

Development of Abstract Relation Types (ART) for Systems and System-of-Systems Evaluation

“The ART of Systems Engineering”

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Abstract Relation Types (ART)

Abstract relation types (ART) are used to:

- represent, describe, and evaluate systems
- establish a computational framework
- clearly define system attributes

ART are based on two fundamental ideas:

- abstract data types
- binary relations

Six ART describe a system

- Context ART
- Concept ART
- Functional Hierarchy ART
- Requirement ART
- Physical Hierarchy ART
- Test ART

Binary Matrix

A binary matrix M is represented by four sets;

$M = \{I_v, I_h, I_v \times I_h, E_{I_v \times I_h}\}$, where:

I_v is an ordered vertical index set

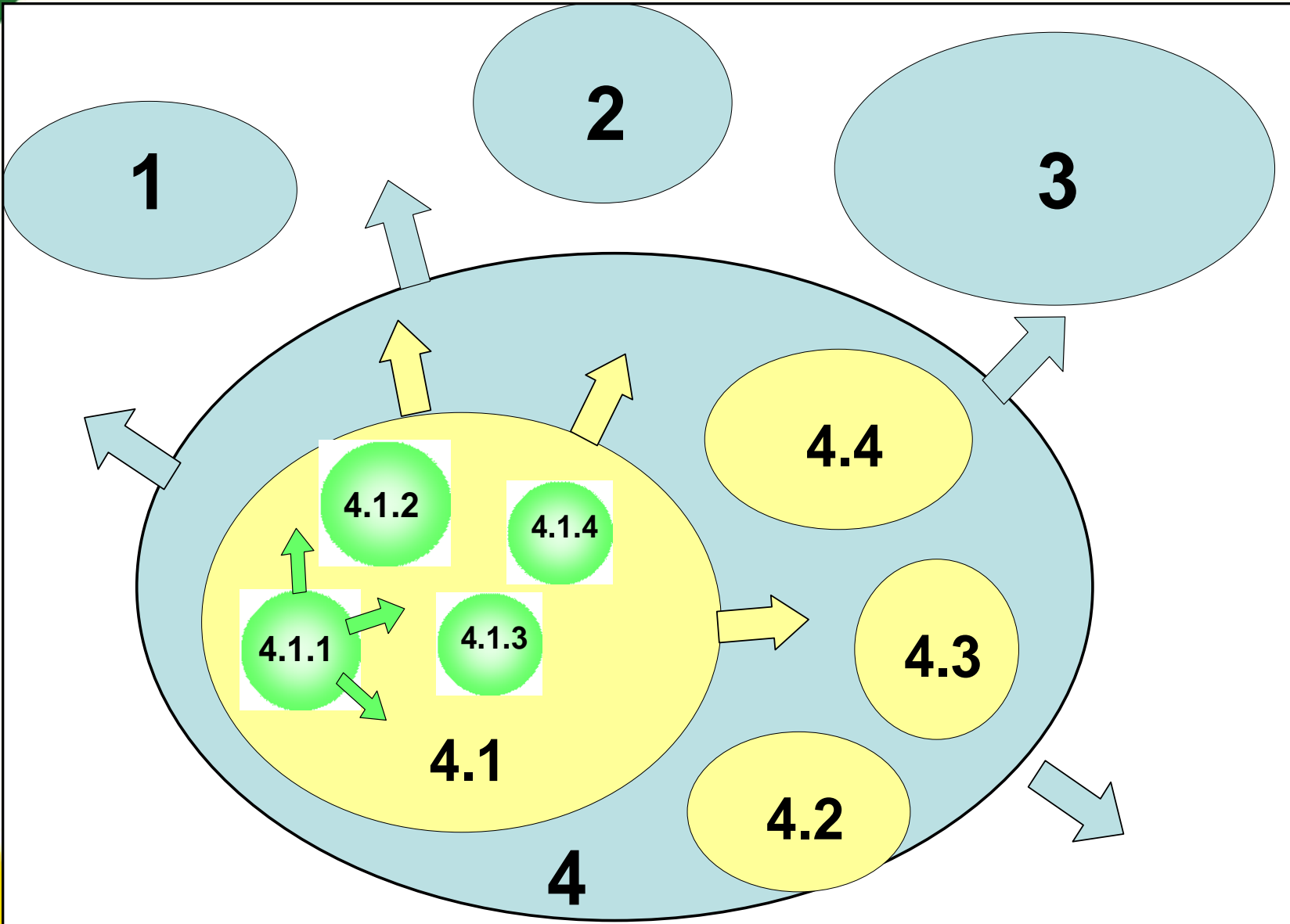
I_h is an ordered horizontal index set

$I_v \times I_h$ is the set of all ordered pairs of I_v, I_h

$E_{I_v \times I_h}$ is the entry set of the matrix.

Some Contextual Relations are:

- Is included in
- Is antecedent to
- Is subordinate to
- Is adjacent to



System Context View

Context Binary Matrix

Set A -- Systems

Set A -- Systems

	4	4.2	4.3	4.4	4.1	4.1.1	4.1.2	4.1.3	4.1.4
4	1	1	1	1	1	0	0	0	0
4.2	1	1	1	1	1	0	0	0	0
4.3	1	1	1	1	1	0	0	0	0
4.4	1	1	1	1	1	0	0	0	0
4.1	1	1	1	1	1	1	1	1	1
4.1.1	0	0	0	0	1	1	1	1	1
4.1.2	0	0	0	0	1	1	1	1	1
4.1.3	0	0	0	0	1	1	1	1	1
4.1.4	0	0	0	0	1	1	1	1	1

Context Binary Matrix

Set A -- Systems

		<i>Set B -- System Attributes</i>							
		<i>Physical Attributes</i>				<i>Service Attributes</i>			
		<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>	<i>g</i>	<i>h</i>
4		1	0	1	1	1	1	1	1
4.2		1	0	1	1	1	1	1	1
4.3		1	1	1	1	1	1	1	0
4.4		1	1	1	1	1	1	0	1
4.1		1	1	1	1	1	1	1	1
4.1.1		0	1	0	0	1	1	0	0
4.1.2		0	1	0	0	1	1	0	0
4.1.3		0	1	0	0	1	1	0	0
4.1.4		0	1	0	0	1	1	0	0

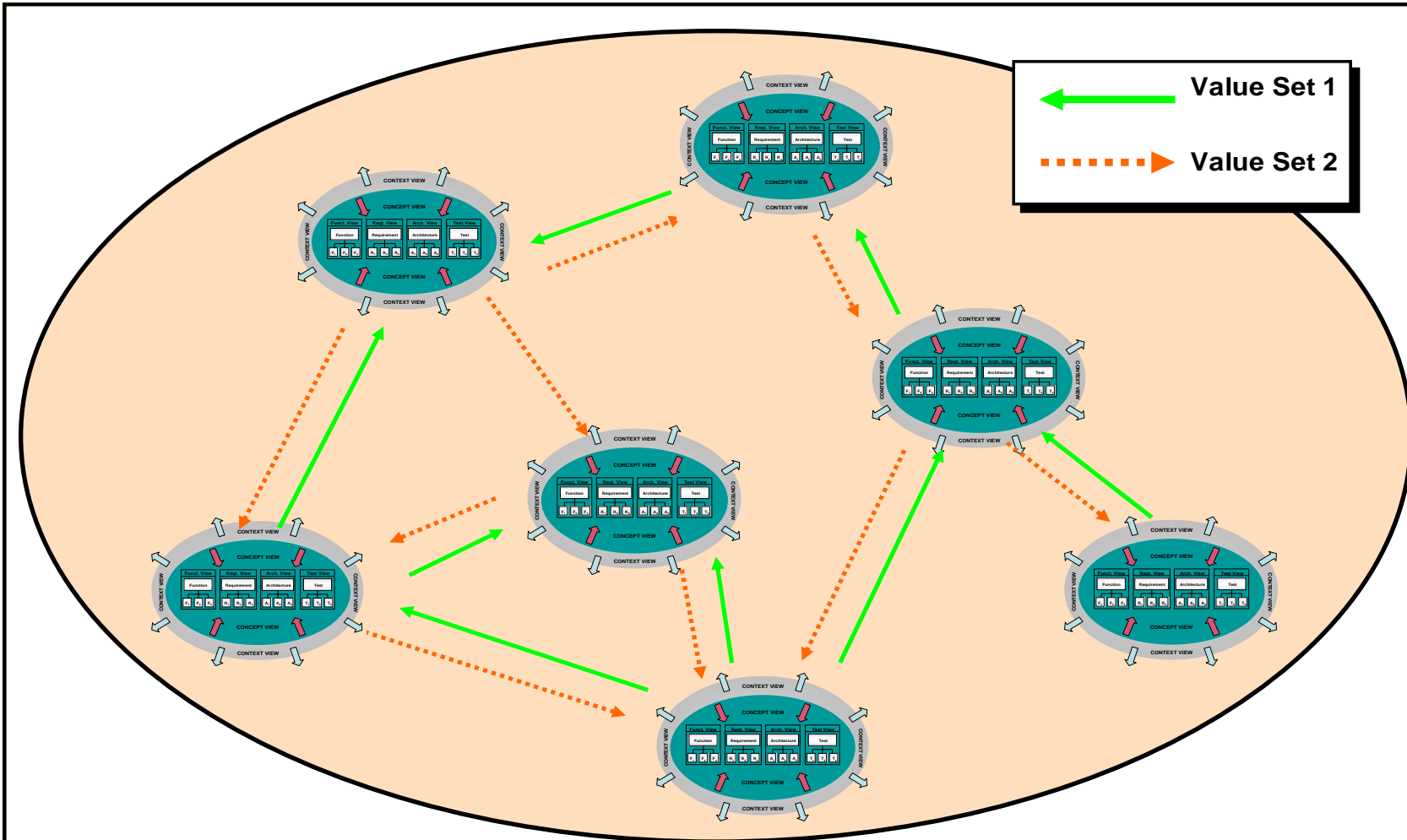
System 4.1.1 context is bounded by system 4.1.

System 4.1 context is bounded by system 4.

Set A elements are systems in the context.

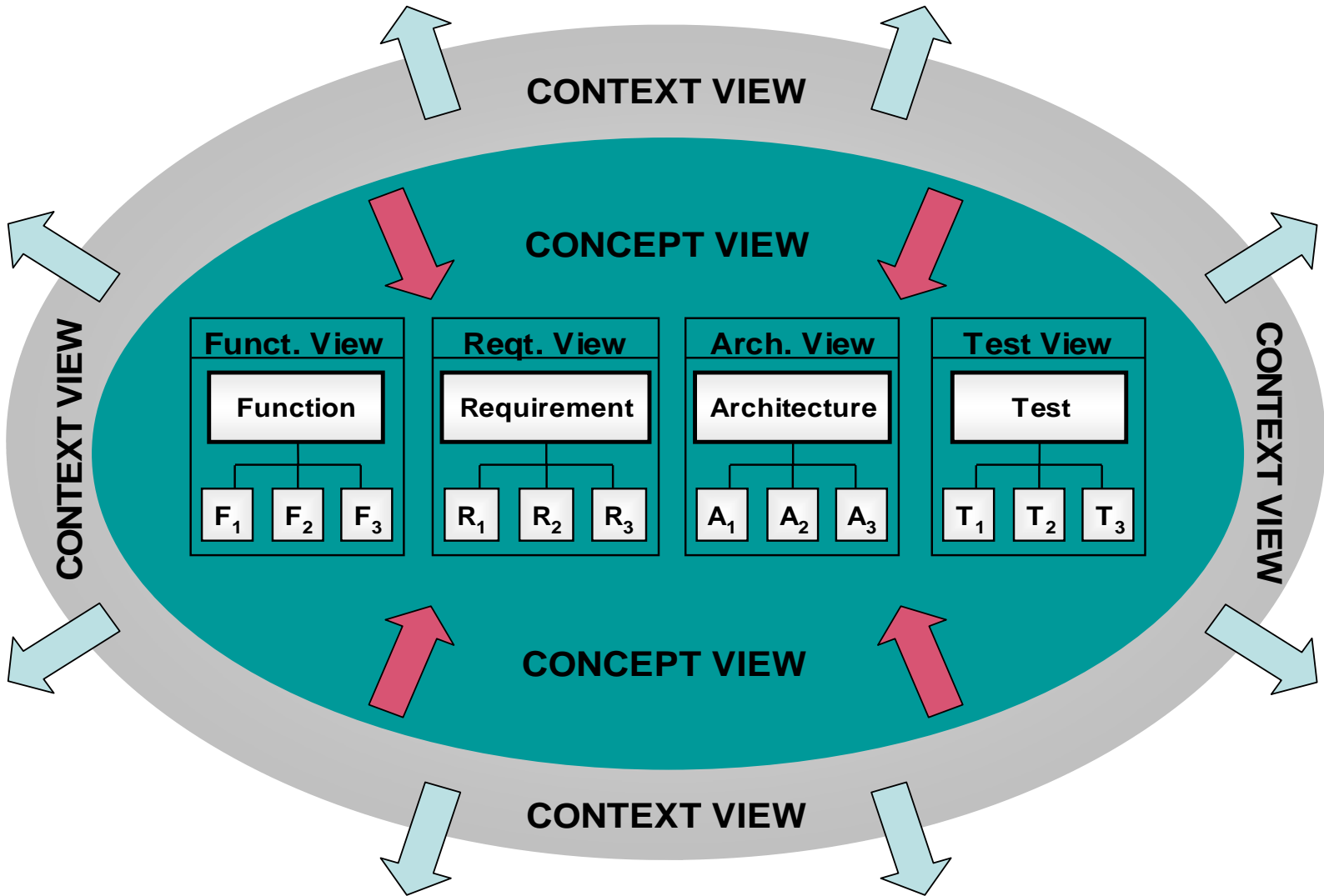
Set B elements are attributes of the systems in the context.

Concept ART



Network of Systems

Six ART System Views



Function and Physical Hierarchy

Num	Function Name
0.0	Execute Task
1.0	Prepare for Task
1.1	Conduct Pre-Task Briefing
1.2	Prepare Personnel for Task
1.3	Prepare Equipment for Task
2.0	Transit to Task Execution Area
2.1	Prepare for Transit
2.2	Load Unit on Transport
2.3	Move to Task Area
3.0	Perform Task
3.1	Evaluate Task Area
3.2	Execute Task Objectives
3.3	Evaluate Task Effectiveness
4.0	Return from Task Area
4.1	Transit to Initial Area
4.2	Evaluate Unit Status
4.3	Record Lessons Learned

Num	Component Name
0.0	Wagon
1.0	Wagon Body
1.1	Metal Floor
1.2	Metal Sides
1.3	Metal Fasteners
2.0	Wooden Sides
2.1	Wood Uprights
2.2	Wood Planks
2.3	Wood Fasteners
3.0	Front Wheel Assembly
3.1	Front Axel
3.2	Front Wheels
3.3	Front Handle Assembly
4.0	Rear Wheel Assembly
4.1	Rear Axel
4.2	Rear Wheels
4.3	Rear Axel Attachment Assembly

Function Hierarchy ART (HART)

	0.0	1.0	2.0	3.0	4.0	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3
0.0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1.1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1.2	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1.3	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2.1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2.2	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2.3	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
3.1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
3.2	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
3.3	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
4.1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
4.2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
4.3	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1

Systems Engineering Executable Language (SEEL)

- The six ART components provide the basis for an executable systems engineering language.
- Patterns formed by the binary matrix associated with each system view are used to create human readable graphs and graphic system representations.
- Executable computer code is designed and deployed as a fundamental component of each ART.
- Executable code methods for the CART have been developed to implement the evaluation of system context configurations.
- Further research is needed to design, develop and deploy the computer executable code associated with SEEL.

Questions



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