MBSE as a Solution to Information Volatility Impacting T&E

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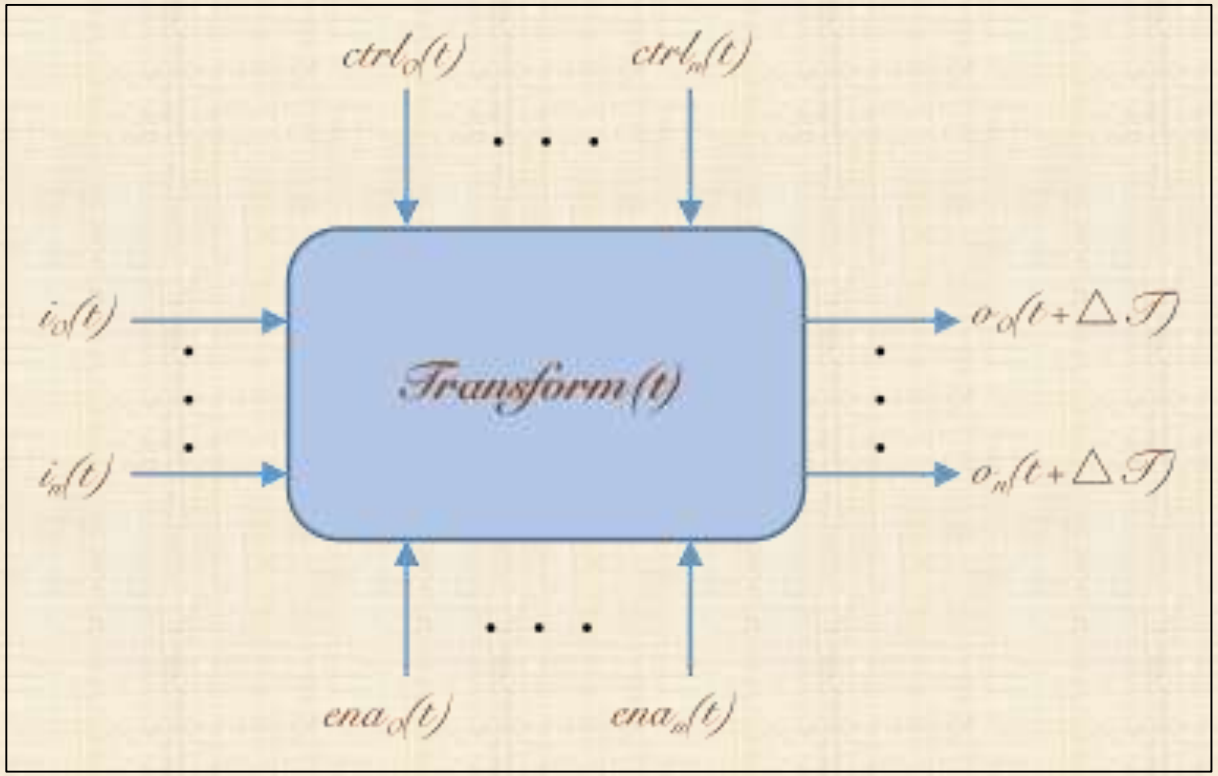
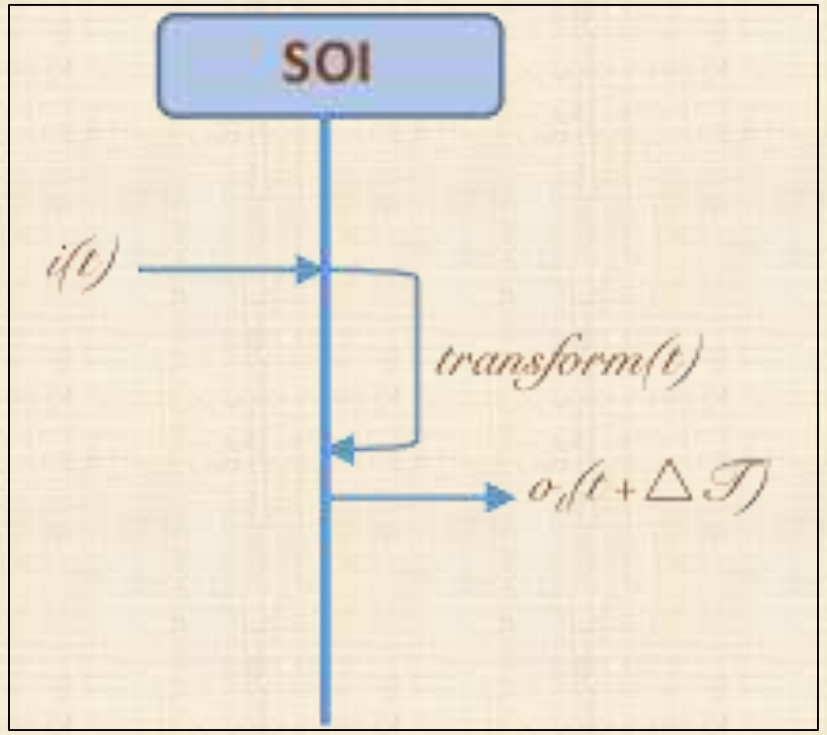
Some Test & Evaluation Needs…

- A clear representation of system informational elements at a blackbox (BB) level.
- A clear representation of system informational elements at a whitebox (WB) level.
- An understanding of system interconnectivity (BB, WB).
- A characterization of system functional dynamic and expected performance.
- A clear understanding of system constraints and “ilities”

Dealing with Information Volatility

System/Subsystem/Micro-systems

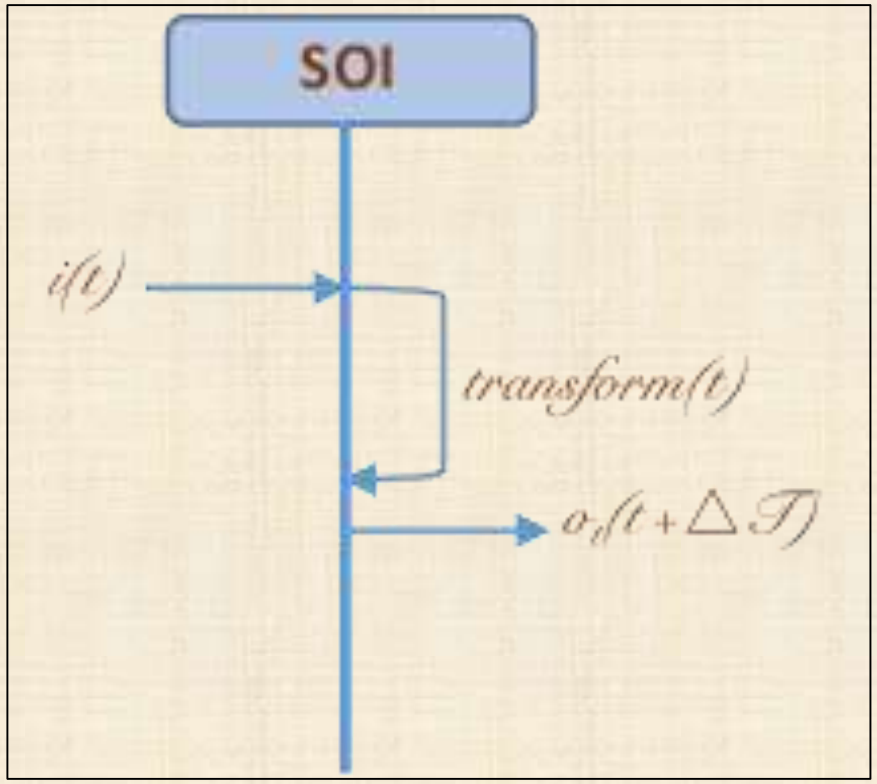




In SOI, S = System/Subsystem/Microsystem

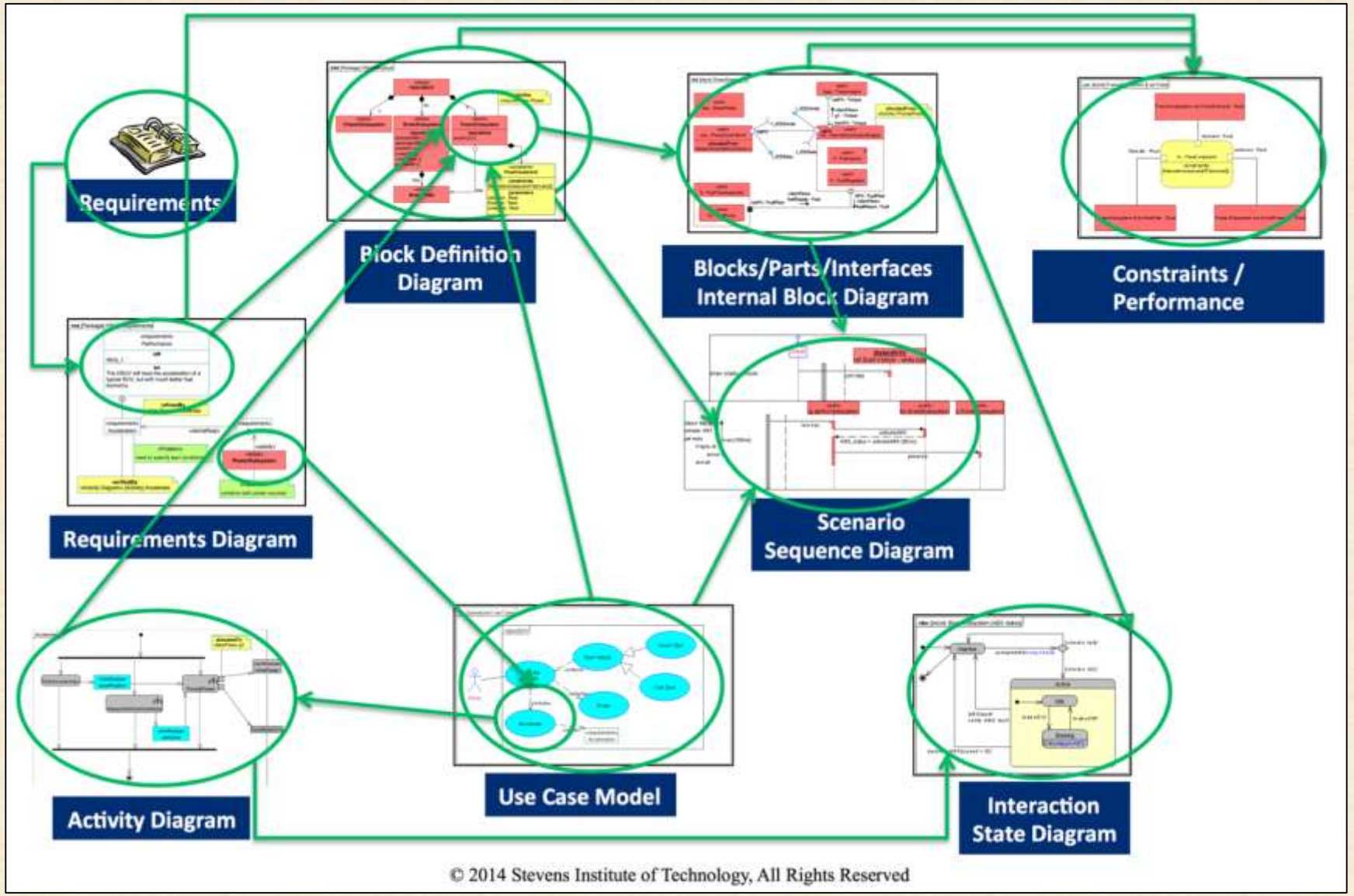
What is the true nature of a requirement?

Upon receipt of <*information element*> from <*source*>,the
<system/subsystem/micro-system> shall
a: <*solve problem/execute transform*>
b: send results to <*destination*>

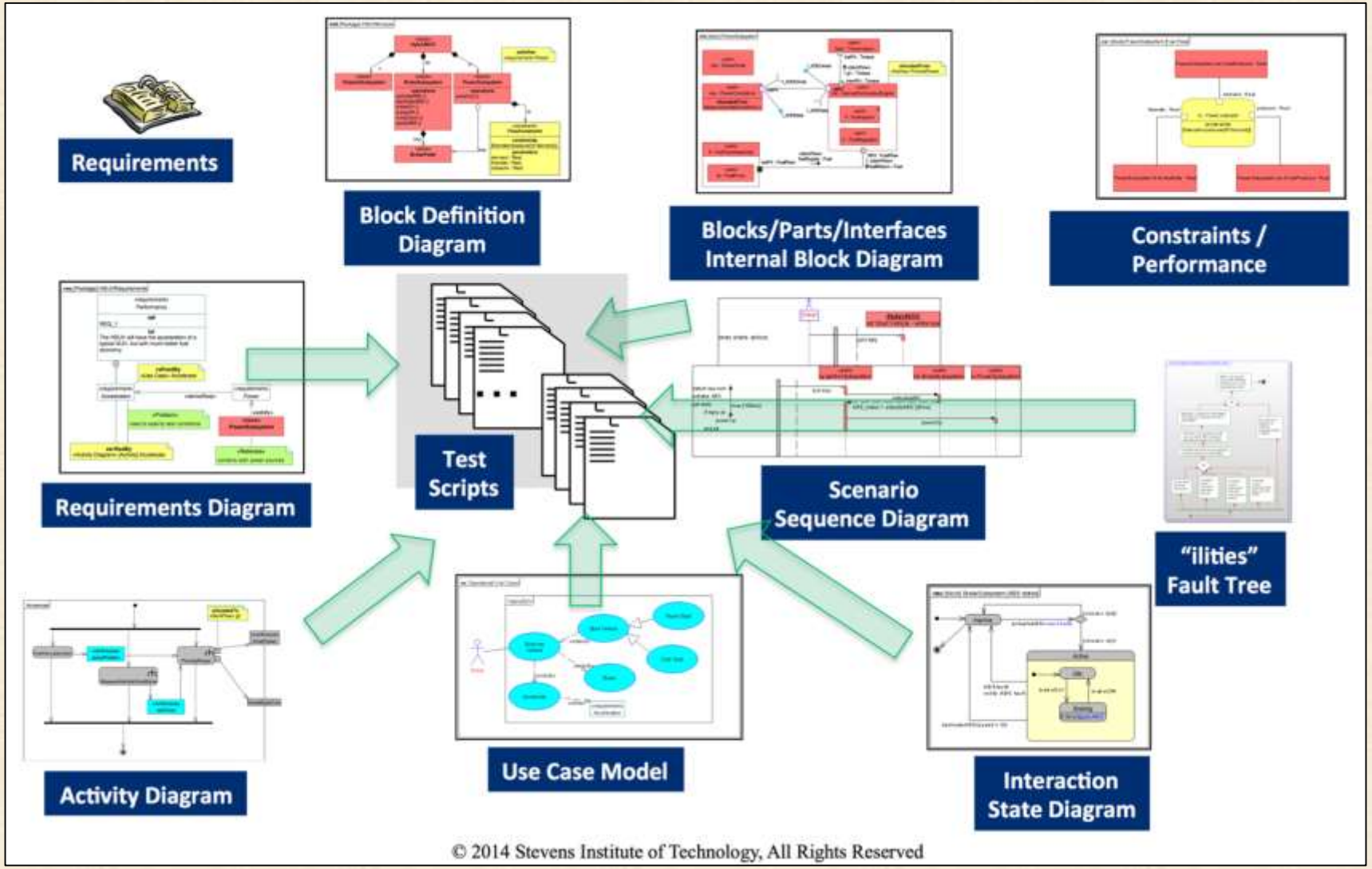


In SOI, S = System/Subsystem/Microsystem

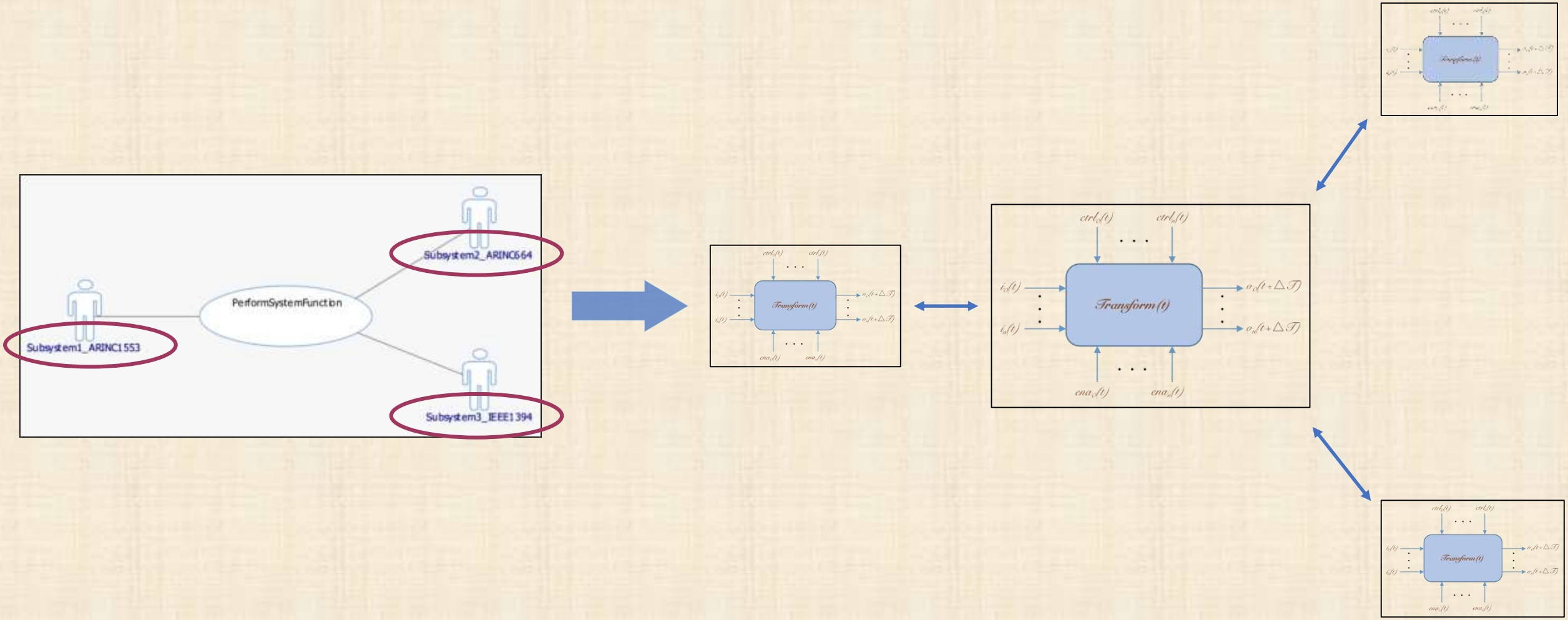
System Design Element Connectivity



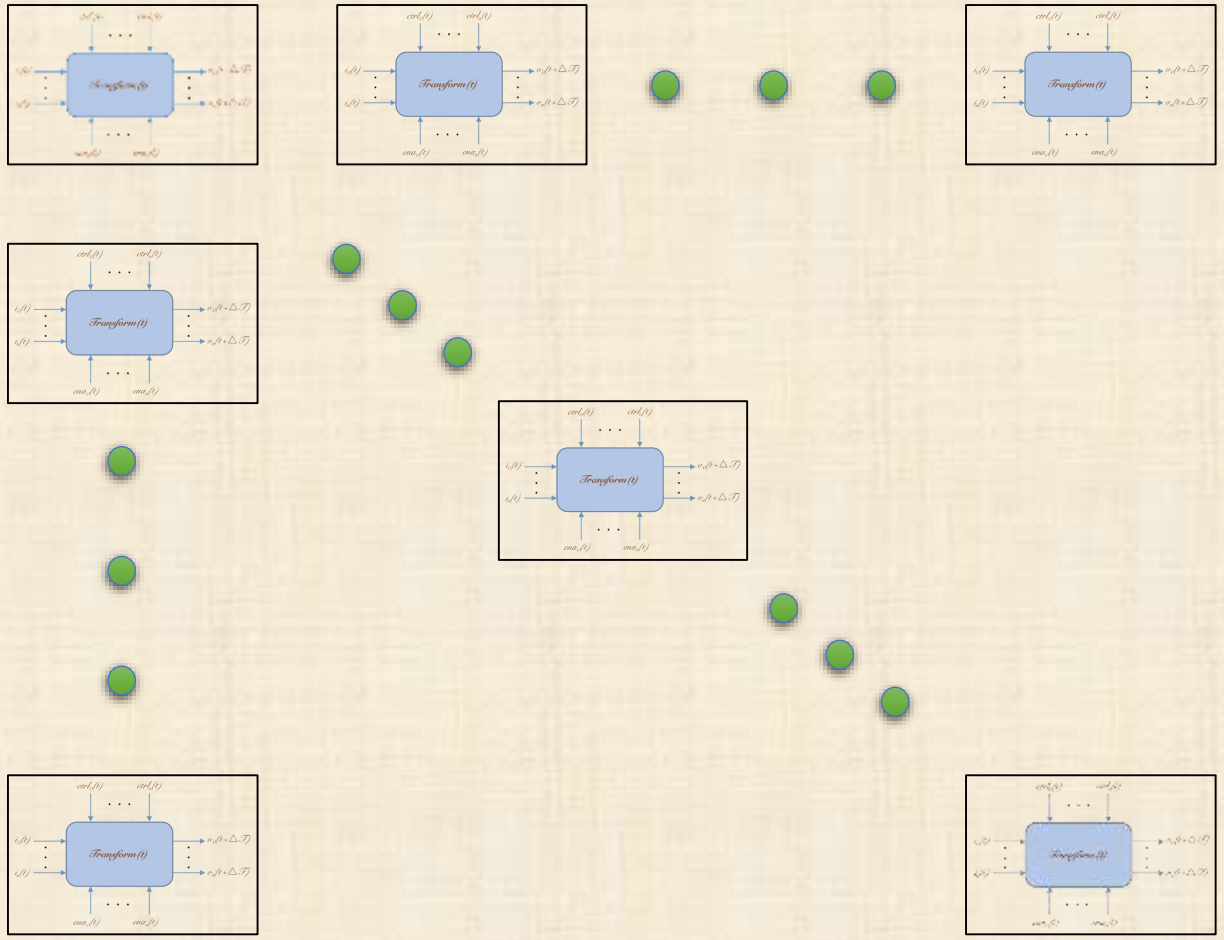
System Design Element Connectivity – cont.



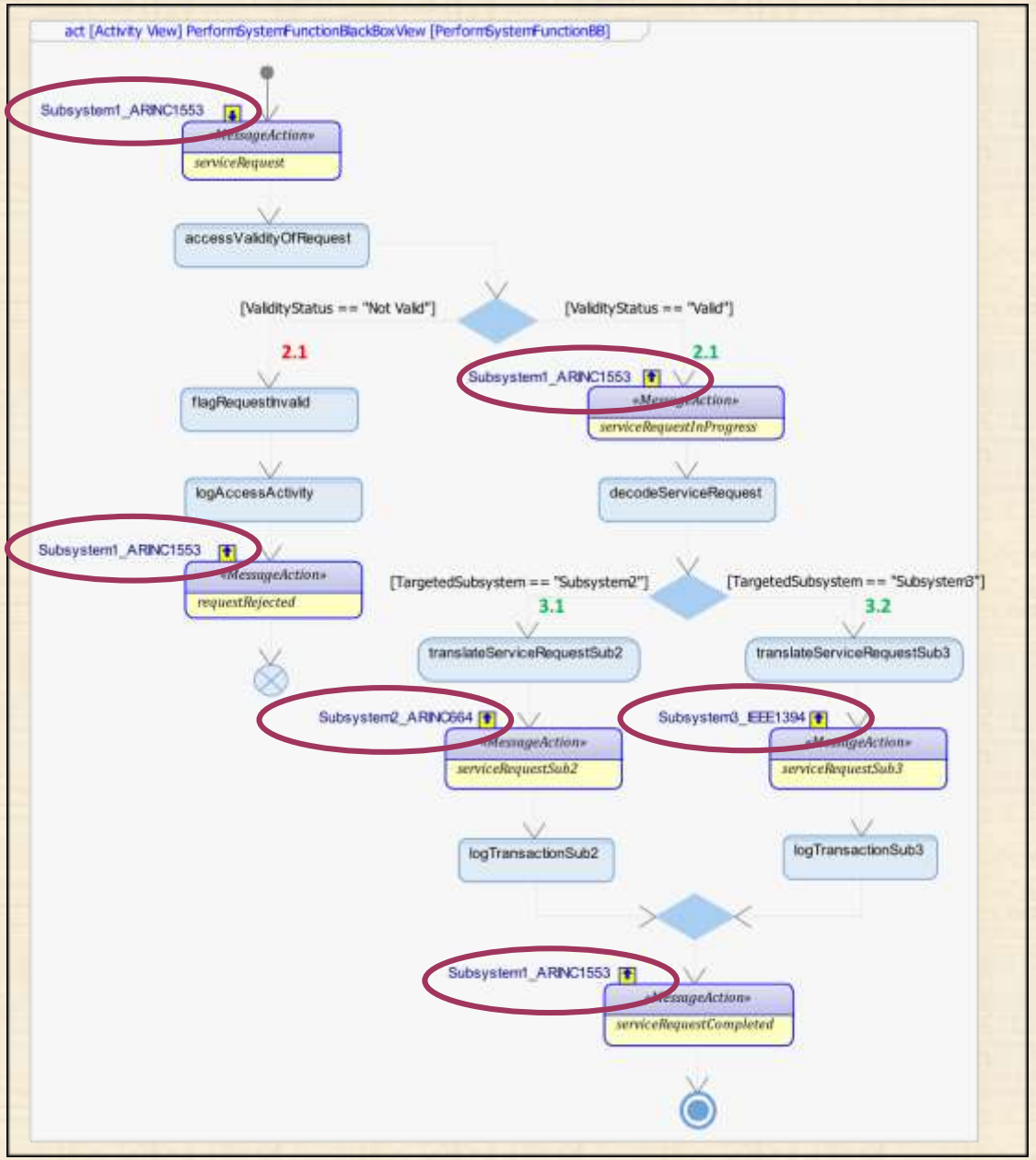
Every system problem has context - who are the players?



A Complicated SoS Network - Several Subsystems/Micro-Systems (*horizontally*, *vertically*)



System problem elaboration - What is the transform blackbox (BB)?

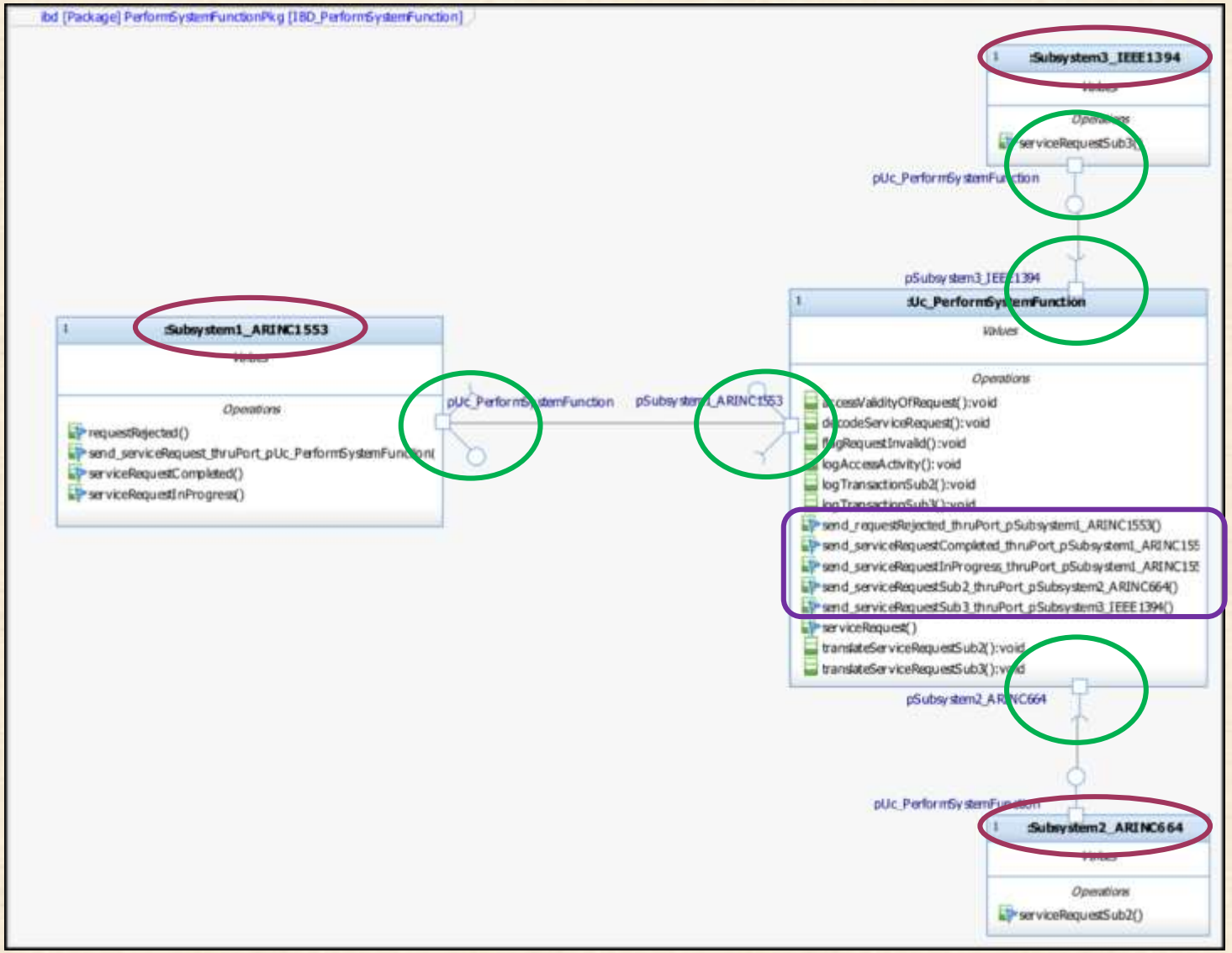


Evaluating the threaded path…

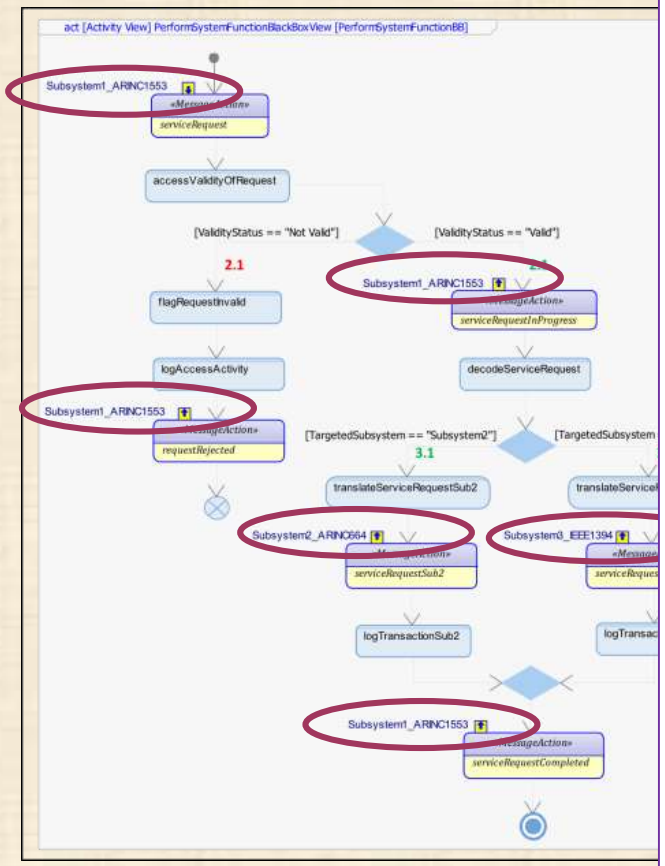
System (black-box functional) Requirements:

1. *Upon receipt of a serviceRequest from Subsystem1, the system shall validate the integrity of the service request.*
2. *The system shall send a serviceRequestInProgress notification to Subsystem1 if validation of the serviceRequest is successful.*
3. *The system shall send a requestRejected notification to Subsystem1 if validation of the serviceRequest is unsuccessful.*
4. *Upon successful validation of a serviceRequest, the system shall decode the serviceRequest to determine its destination.*
5. *When a serviceRequest destination is available, the system shall:*
   a. *package the service request for ARINC 664 transfer if the destination is Subsystem2.*
   b. *send the serviceRequest to Subsystem2.*
6. *When a serviceRequest destination is available, the system shall:*
   a. *package the service request for IEEE 1394 transfer if the destination is Subsystem3.*
   b. *Send the serviceRequest to Subsystem3.*
7. *Upon completion of a serviceRequest send, the system shall*
   a. *record the transaction history.*
   b. *send a serviceRequestCompleted notification to Subsystem1.*

How will the system realize its functional goal in the context of leveled actors?



What's the functio allocation?



Subsystem (white-box functional) Requirements (CSCI_1):

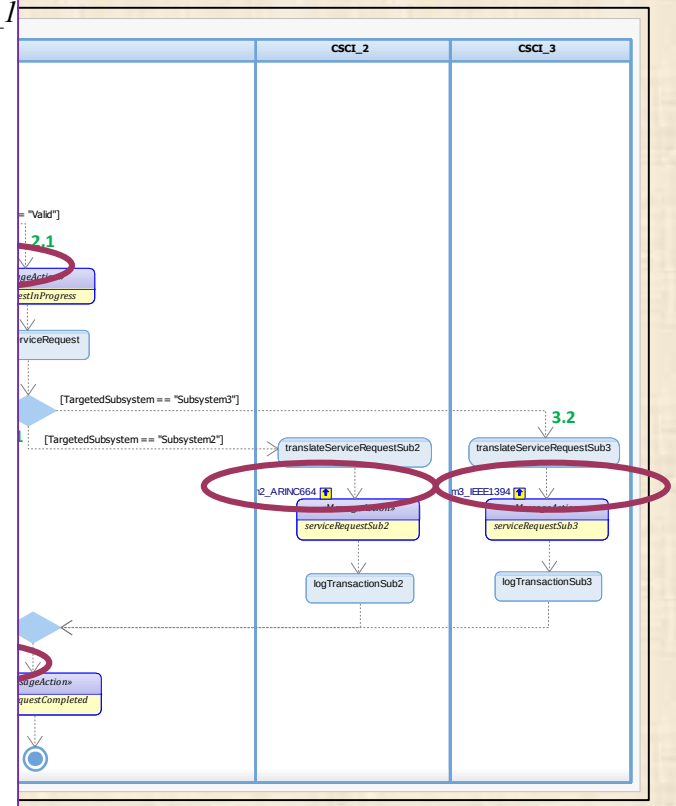
1. *Upon receipt of a serviceRequest from Subsystem1, CSCI_1 shall validate the integrity of the service request.*
2. *The CSCI_1 shall send a serviceRequestInProgress notification to Subsystem1 if validation of the serviceRequest is successful.*
3. *The CSCI_1 shall send a requestRejected notification to Subsystem1 if validation of the serviceRequest is unsuccessful.*
4. *Upon successful validation of a serviceRequest, the CSCI_1 shall*
   a. *decode the serviceRequest to determine its destination.*
   b. *send a translateServiceRequest to CSCI_2.*
5. *Upon receiving a serviceRequestCompleted notification from CSCI_2, CSCI_1 shall send a serviceRequestCompleted notification to Subsystem1.*

Subsystem (white-box functional) Requirements (CSCI_2):

1. *Upon receipt of a translateServiceRequest from CSCI_1, CSCI_2 shall:*
   a. *package the service request for ARINC 664 transfer to Subsystem2.*
   b. *send the translated serviceRequest to Subsystem2.*
   c. *record the transaction history.*
   d. *send a serviceRequestCompleted notification to CSCI_1.*

Subsystem (white-box functional) Requirements (CSCI_3):

1. *Upon receipt of a translateServiceRequest from CSCI_1, CSCI_3 shall:*
   a. *package the service request for IEEE 1394 transfer to Subsystem3.*
   b. *send the translated serviceRequest to Subsystem3.*
   c. *record the transaction history.*
   d. *send a serviceRequestCompleted notification to CSCI_1.*



Division of labor - Providing the system end-to-end solution/transform.

What are the players communicating and with whom?

	A	B	C	D	E	F	G	H
1					*Provides*			
2			Subsystem1_ARINC1553	CSCI_1	CSCI_2	Subsystem2_ARINC664	CSCI_3	Subsystem3_IEEE1394
3		Subsystem1_ARINC1553	X	iSubsystem1_ARINC1553_CSCI_1				
4	*Requires*	CSCI_1	iCSCI_1_Subsystem1_ARINC1553	X	iCSCI_1_CSCI_2		iCSCI_1_CSCI_3	
5		CSCI_2		iCSCI_2_CSCI_1	X	iCSCI_2_Subsystem2_ARINC664		
6		Subsystem2_ARINC664				X		
7		CSCI_3		iCSCI_3_CSCI_1			X	iCSCI_3_Subsystem3_IEEE1394
8		Subsystem3_IEEE1394						X

Model Based Systems Engineering

- Provides a systematic approach to arriving at the layered design artifacts needed for successful testing and evaluation of complicated systems.
- Provides concise testing and evaluation requirements derived directly from system thread decomposition - language agnostic sequence diagrams.
- Provides a clear understanding of system dynamic through depiction of system functional dynamic per analysis of requirements.
- Sets the stage for Design Structured Matrix (DSM) analysis – Activity Based DSM.
- Facilitates the characterization of the complicated system in terms of functional nodes (subsystems/micro systems) conducive to Bayesian Network analysis techniques.

In summary, we…

- started out with some simple mission requirements and constraints.
- performed Requirements Analysis to arrive at a single simple Use Case for the simple system.
- performed System Functional Analysis leading to the definition of leveled system BB operations needed to meet the operational goal of the simple system.
- performed Architectural Analysis leading to our “very elaborate” system architecture of three Computer Software Configuration Items (CSCIs).
- performed some architectural design resulting in the allocation of systems functions to WB parts of the simple system.
- ended up with end-to-end interface connectivity and information element exchanges deemed necessary to meet system operational goal.

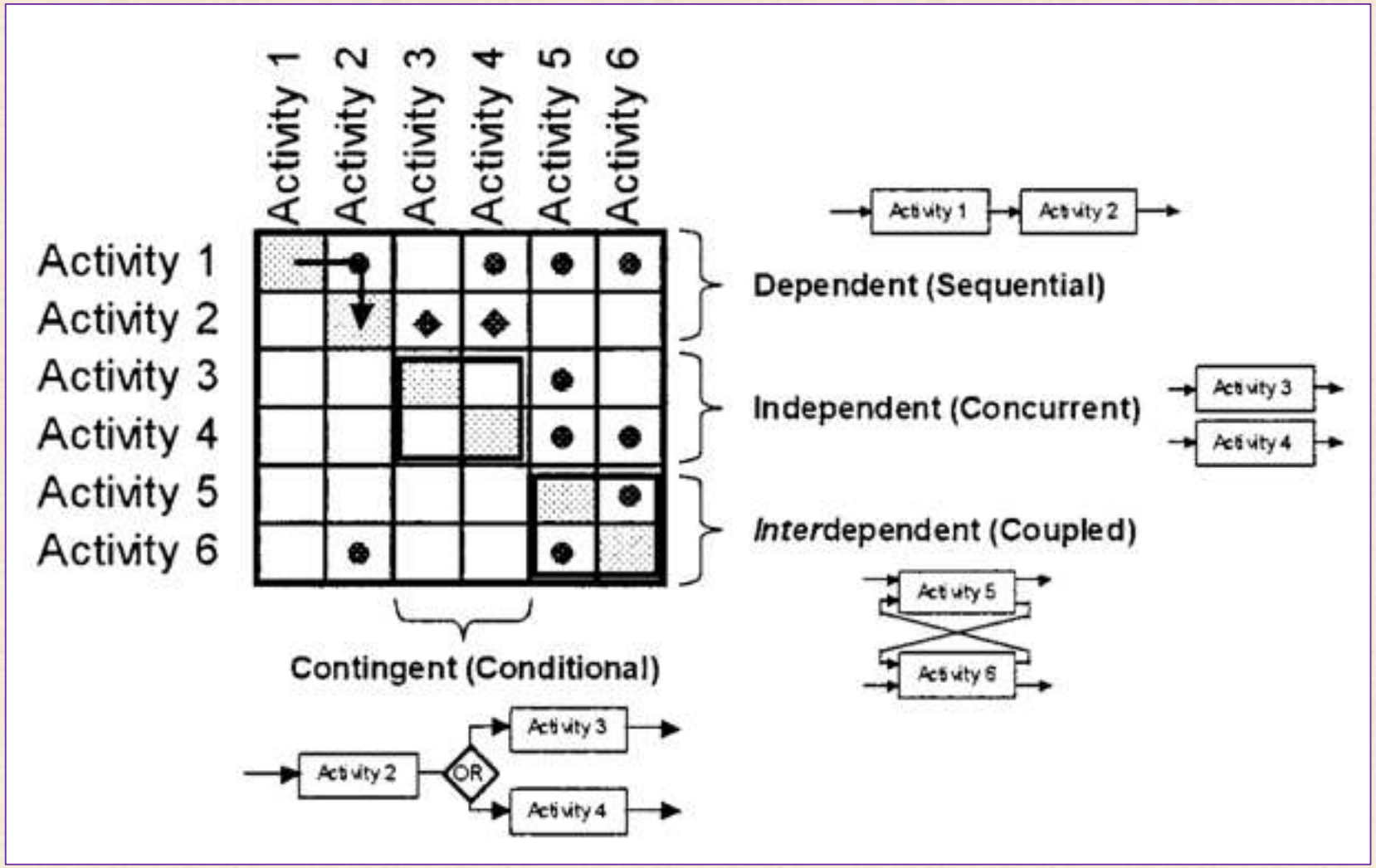
Backup Slides

Model Based Systems Engineering (MBSE): “The formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases” (INCOSE, 2015).

Object Oriented Systems Engineering Method (OOSEM): “an end-to-end MBSE method, where the artifacts of the method are modeling artifacts that are managed and controlled throughout the SE process”(INCOSE, 2015) .

Systems Thinking is a way of thinking used to address complex and uncertain real world problems. It recognizes that the world is a set of highly interconnected technical and social entities which are hierarchically organized producing emergent behavior - (INCOSEUK, 2010).

Activity-Based DSM – (*adapted from [1]*)



References

- [1] Browning, T. R. (2001). Applying the design structure matrix to system decomposition and integration problems: a review and new directions. *IEEE Transactions on Engineering management*, *48*(3), 292-306.
- [2] Von Bertalanffy, L. (1950). The theory of open systems in physics and biology. Science, 111(2872), 23-29.