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Customer Success Is Our Mission

Net-Ready KPP Architecture Evaluation Tool

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26 October 2011

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Outline

- Program overview
- Rules analysis
- Inference engine
- Web service and client
- Future directions

The authors would like to thank the Test Resource Management Center (TRMC) Test and Evaluation / Science and Technology (T&E / S&T) Program for their support. This work was funded by the T&E/S&T Program through the Netcentric System Test (NST) focus area under contract with PEO STRI, Orlando, FL, contract N68936-09-C-0152.

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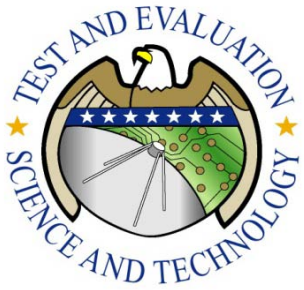
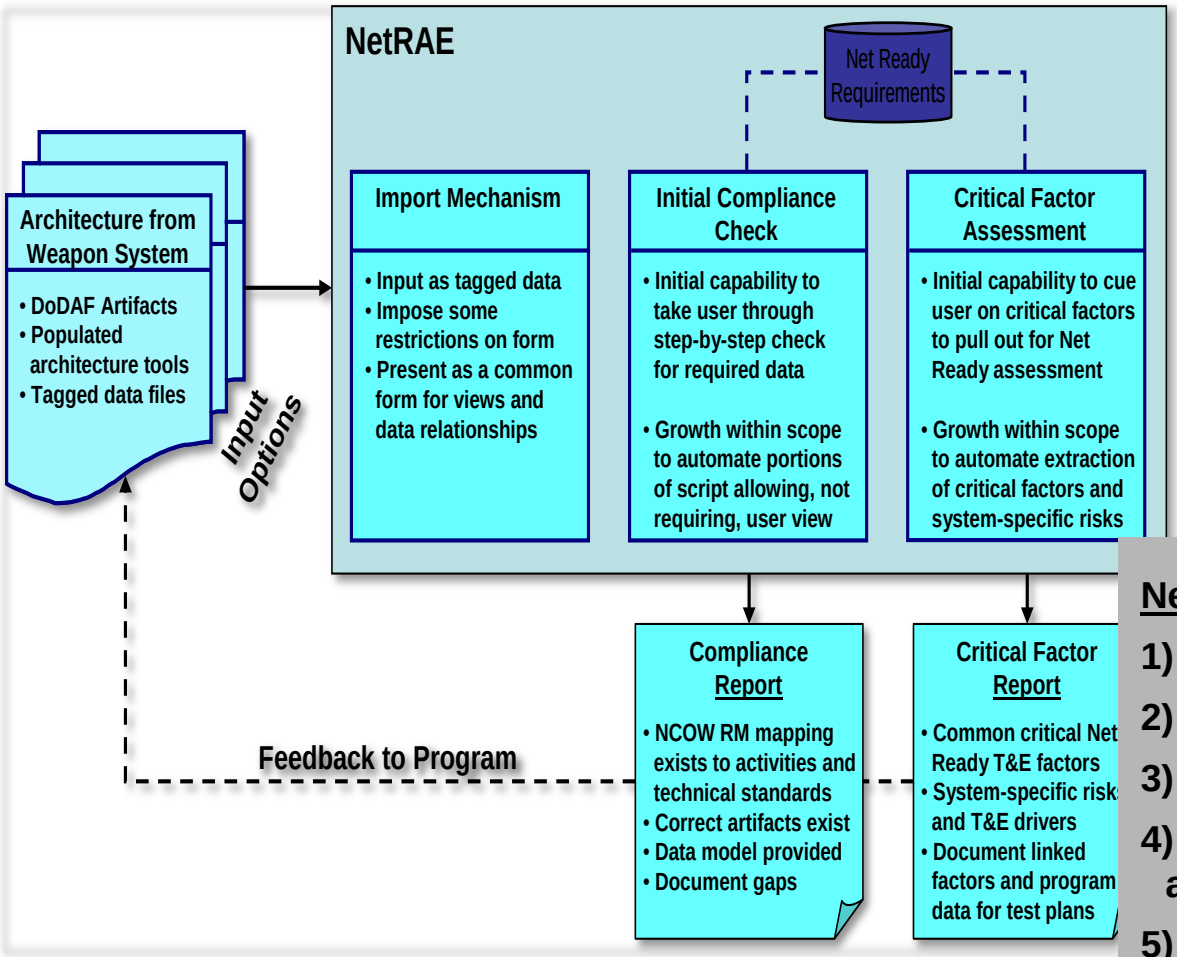
Program Overview (1 of 2)

- **Test & Evaluation Need**
  - Net-Centric Systems Test Science & Technology group identified a need to accurately evaluate systems for compliance with NR-KPP requirements.
  - Need included ability to assess tactical system Service Oriented Architecture and map the assessment findings to the NR-KPP requirements.
- **Science & Technology Challenge**
  - Conduct R&D for creation of tool and methodology for **automated** evaluation of mandatory NR-KPP compliance by assessing system's architectural artifacts.
  - Output of resulting tool was to contain sufficient information to provide the user with explanations and alerts on **varying degrees** of NR-KPP compliance.
  - Prototype to determine NR-KPP compliance for a netted weapon system.
- **NetRAE Tool Development**
  - Three-phase program from 2008 through 2010
  - Final prototype included existence and relationship rules compliant with Joint Interoperability Test Command's (JITC's) rules, an Inference Engine, a web service and application, and rules database for a central repository.



Program Overview (2 of 2)



NetRAE NR-KPP Assessment Steps

1) Architecture created in Rhapsody
2) Artifacts imported into NetRAE tool
3) Check for existence and accuracy
4) Assess critical factors for degree of architecture end-to-end performance
5) Feedback to program

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Rules Analysis (1 of 4)

- **Requirement**
  - Net-centric systems must comply with CJCSI 6212.01E, 15 Dec 2008, “Interoperability and Supportability of Information Technology and National Security Systems”
  - Metrics used assess information exchange end-to-end operational effectiveness for:
    - Net-centric data & services strategies
    - Applicable GIG Technical Guidance
    - DoD Information Assurance and Critical Infrastructure requirements
    - Supportability requirements
    - “Solution” architectures

[The required DoDAF artifacts for various DoD acquisition documents are shown in the diagram at right]

ICD – Initial Capabilities Document
CDD – Capability Development Document
ISP – Information Support Plan
TISP – Tailored ISP
CPD – Capability Production Document

Document	Supportability Compliance	DOD Enterprise Architecture Products (IAW DODAF) (see Note 5)																Data/Service Exposure Sheets	IA Compliance	GTG Compliance
		AV-1 /AV-2	OV-1	OV-2	OV-3	OV-4	OV-5	OV-6C	OV-7	SV-1	SV-2	SV-4	SV-5	SV-6	SV-11	TV-1	TV-2			
ICD			X																	
CDD	X	3	X	X	X	X	X	X			X	X	X	X		2	2	1	X	X
CPD	X	3	X	X	X	X	X	X	1		X	X	X	X	1	2	2	1	X	X
ISP	X	3	X	X	X	X	X	X	4		X	X	X	X	4	2	2	1	X	X
TISP	X	3	X		X		X	X		X			X	X		2	2	1	X	X
ISP Annex (Svcs/ Apps)	X	3	X				X				X	X	X	X		2	2	1	X	X
X	Required (PM needs to check with their Component for any additional architectural/regulatory requirements for CDDs, CPDs, ISPs/TISPs. (e.g., HQDA requires the SV-10c)																			
Note 1	Required only when IT and NSS collects, processes, or uses any shared data or when IT and NSS exposes, consumes or implements shared services,																			
Note 2	The TV-1 and TV-2 are built using the DISRonline and must be posted for compliance.																			
Note 3	The AV-1 must be uploaded onto DARS and must be registered in DARS for compliance																			
Note 4	Only required for Milestone C, if applicable (see Note 1)																			
Note 5	The naming of the architecture views is expected to change with the release of DODAF v2.0 (e.g., StdV, SvcV, StdV, DIV). The requirements of this matrix will not change.																			

Rules Analysis (2 of 4)

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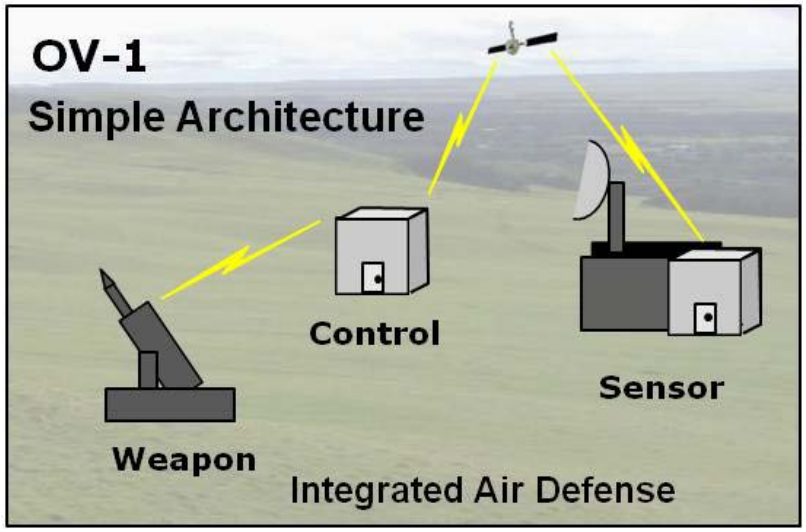
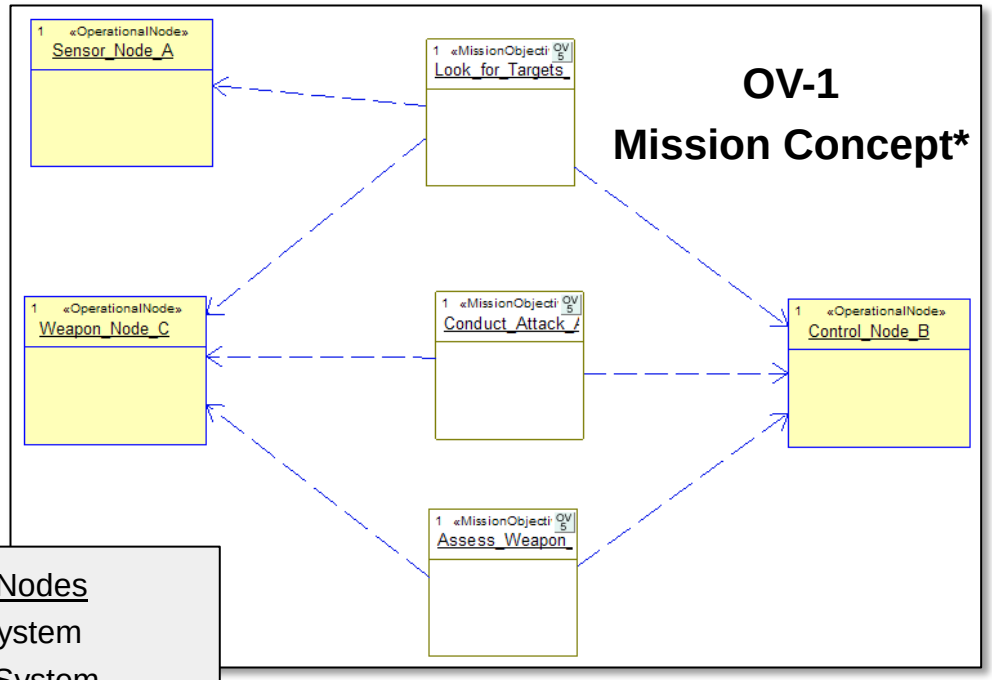
Example Architecture Developed





- Three Operational Nodes
  - Weapon Node
  - Control Node
  - Sensor Node
- Three Activity Diagrams
  - Look for Target (Critical Activity)
  - Conduct Attack (Critical Activity)
  - Assess Weapon Readiness
- Four System Nodes
  - Sensor System
  - Weapon System
  - C2 Engagement
  - C2 Inventory
- Two Interfaces
  - Sensor System to C2
  - C2 to Weapon System

Includes Models:

- OV-1 Graphic, Mission Concept (*Rhapsody specific)
- OV-2, OV-3. OV-4, OV-5, OV-6c, OV-7
- SV-1, SV-2, SV-3, SV-4, SV-5, SV-6, SV-10c

Rules Analysis (3 of 4)

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NetRAE v1.1 Rule Types

- Existence-type examples
  - Rule: “Is the OV-4 present?”
    - NetRAE v1.1: “OV-4 Organizational Relationship Chart exists.”
  - Rule: “Is the OV-7 present?
    - NetRAE v1.1: “OV-7 Logical Data Model exists.”
- Relationship-type examples
  - Rule: “Is the OV-5 linkage to OV-6c clear?”
    - NetRAE v1.1: “Each OV-5 maps to one or more OV-6cs.”
  - Rule: “Does the OV-5 include required operational nodes/activities?”
    - NetRAE v1.1: “Each OV-1 mission objective/node maps to an identical OV-5 activity/node.”

Compliance Enables the Evaluator to UNDERSTAND the Architecture

Rules Analysis (4 of 4)

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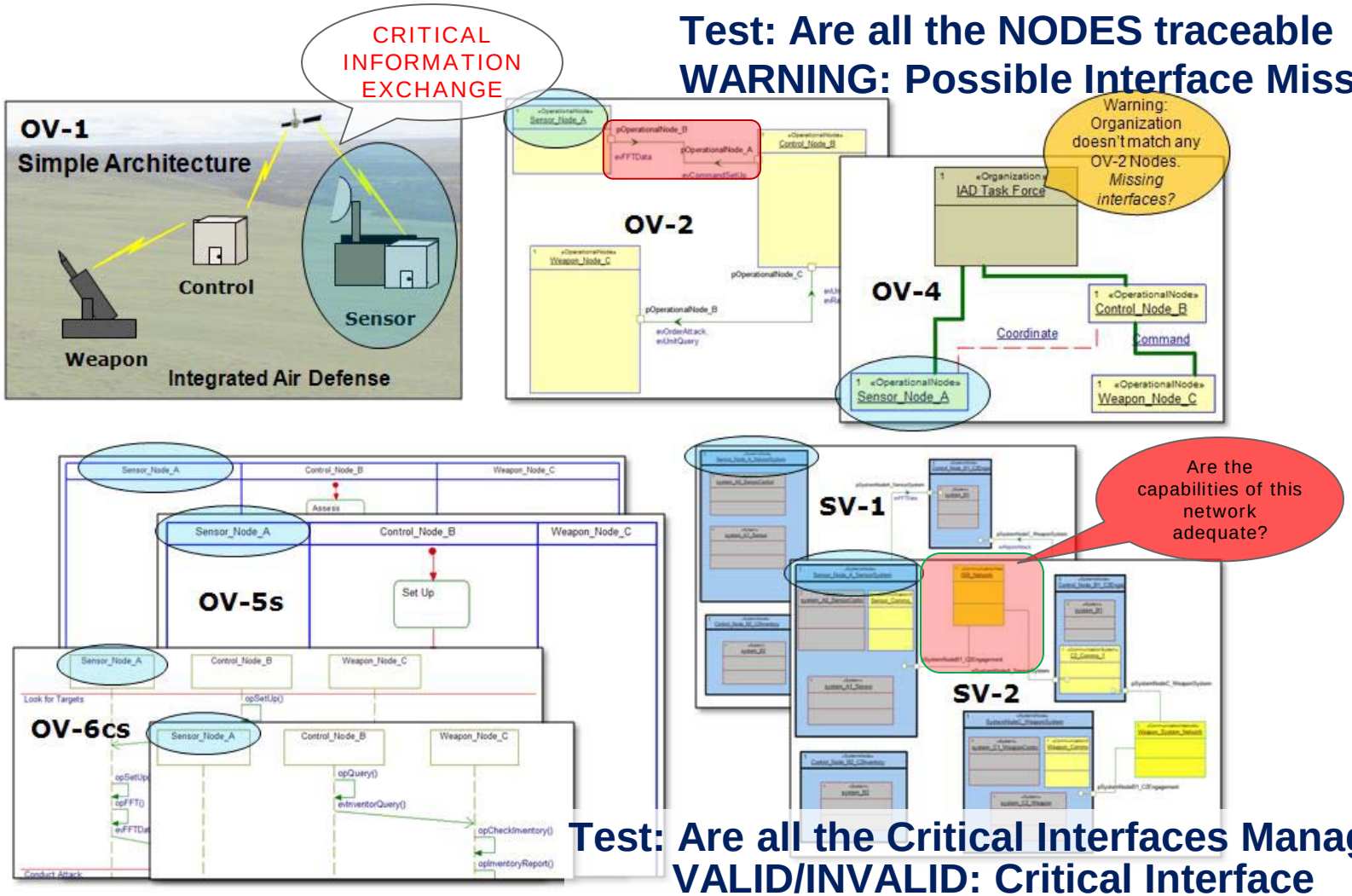

Test: Are all the NODES traceable
WARNING: Possible Interface Missing

Test: Are all the Critical Interfaces Managed
VALID/INVALID: Critical Interface

Inference Engine (1 of 4)

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Inference Engine Overview

Conclusions from comparing reasoning methodologies:

1. Possibility Theory (Fuzzy Logic) most straight forward approach to meet NetRAE's rule needs
2. Decision Trees second as viable option (depending mostly on input data and required rule set)

Metrics vs. Methods	Possibility Theory (Fuzzy logic)	Bayesian	Certainty Theory	Dempster-Shafer	Decision Trees
Lit search of "Compliance Auditing" using this method	Many	Some	None	None	Some
Academic community using methodology (over last 10 yrs)	Many	Many	Little	Some	Many
NetRAE assumed inputs fit model's inputs and assumptions	Yes	No	Yes	Yes	Most
Straight forward; easy to understand	Yes	Yes	No	No	Yes

Inference Engine (2 of 4)

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Rule-Based Design Definition

- User queries input data source (through inference engine) which searches testable data and produces results on the input data source
- Knowledge base is represented in the form of sets of rules (with varying levels of uncertainty) and includes semantic context of the input objects
- Attributes & relationships between objects of interest are detailed in the semantic network

Example of a production rule form (in the context of NetRAE)

IF <condition (or evidence)> THEN <conclusion (or hypothesis)>

where <condition> and <conclusion> are variants:

Condition	Conclusion
View A is Found	Rule is Valid
View A Element 1 is Not Found	Rule is Invalid
View A is Found & View A Element 1 is Not Found	Rule is Invalid
Relationship link 1 between views Found & Relationship link N between view Found	Rule is Valid
Etc … (any other variations of items using AND, OR, and NOT)	Etc …

Inference Engine (3 of 4)

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NetRAE Fuzzy Rules Example

Rule Identifier	View	Element	Rule	Found Results	Not Found Results
OpNodes_1	OV-2, OV-1	Operational Nodes	For a Node in OV-2, there is a representative Node in the OV-1.	Valid	Invalid
OpNodes_3	OV-2, OV-5	Operational Nodes Mapped to Operational Activities	For a Node in OV-2 there is at least one OV-5	Valid	Invalid
OpNodes_4	OV-2, OV-6c	Operational Nodes Mapped to Event Sequence Life Lines	For a Node in OV-2 there is at least one instance of a Liveline in at least one OV-6c	Valid	Invalid
OpNodes_2	OV-2, OV-4	Operational Nodes & Organization Nodes	For a Node in OV-2, there is a representative Node in the OV-4.	Valid	Warning
Op_Nodes_0	OV-1, OV-2, OV-3, OV-4, OV-5, OV-6c	For each Operational Node in OV-2	Provide results of OpNode_1 thru OpNode_4	Warning	Warning

Binary Results (0/1)

Non-Binary Results (0-1)

Inference Engine (4 of 4)

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Rules for OpNodes_2 (Non-Binary Results Desired)

- **OpNodes_2**: For a Node in OV-2, there is a representative Node in the OV-4

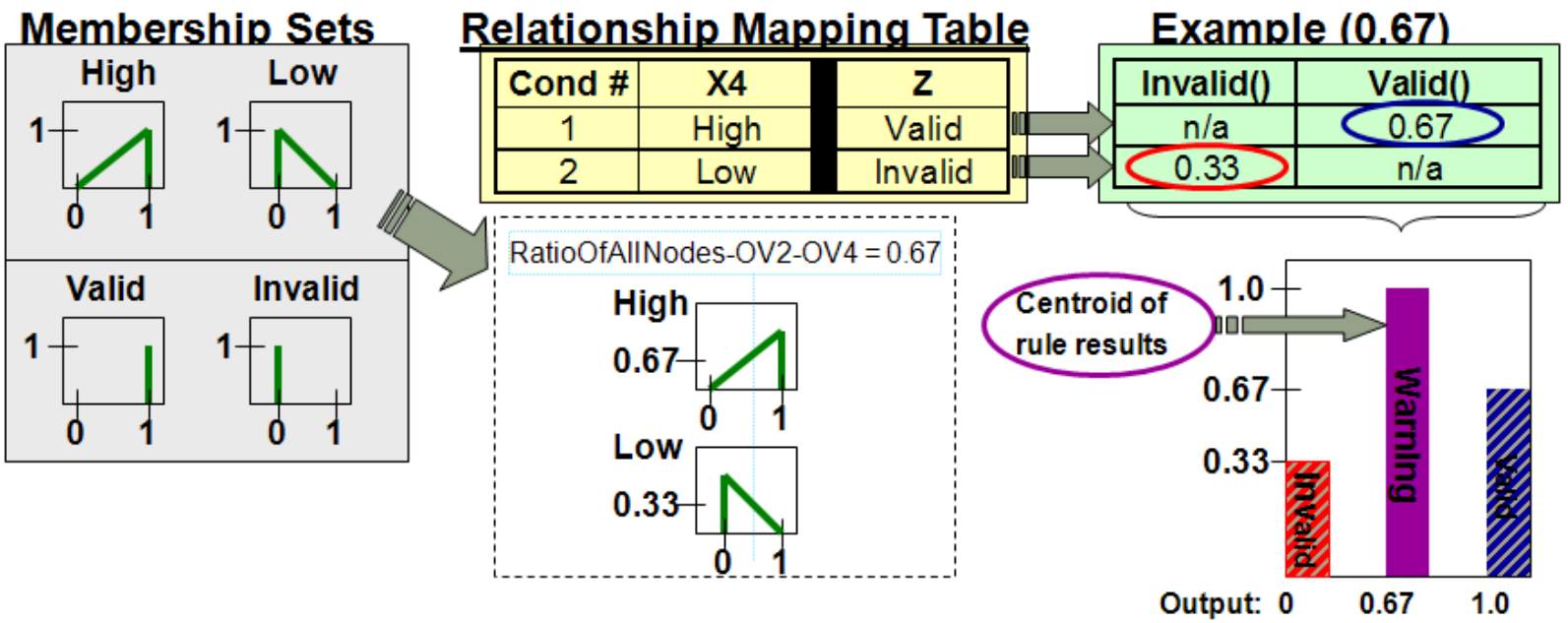
Example below assumes that 2 of 3 possible links between OV-2 & OV-4 were found

Rule Form

IF (RatioOfAllNodes-OV2-OV4 is X4) THEN (OpNodes_2 is Z)

$$\text{RatioOfAll Nodes - OV2 - OV4} = \frac{\text{\# of links found}}{\text{total OV2 nodes found}}$$

Definition of Non-Binary Input Variable:



Web Service and Client

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- Stated Need
  - Provide a connection to non-Rhapsody architecting tools
  - Provide a capability for users without Rhapsody knowledge
  - Reduce the number of Rhapsody licenses to be acquired
- Web Service
  - Supports local or remote (via network/internet) input of architecture and rules
  - Allows evaluation results to be returned via download
- Web Client
  - Client enables automation of architecture submission process
  - Client software needed due to complex data types required by Service
  - Client can be used to submit files and receive analysis report
  - Allows evaluations to be requested by person or automated by software

Future Directions

- **Research**
  - Natural language input
  - Develop method to evaluate artifacts provided by non-architecting tools
  - Explanation facility for possibility output
  - Learning algorithm for advanced inference engine
- **Development**
  - Incorporate DoDAF Metamodel (DM2) capability
  - Develop interface to other UML architecture tools (e.g. System Architect)
  - Secure user authorization for service
- **Prototype for Demonstration Testing**
  - Demonstrate implementation in tool of Possibility Theory algorithms
  - Leverage developed architecture prototypes
  - Provide JITC near term tool to assist existing architecture evaluations
- **Research funded by US Army BAA**
  - Organization: PEO / STRI (Simulation, Training and Instrumentation)
  - Title: “Network Systems Test Science & Technology (NST S&T)”
  - Timeframe: April 2008-2013, covering six annual multi-year efforts

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