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Architecture Analysis Methods

Agenda

1) Background

2) Challenges

3) Conceptual Foundations

4) Analysis Methods

5) Concluding Remarks

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Background

Systems are becoming more and more complex

White, 2005

Communities of Interest
Collaboration Nets

Systems of systems

Net Centric Operation
Network Enabled Capability

Network centric systems

System Architecture
Business process

analysis

Multi-Missions

Distributed systems

Mission

System Engineering

Platform centric systems

Equipment based systems

System integration

Jean-Luc Garnier, Thales Corporation

It is established that Architecture as a discipline helps address this Complexity

Architecture Evaluation Landscape

| Evaluation	Methods	Standards	Assessment	Analysis
Qualitative	SAAM	ISO/IEC/IEEE 42020	AQA	Resource Usage
Quantitative	ATAM	ISO/IEC/IEEE 42030	QUASAR	Response Time
Informal	CBAM		Value	Business Latency
Quality Attributes	ALMA		Estimates	Workload
	FAAM		Tradeoffs	Failure frequency

Considerable effort needs to be expended by Architects for Analysis/Evaluation/Assessment

There is very little Technology support for Analyzing Architectures

- **Architecture Standards**
  - 42020 (Published in 2019)
  - 42030 (Published in 2019)

- **Evaluation Approaches**
  - Quantitative, Qualitative, Informal

- **Analysis Methods**
  - Scenario based, Cost based, Characteristics based

- **Assessments**
  - Value, Quality, Estimates, Gaps, Tradeoffs

- **Nature of Analysis**
  - Resource, Response, Workload, Failures, Failure Effect

Work product of Architecting

Content View

Activity View

Logical View

Device View
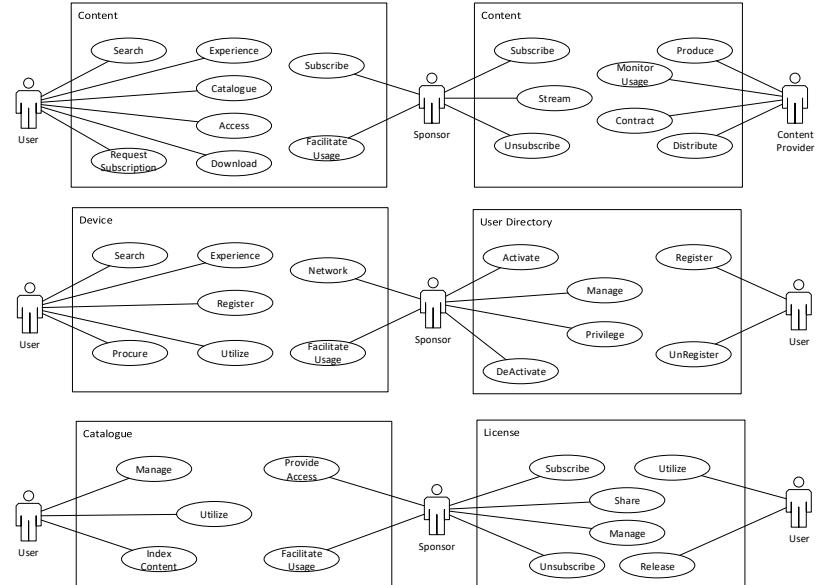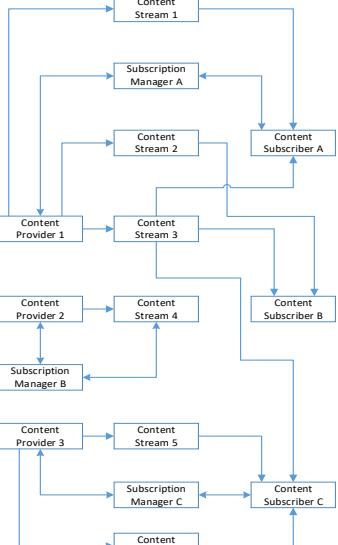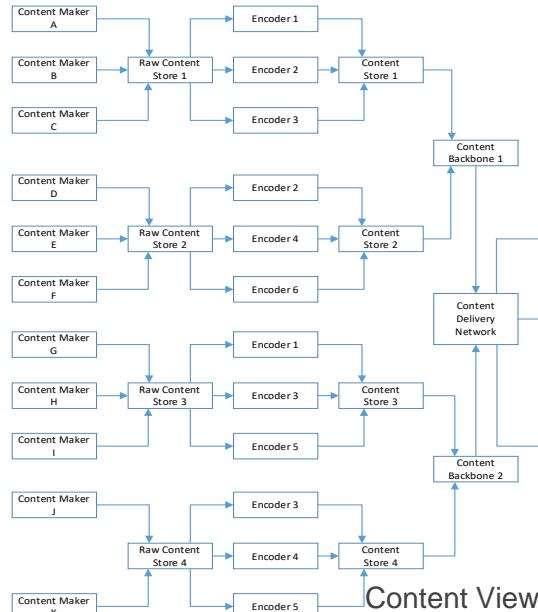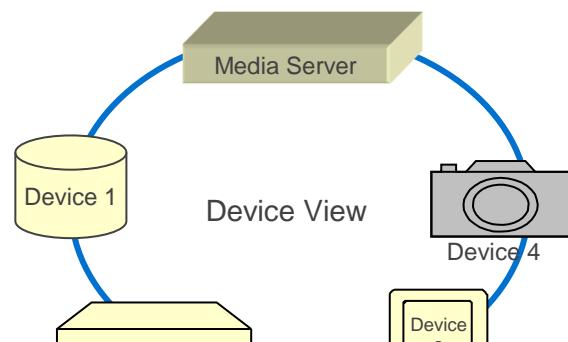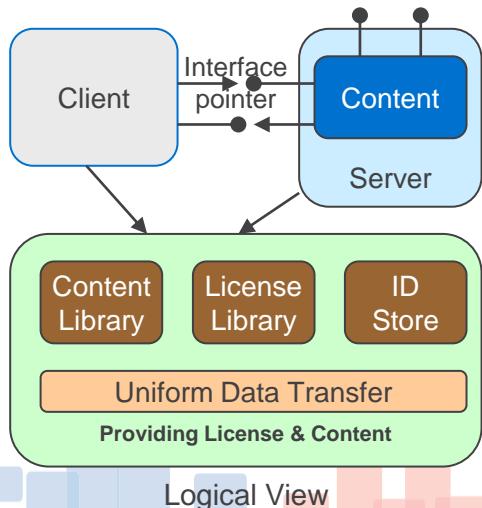
Kernel View

It is very difficult to identify the different architecture characteristics from these views
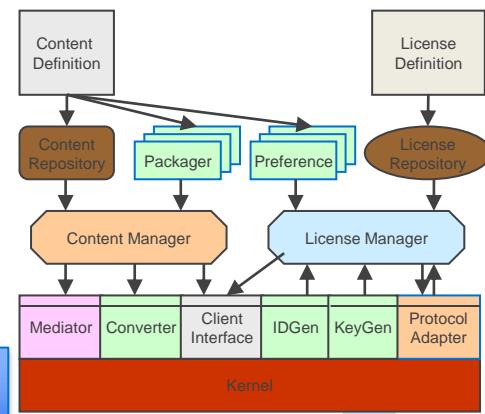
Challenges

Typical Evaluation Questions

Does the architecture of the system of interest aid in fulfilling its purpose?

What are the risks that needs to be mitigated?

What are the opportunities for improving the architecture?

Are all the requirements addressed and is there enough traceability?

What are the stakeholder concerns that are addressed by the architecture?

What is the progress made towards achieving the architecture objectives?

What are the architecture principles adhered by the architecture?

What are the architecture and system characteristics that are addressed?

What are the defects introduced by the architecture?

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Conceptual Foundations

ISO/IEC/IEEE 42020 – Architecture Evaluation Process

1) Prepare for and plan the architecture evaluation effort

2) Monitor, assess and control the architecture evaluation activities

3) Determine evaluation objectives and criteria

4) Determine evaluation methods and integrate with evaluation objectives and criteria

5) Establish measurement techniques, methods and tools

6) Collect and review evaluation-related information

7) Analyze architecture concepts and properties and assess stakeholder value

8) Characterize architecture(s) based on assessment results

9) Formulate findings and recommendations

10) Capture and communicate evaluation results

ISO/IEC/IEEE 42030 – Architecture Evaluation

Context of Architecture Evaluation

Architecture Evaluation Work Products

Architecture Entity — situated in → Environment

Stakeholder — has an interest in → Architecture Entity

Stakeholder → Architecture

Architecture — characterizes

Architecture Evaluation Plan — guides → Architecture

Stakeholder < defined as Concern

Architecture Evaluation — determines the value of → Architecture

Architecture Evaluation — addresses → Concern

Architecture Evaluation — produces → Architecture Evaluation Report

Evaluation Tier

Evaluation Factor — frames → Concern

Evaluation Objective — addresses → Concern

Evaluation Factor — is relevant to → Evaluation Objective

Evaluation Objective — drives → Evaluation Approach

Evaluation Approach — specifies

Evaluation Approach — produces → Evaluation Result

Evaluation Result — influences → Architecture Evaluation Report

Assessment Tier

Assessment Factor — frames

Assessment Factor — is relevant to → Assessment Objective

Assessment Objective — satisfies → Evaluation Objective

Assessment Objective — drives → Assessment Method

Assessment Method — specifies → Evaluation Approach

Assessment Method — produces → Assessment Result

Assessment Result — influences → Evaluation Result

Analysis Tier

Analysis Factor — frames

Analysis Factor — is relevant to → Analysis Objective

Analysis Objective — satisfies → Assessment Objective

Analysis Objective — drives → Analysis Method

Analysis Method — specifies → Assessment Method

Analysis Method — produces → Analysis Result

Analysis Result — influences → Assessment Result

Approach to Evaluating Architectures

Architecture

evaluates

Architecture Evaluation Approach

applies

Value Assessment Method

invokes

Architecture Analysis Method

Architecture Evaluation Objectives

frames

Value Assessment Objectives

supported by

Architecture Analysis Objectives

Evaluation Results

Assessment Criteria

drives

Analysis Criteria

drives
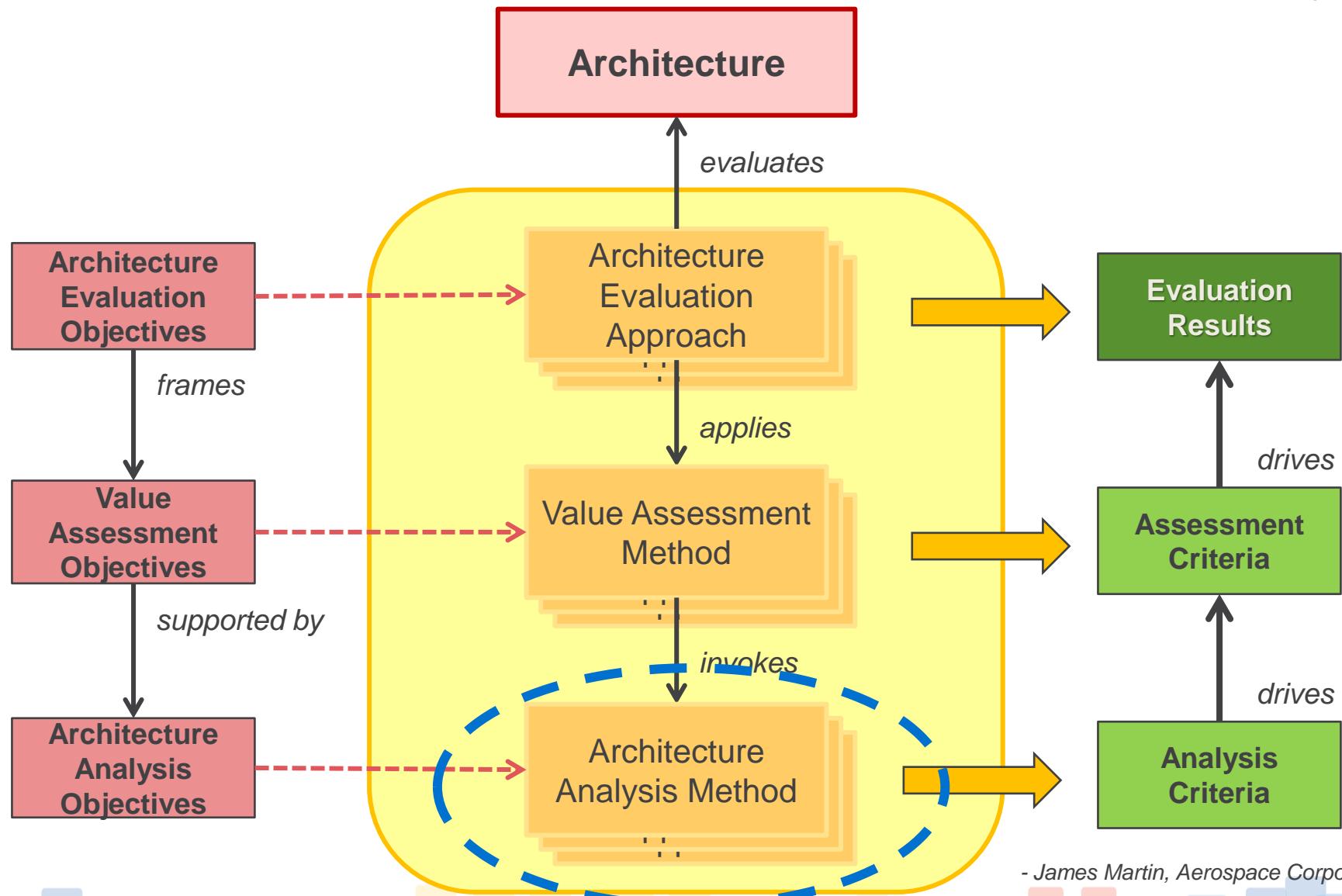
- James Martin, Aerospace Corporation

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Terminology

- **Directed Graph**
  - Set of vertices and a collection of directed edges that each connects an ordered pair of vertices

- **Incidence Matrix**
  - Incidence relationship between two architectural entities expressed in the form of a matrix

- **Adjacency Matrix**
  - Square matrix representing a graph indicating whether pairs of vertices are adjacent

- **Reachability Matrix**
  - Square matrix representing a graph indicating whether one vertex can reach another within a graph

- **Network Analysis**
  - Examination of relationship between entities to understand the underlying structure and behavior

Analysis Methods

Model for Analysis (Archimetal case study)

Source: https://publications.opengroup.org/more-categories/archimate-models/y195m
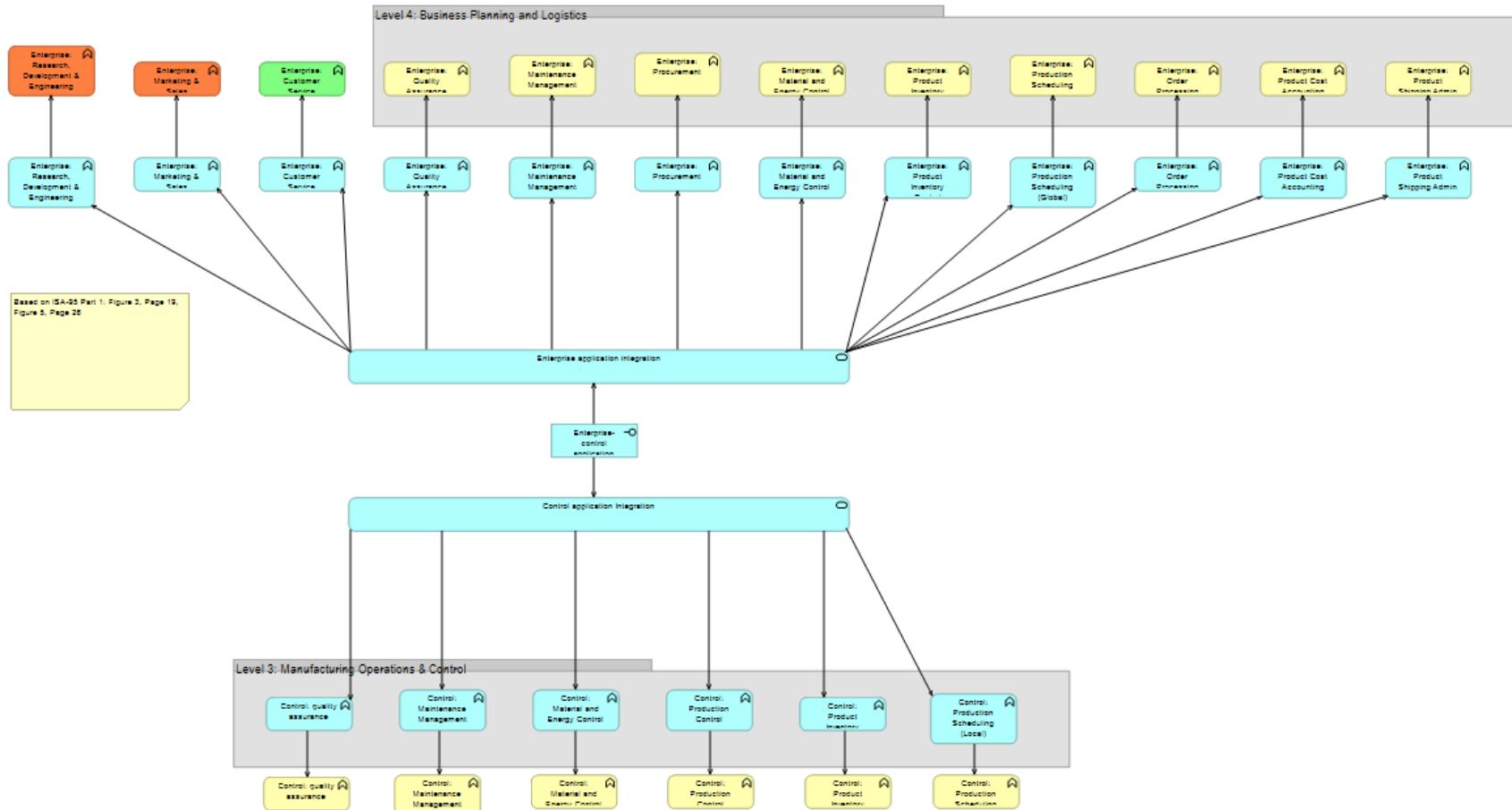
Impact Analysis

Analysis Method:

1. Identify the set of architecture entities and related relations

2. Establish the incidence matrix for these entities and relations

3. Determine the adjacency matrix from the incidence matrix

4. Determine the reachability matrix from the adjacency matrix

5. Impact factor for each entity is the count of non-zero elements in the column corresponding to that entity

6. Indicates the transitive strength of each entity on other entities
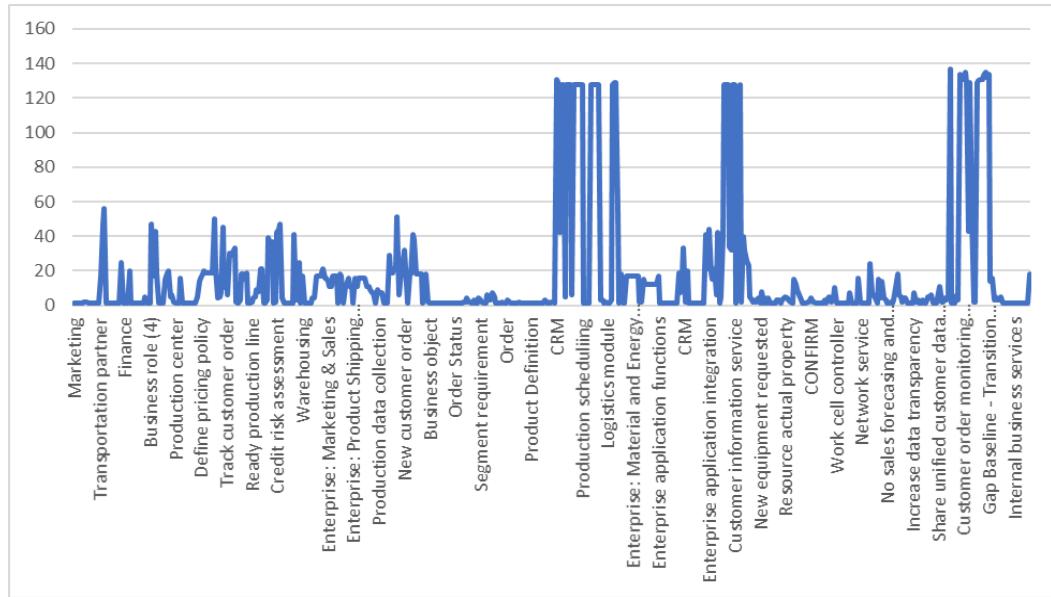
Method applied to the Archimetal Model and the results visualized

Effect Analysis
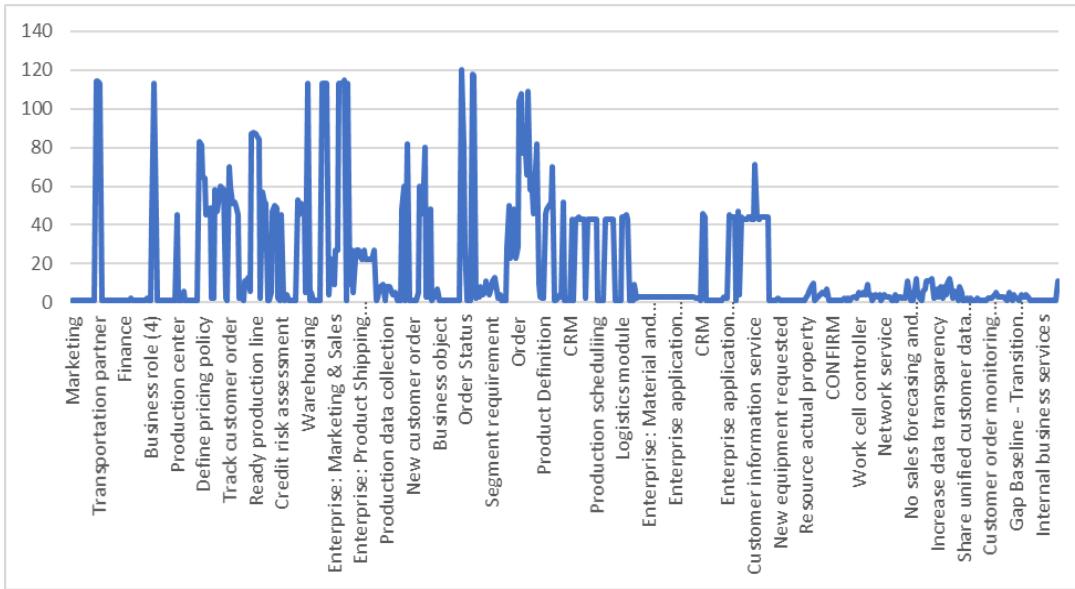
Method applied to the Archimetal Model and the results visualized

Analysis Method:

1. Identify the set of architecture entities and related relations

2. Establish the incidence matrix for these entities and relations

3. Determine the adjacency matrix from the incidence matrix

4. Determine the reachability matrix from the adjacency matrix

5. Impact factor for each entity is the count of non-zero elements in the row corresponding to that entity

6. Indicates the strength of the transitive relationship of the entities

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Cyclic Analysis

Analysis Method:

1. Identify the set of architecture entities and related relations

2. Establish the incidence matrix for these entities and relations

3. Determine the adjacency matrix from the incidence matrix

4. Determine the reachability matrix from the adjacency matrix

5. Cyclic factor is the count of non-zero pair values between an entity and another entity

6. Indicates the strength of the feedback based on transitive relations of the entities
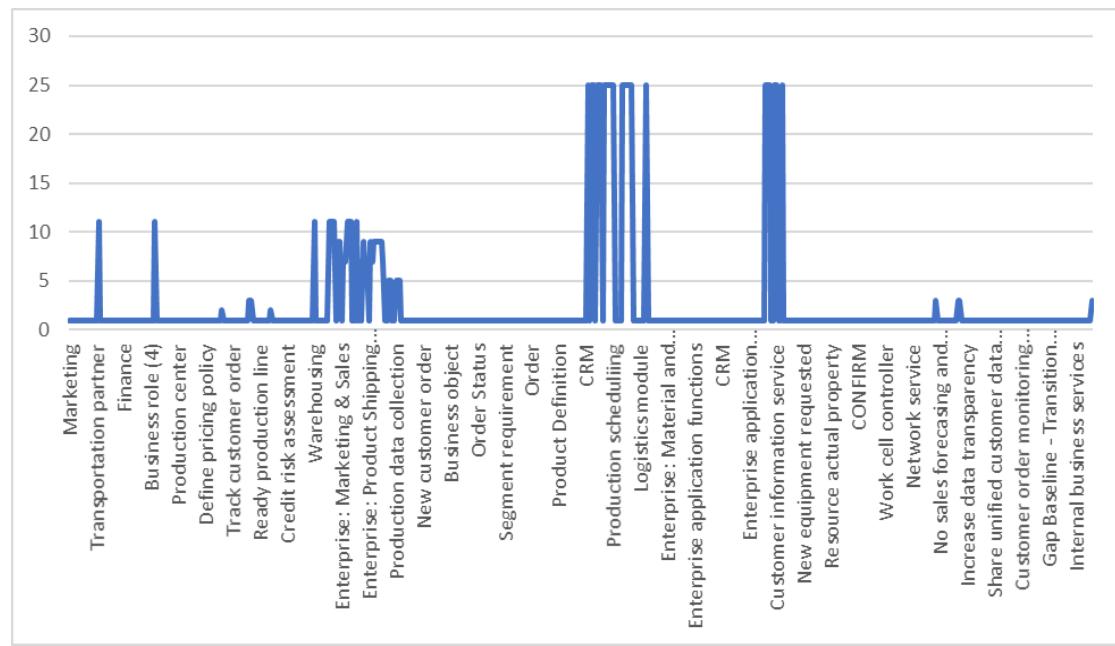
Method applied to the Archimetal Model and the results visualized

Redundancy Analysis
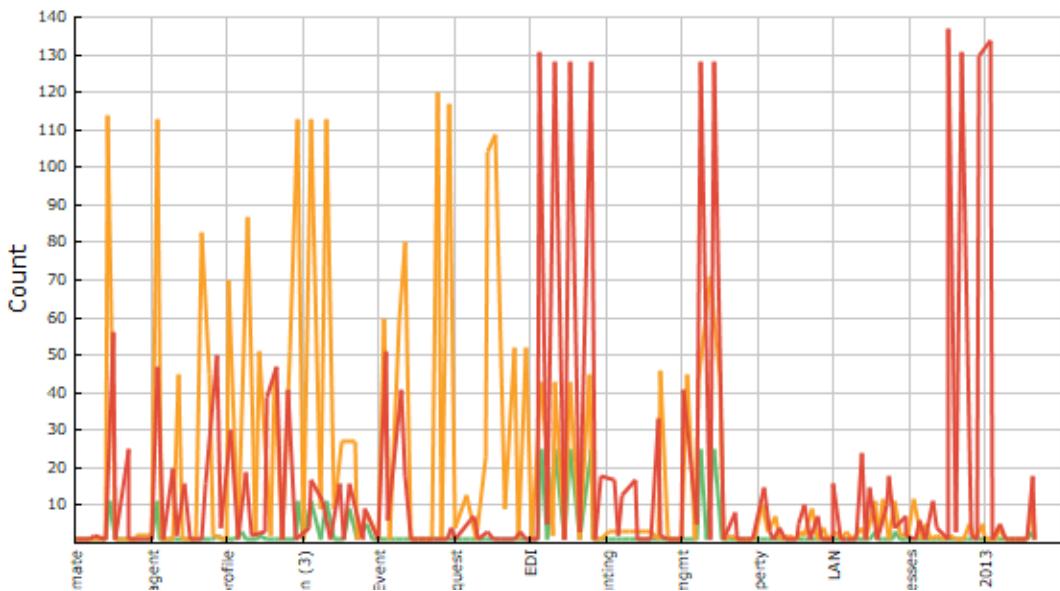
Method applied to the Archimetal Model and the results visualized.
All the entities on the X axis are redundant

Analysis Method:

1. Identify the set of architecture entities and related relations

2. Establish the incidence matrix for these entities and relations

3. Determine the adjacency matrix from the incidence matrix

4. Determine the reachability matrix from the adjacency matrix

5. Identify those entities whose pair value with another entity is 1

6. Indicates the redundancy of an entity

Head and Tail Analysis

Analysis Method:

1. Identify the set of architecture entities and related relations

2. Establish the incidence matrix fo these entities and relations

3. Determine the adjacency matrix from the incidence matrix

4. Determine the reachability matrix from the adjacency matrix

5. All entities with many non-zero value in column and 1 non-zero value in row are Heads.

6. All entities with many non-zero value in the row and 1 non-zero value in column are Tails.

Heads

1. Archimate.Business.Business Actor.Contact
2. Archimate.Business.Business Actor.Lead
3. Archimate.Business.Business Actor.Opportunity
4. Archimate.Business.Business Actor.HQ
5. Archimate.Business.Business Actor.DC Benelux
6. Archimate.Business.Business Actor.Production center
7. Archimate.Business.Business Actor.ArchiMetal
8. Archimate.Business.Business Actor.ArchiBuilder
9. Archimate.Business.Business Role.Credit specialist
10. Archimate.Business.Business Role.Customer representative
11. Archimate.Business.Business Role.Manufacturing engineer
12. Archimate.Business.Business Role.Sales representative
13. Archimate.Business.Business Role.Logistics planner

Tails

1. Archimate.Business.Business Actor.Supply partner
2. Archimate.Business.Business Actor.Transportation partner
3. Archimate.Business.Business Actor.Enterprise
4. Archimate.Business.Business Actor.Purchasing agent
5. Archimate.Business.Business Role.Production center
6. Archimate.Business.Business Interface.Enterprise-control functional interface
7. Archimate.Business.Business Process.Price
8. Archimate.Business.Business Process.Send delivery orders
9. Archimate.Business.Business Process.Produce order
10. Archimate.Business.Business Process.Send notification to customer
11. Archimate.Business.Business Process.Inform DCs
12. Archimate.Business.Business Function.Business function

Method applied to the Archimetal Model and the results visualized

Merge and Burst point Analysis
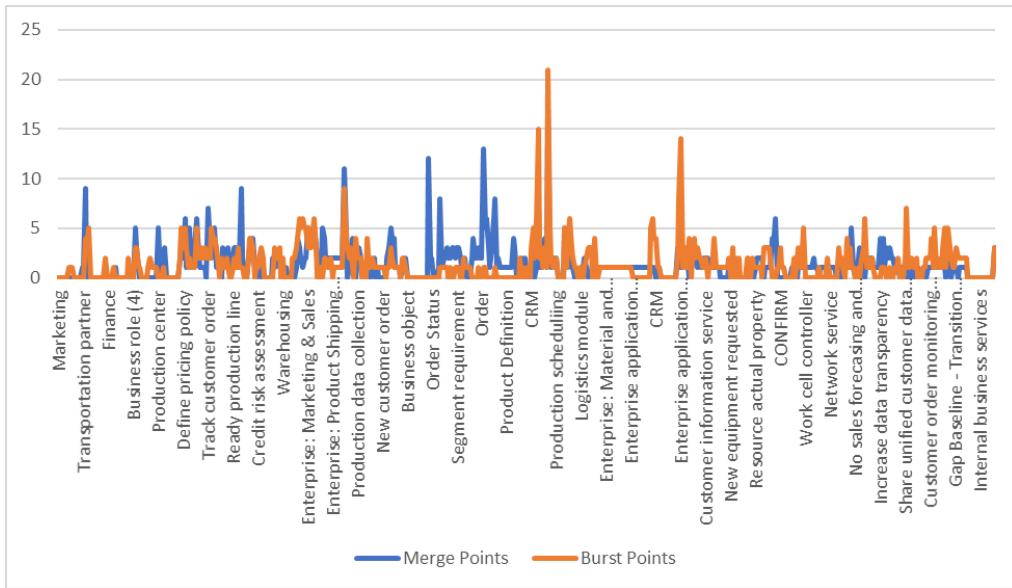
Method applied to the Archimetal Model and the results visualized

Analysis Method:

1. Identify the set of architecture entities and related relations

2. Establish the incidence matrix for these entities and relations

3. Determine the adjacency matrix from the incidence matrix

4. Burst point is the count of non-zero value in a column corresponding to the entity

5. Merge point is the count of non-zero value in a row corresponding to the entity

6. Indicates the thrust areas and leverage points in the model

Traceability Analysis

Analysis Method:

1. Identify the set of architecture entities and related relations

2. Establish the incidence matrix for these entities and relations

3. Determine the adjacency matrix from the incidence matrix

4. Determine the reachability matrix from the adjacency matrix

5. The traceability strength between two entities is the cell value at the intersection of the row and column

6. Indicates whether there is a path between the identified entities

	A	B	C	D	E	F	G	H	I	J	K	
1		Archim	Strate	Resou	Capabi	Course	Busine	Busine	Marke	Sales	Sales	Service
2	Archimate	1	0	0	0	0	0	0	0	0	0	0
3	Strategy	0	1	0	0	0	0	0	0	0	0	0
4	Resource	0	0	1	0	0	0	0	0	0	0	0
5	Capability	0	0	0	1	0	0	0	0	0	0	0
6	Course Of Action	0	0	0	0	1	0	0	0	0	0	0
7	Business	0	0	0	0	0	1	0	0	0	0	0
8	Business Actor	0	0	0	0	0	0	1	0	0	0	0
9	Marketing	0	0	0	0	0	0	0	1	0	0	0
10	Sales manager	0	0	0	0	0	0	0	0	1	0	0
11	Sales professional	0	0	0	0	0	0	0	0	0	1	0
12	Service professional	0	0	0	0	0	0	0	0	0	0	1
13	Business intelligence analysi	0	0	0	0	0	0	0	0	0	0	0
14	Contact center agent	0	0	0	0	0	0	0	0	0	0	0
15	Contact	0	0	0	0	0	0	0	0	0	0	0
16	Lead	0	0	0	0	0	0	0	0	0	0	0
17	Opportunity	0	0	0	0	0	0	0	0	0	0	0
18	Business actor	0	0	0	0	0	0	0	0	0	0	0
19	Supplier	0	0	0	0	0	0	0	0	0	0	0

Method applied to the Archimetal Model and the results visualized

Sentiment Analysis
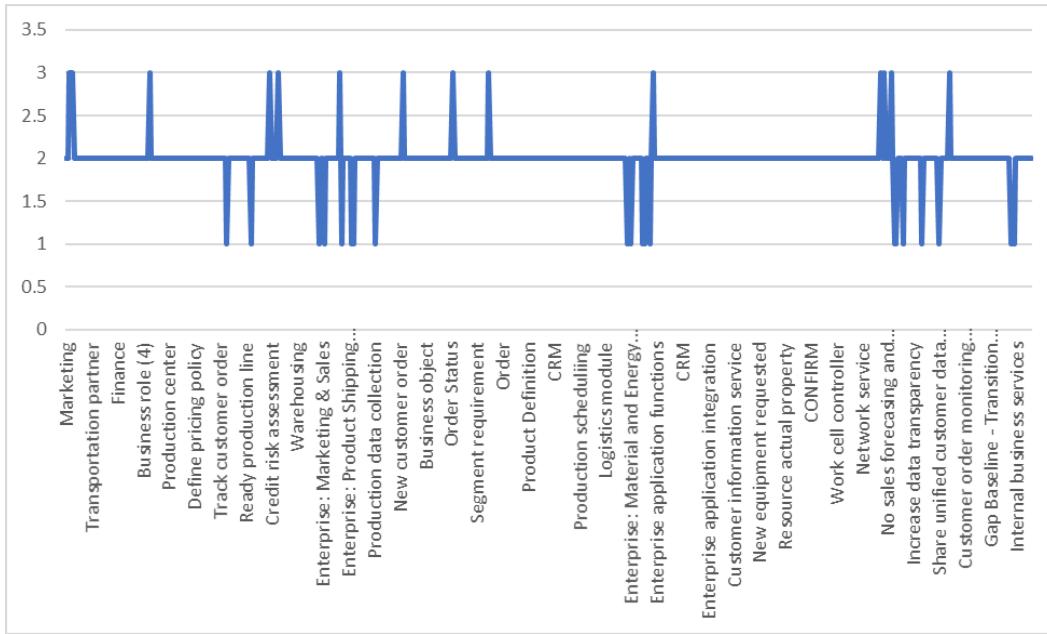
Method applied to the Archimetal Model and the results visualized

Analysis Method:

1. Identify the set of architecture entities and related relations

2. Establish the incidence matrix for these entities and relations

3. Determine the adjacency matrix from the incidence matrix

4. Generate the textual relationship of each relationship

5. Use Sentiment analysis NLP toolkit to analyze the relations and express visually

6. Indicates the opinionated data of the model

Network Analysis

Analysis Method:

1. Identify the set of architecture entities and related relations

2. Establish the incidence matrix for these entities and relations

3. Determine the adjacency matrix from the incidence matrix

4. Construct a directed graph using the adjacency matrix

5. Analyze the directed graph using techniques like

    – *Critical path*
    – *Positive and negative Feedback loop*
    – *Network optimization*
    – *Network immunization*
    – *Eigenvector centrality*
    – *Network robustness and so on.*

Demonstration of the Methods

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Concluding Remarks

Summary

- Architecture is gaining prominence in dealing with complexity in systems

- Architecture evaluations are performed to draw meaningful insights about the architecture

- Organizations find it difficult to evaluate architectures
  - few well-known proprietary analysis methods
  - architecture descriptions use different terminologies
  - architecture/system characteristics are wide and varying in nature
  - considerable manual skill and effort involved

Summary…

This paper presents few analysis methods for technology-based analysis of architecture views or models

1) Impact analysis to understand the effect of an architecture decision on the overall architecture

2) Effect analysis to understand the effect of an architecture on a particular architecture element

3) Cyclic analysis to understand the nature of the feedback between different architecture elements

4) Redundancy analysis to understand whether an architectural element is contributing meaningfully

Summary

5. Head and Tail analysis to determine the head or tail from the network of architecture elements

6. Merge point and Burst point analysis to understand the key thrust areas in an architecture

7. Traceability analysis to determine the dependencies between the various architecture elements

8. Sentiment analysis to understand the sentiments or attitudes of stakeholders about an architecture

9. Network analysis to understand the network phenomena of an architecture

Thank You