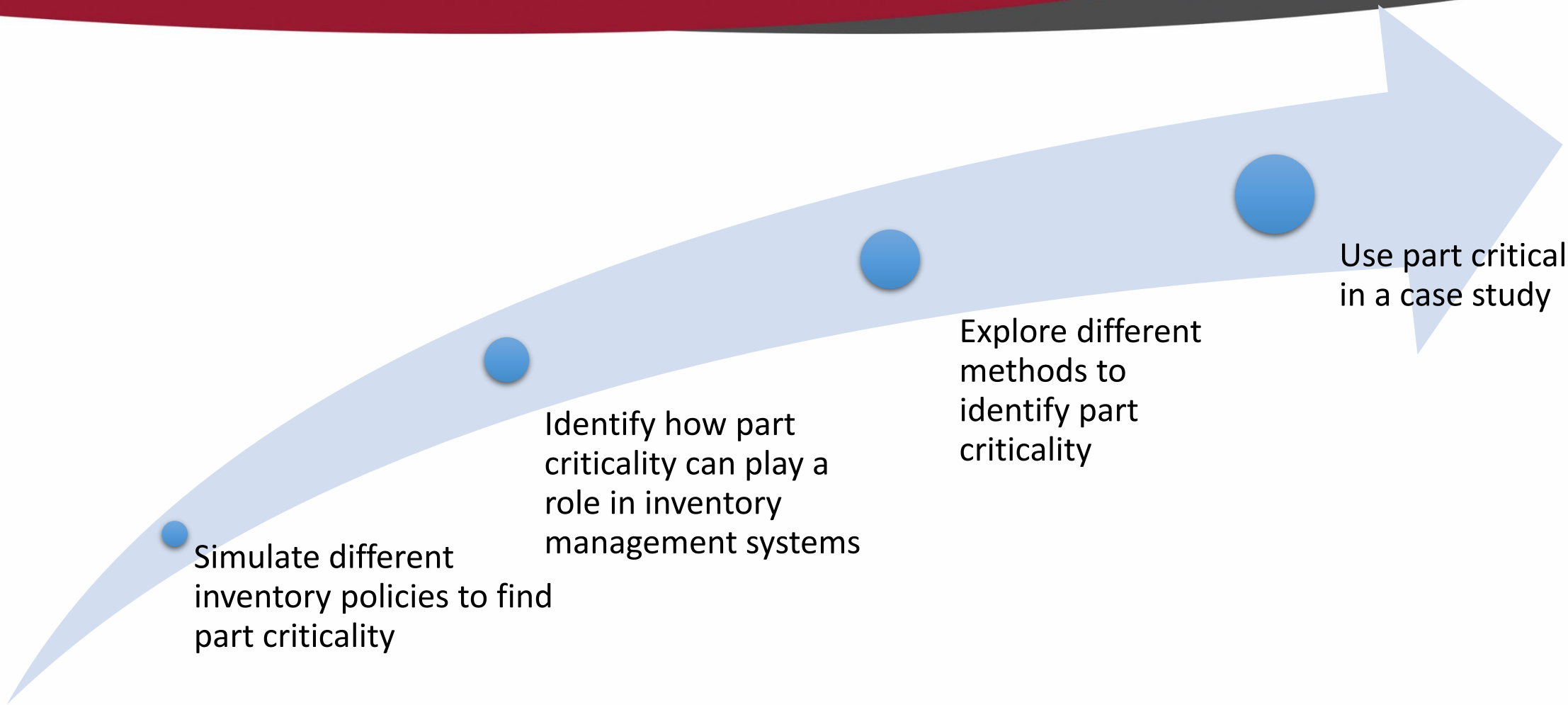
PLM Connection

- Helps create **better data transfer**
  - Product structure needs to be in certain format for algorithm to work
- Part criticality can be applied to other times in the product life cycle
  - Which parts break most often/need replacements
  - Similar to **spare parts criticality**
- Increased **demand on suppliers for performance** and quality
  - Important to choose the best possible supplier for timing and quality

NEXT STEPS



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Thank you for coming and your attention

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