Defense Acquisition in Transition
6th Annual Symposium

Acquisition Risks in a World of Joint Capabilities

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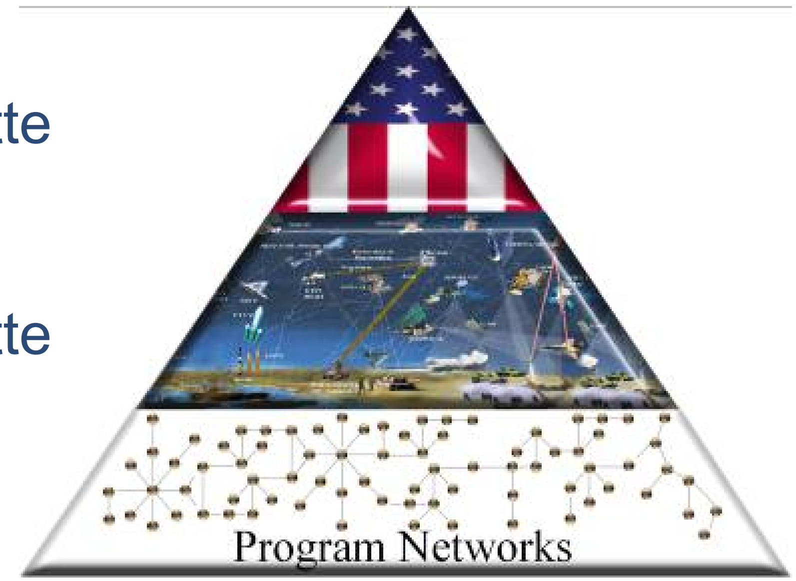

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Joint Capabilities

Join Capabilities and Network Centric Warfare

is an emerging theory of war based on the concepts of nonlinearity, complexity, and chaos. It is less deterministic and more emergent; it has less focus on the physical than the behavioral;

and it has less focus on things than on relationships

ADM Cebrowski

Complexity and Joint Capabilities

Nonlinear interaction	Combat forces composed of a large number of nonlinearly interacting parts
Decentralized Control	There is no master “oracle” dictating the actions of each and every combatant
Self-Organization	Local action, which often appears “chaotic,” induces long-range order
Non-equilibrium Order	Military conflicts, by their nature, proceed far from equilibrium. Correlation of local effects is key
Adaptation	Combat forces must continually adapt and coevolve in a changing environment
Collectivist Dynamics	There is a continual feedback between the behavior of combatants and the command structure

-- Moffat

Acquisition Reforms

Weapon Systems Acquisition Reform Act (WSARA) of 2009 Enacted as Public Law 111-23 on May 22, 2009

Implementing Management for Performance and Related Reforms to Obtain Value in Every Acquisition Act, or the IMPROVE Acquisition Act, by 417-3 on April 28.

Challenges with the requirements process are a major factor in poor acquisition outcomes

The requirements process for the acquisition of services is almost entirely ad hoc.

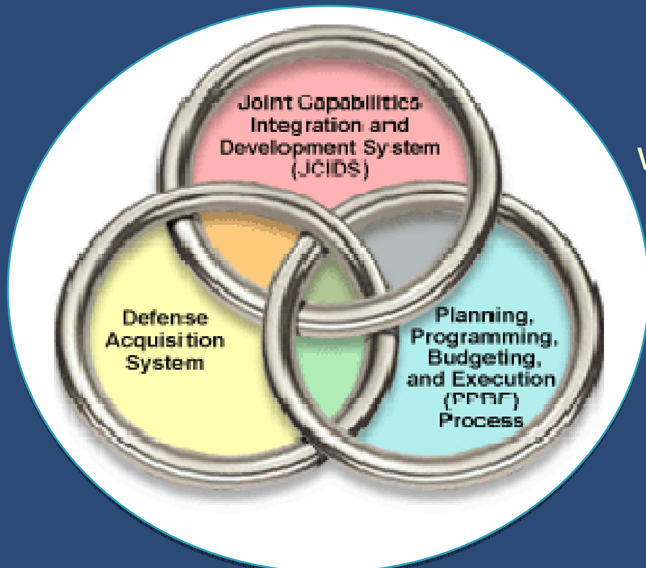
The process for developing requirements for the acquisition of weapon systems lacks the expertise and capacity required to vet joint military requirements.

Joint staff lacks some of the analytical expertise necessary to ensure that the JCIDS process rigorously vets proposed requirements

Joint Capabilities

An integrated approach to strategic planning, capabilities needs assessment, systems acquisition, and program and budget development.

To identify and assess joint military capability needs that serve as the basis for the development and production of acquisition programs



To assess and resolve gaps in military joint warfighting capabilities. To effectively integrate capabilities identification and acquisition provide capabilities-based approach to requirements generation

To provide joint analytic decision support with PPBE milestones

Because the future operating environment will be characterized by uncertainty, complexity, rapid change, and persistent conflict, DoD leadership has explicitly sought the capability to act jointly

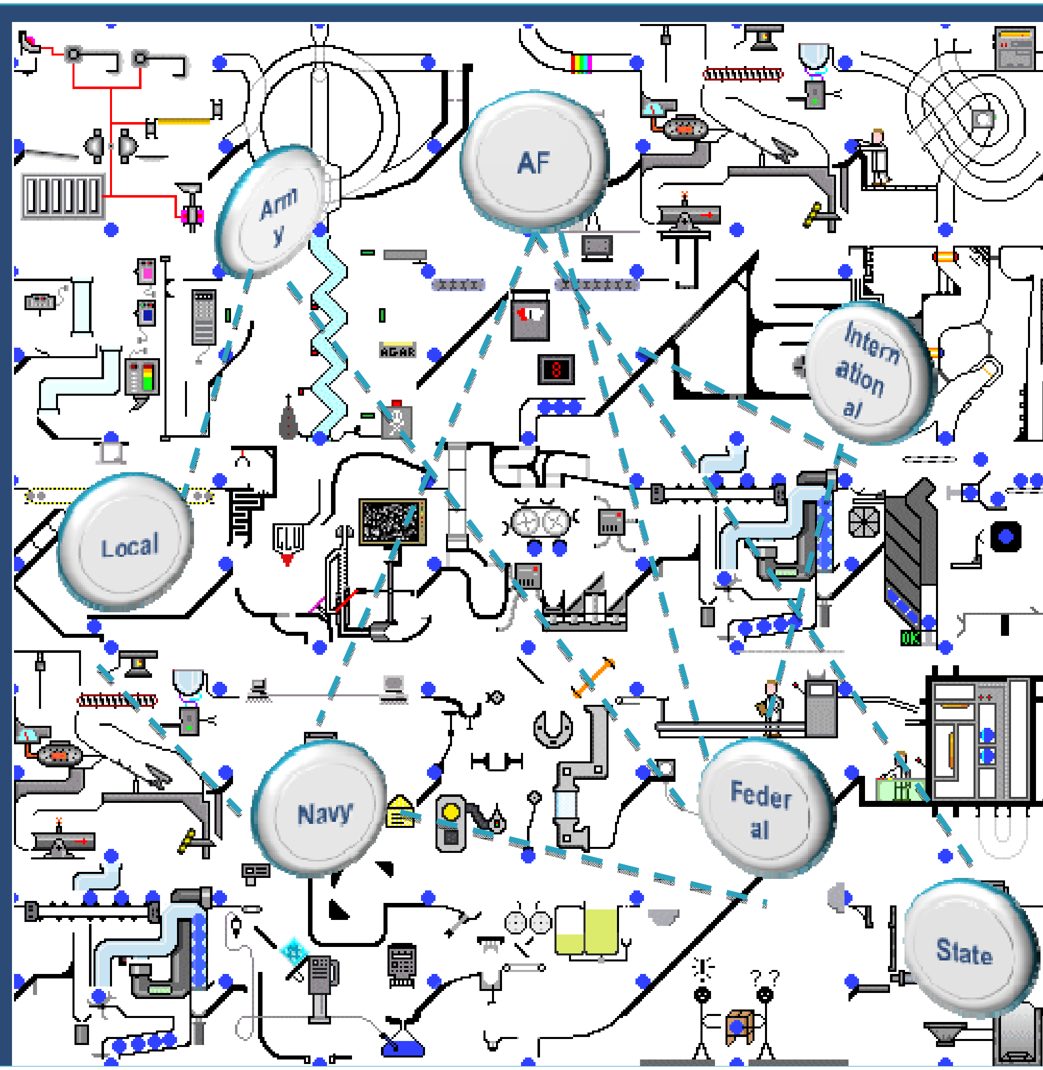
Interdependency :: Complexity

Complexity is based on

relations, and by

extension,

principles of organization



Research Goals

Are to identify the:

- Characteristics,
- Behavior, and
- Effects

of the Programmatic Networks that drive Joint Capabilities and Network Centric Activities

Vulnerabilities

- Incomplete Information
- Incomplete Payoff Structures
- Inability to Isolate Cause and Effect
- Unknown Response Options
- Multiple and Conflicting Representations of Environmental Variety
- Perturbations
- Multiple Constraints

- labor allocations
- production
- consumption
- investment decisions

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Vulnerabilities

Bandwidth

Congestion

Noise

Stability

Redundancy

Transaction Costs

Reliability

Integrity

Performance

Cost Overruns

Schedule Delays

Feature Shortfalls

Interdependency Dimensions

Direction

- Pooled
- Sequential
- Reciprocal

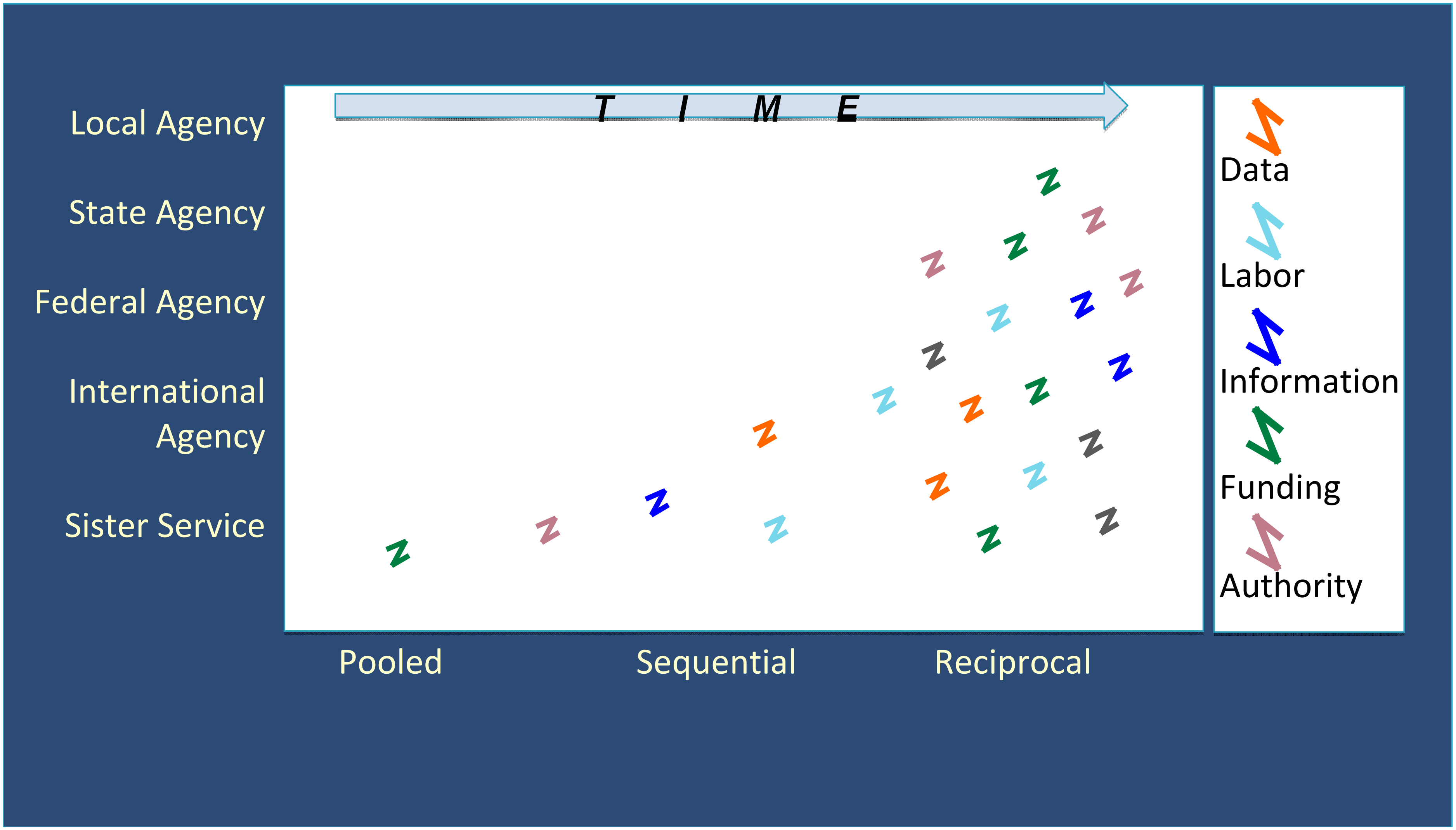
Resource

- Financial
- Data
- Authority
- Labor
- Information

Agency

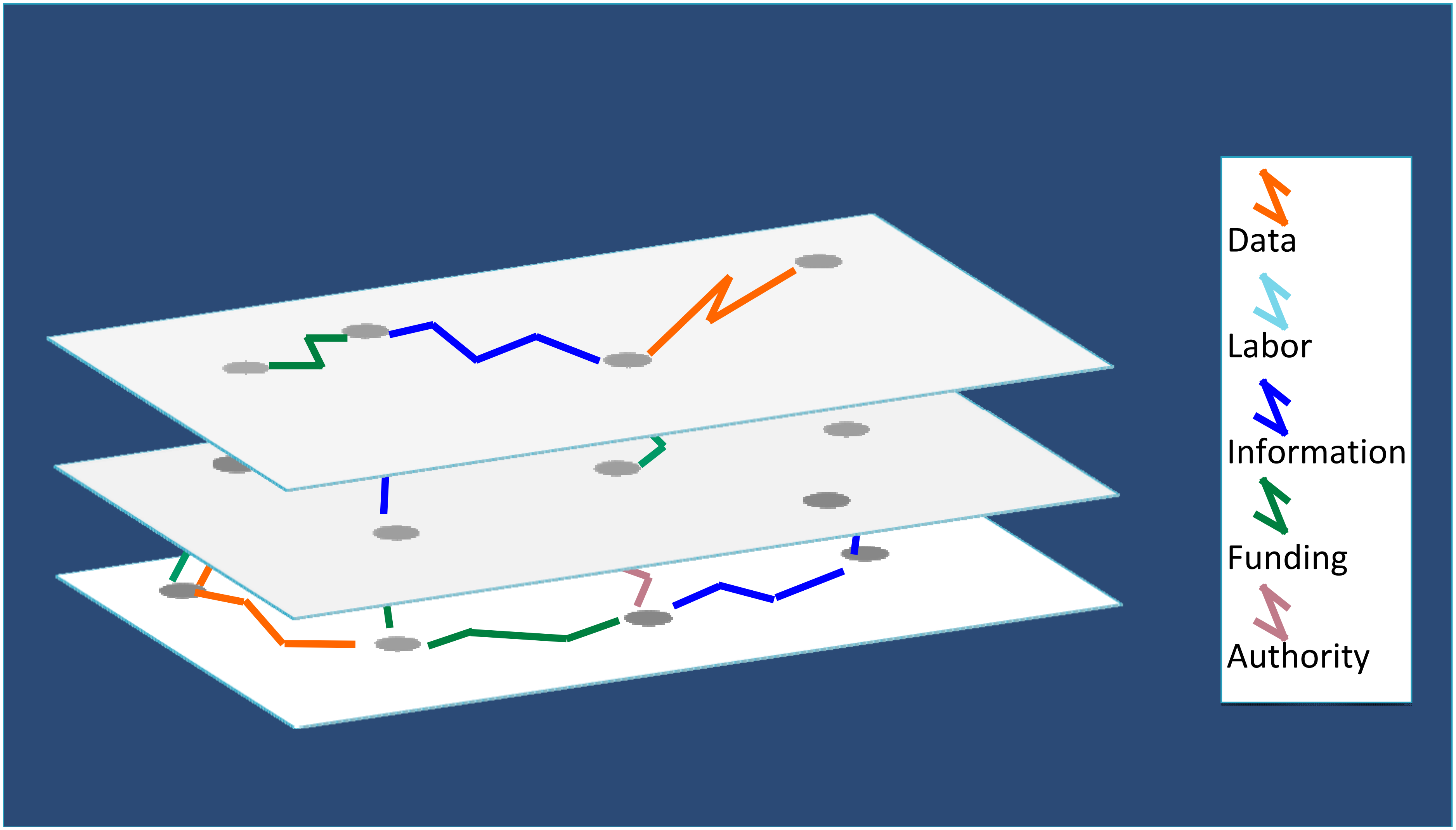
- Service
- Government
- International
- Contractor

Pattern Illustrations



Pattern & Binding Illustrations

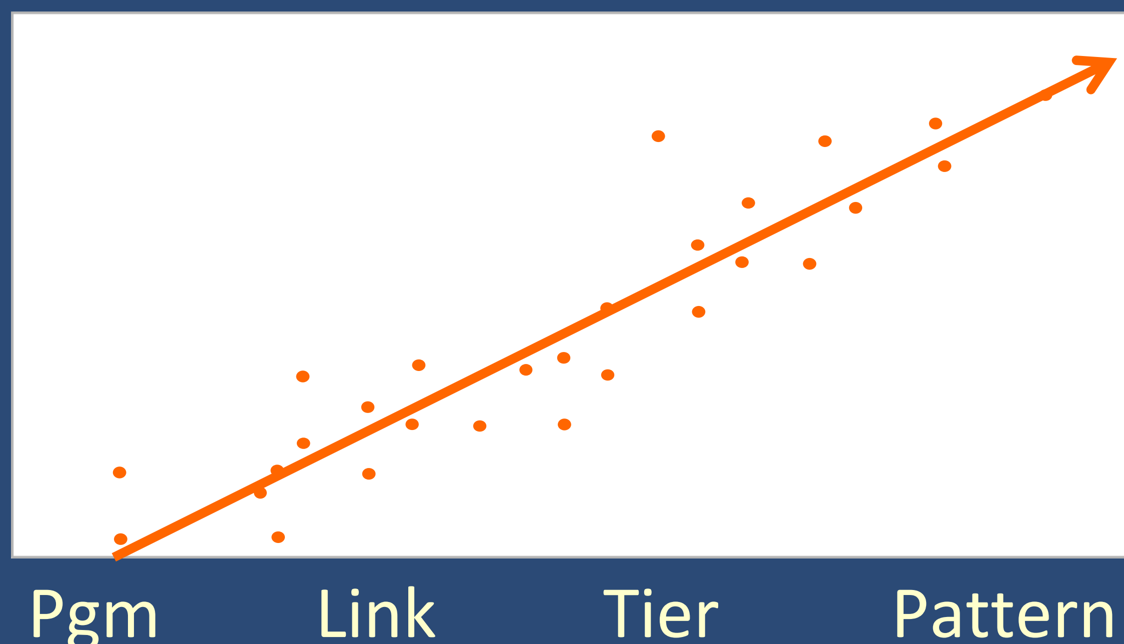
Program, Link, Tier, Pattern Knowledge



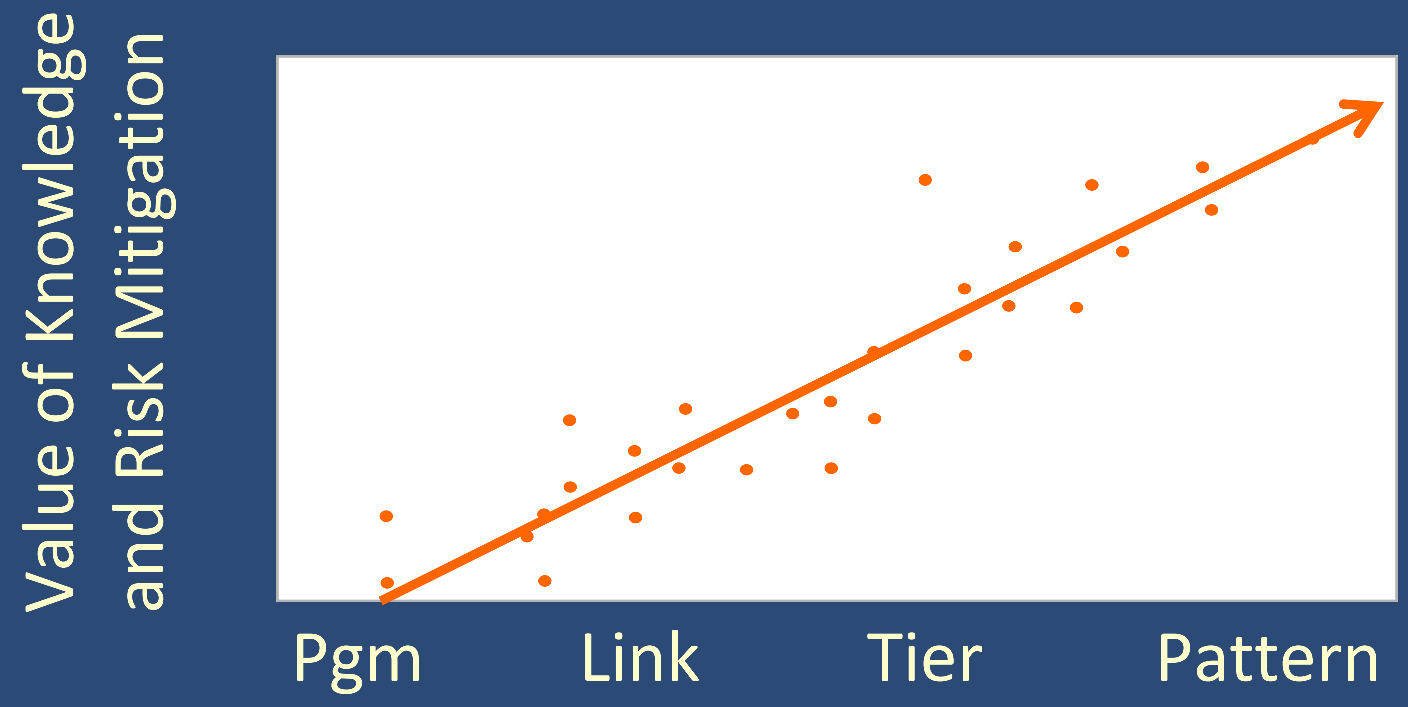
Value Proposition

Knowledge of:

Bandwidth
Congestion
Noise
Redundancy
Instability



Value Proposition



Research Objectives

Applied Research :: 2010

- Map program interdependence to reveal the directionality of influence of cause-effect relationships

- Test the cascading risks that upstream programs exert on downstream programs in light of data and funding exchanges

- Test the extent to which the cost overruns & schedule delays of upstream programs cascade on to interdependent downstream programs

- Employ the findings to make recommendations on potential governance mechanisms that may prove capable of mitigating the risks of interdependencies

- Provide a research code book of acquisition data elements for future research efforts

Data Interdependencies

Growing Interdependencies and Growing Complexity

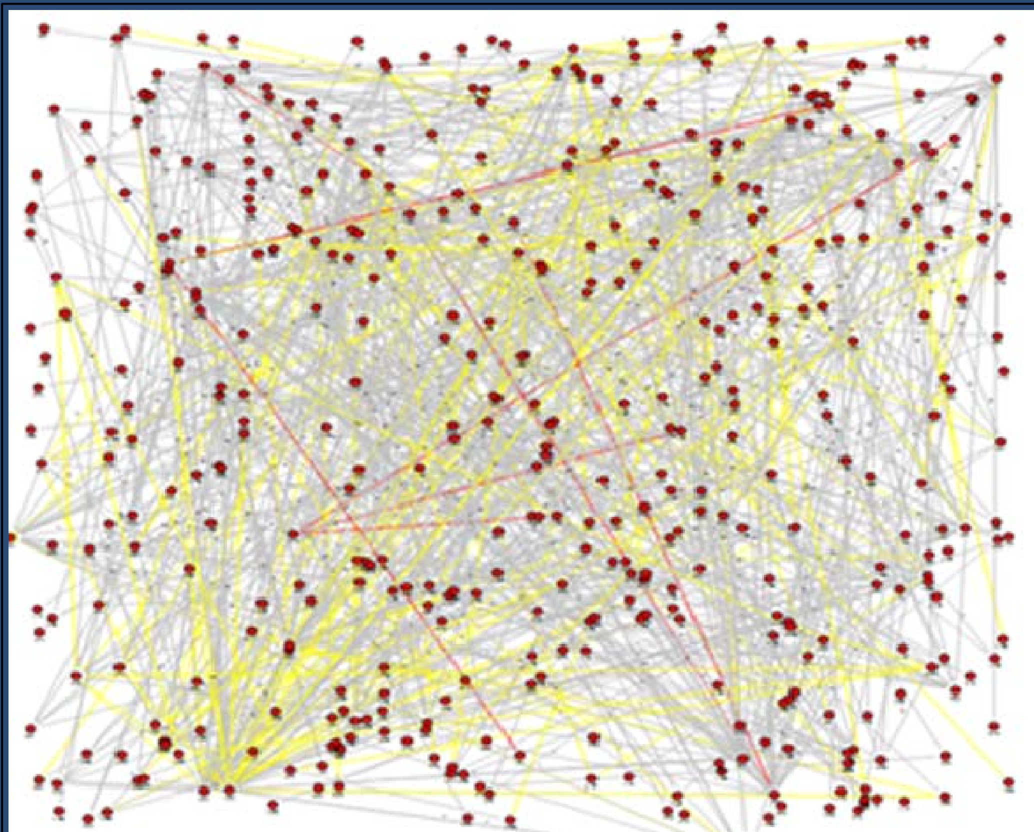
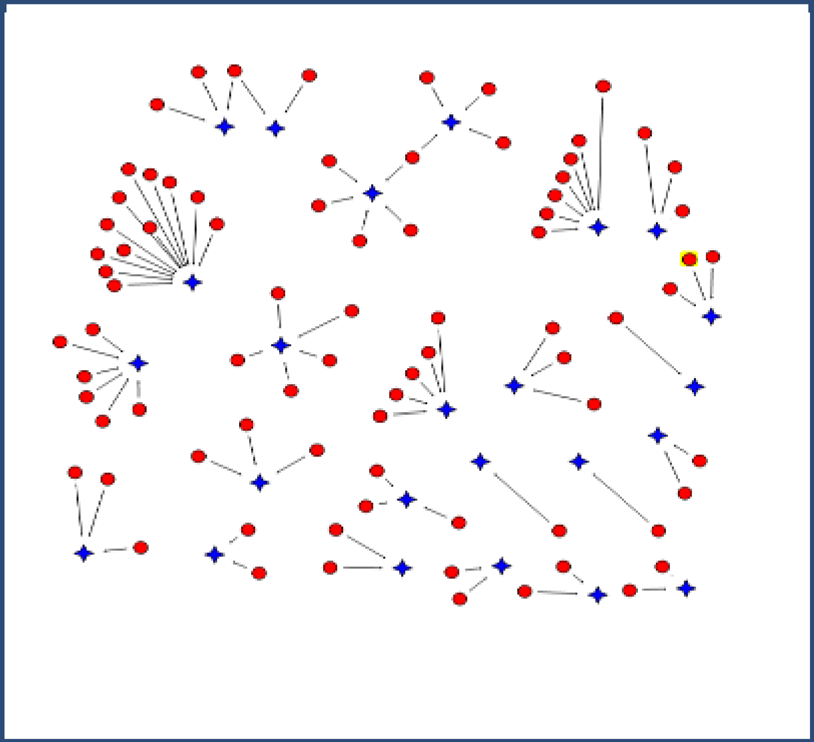


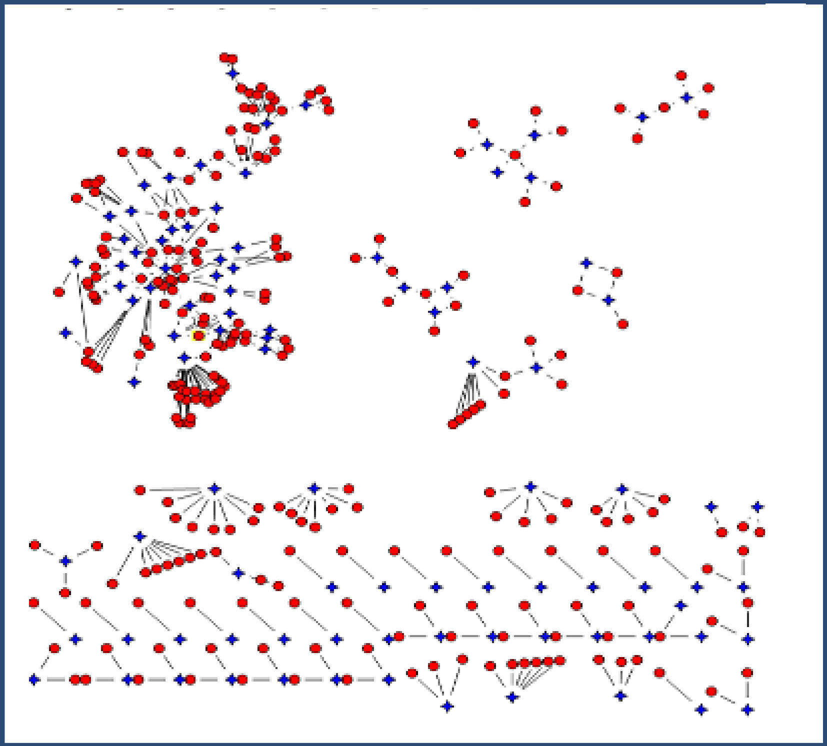
Figure 1: MDAP Data Interdependencies in 2005

Program Element Interdependencies

Growing Interdependencies and Growing Complexity



PE MDAP Relationships 1997



PE MDAP Relationships 2007

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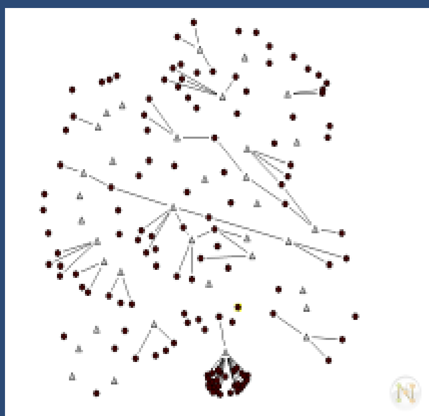
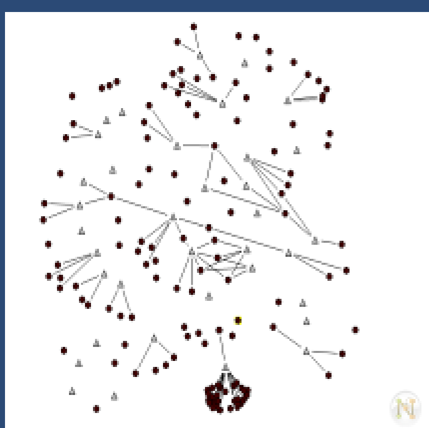
Program Element Interdependencies

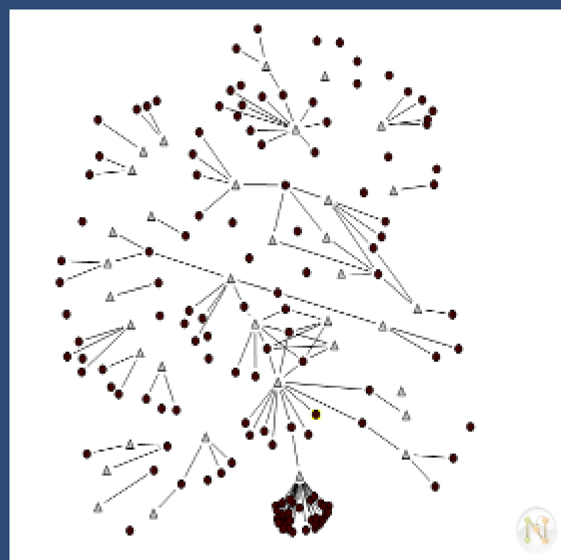
Growing Interdependencies and Growing Complexity



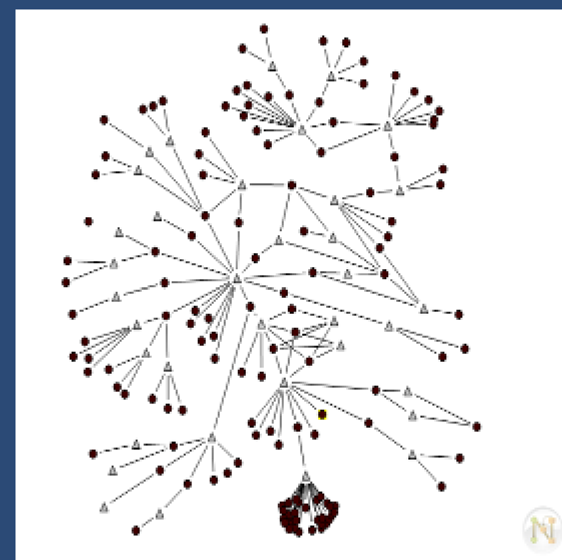
2004



2005

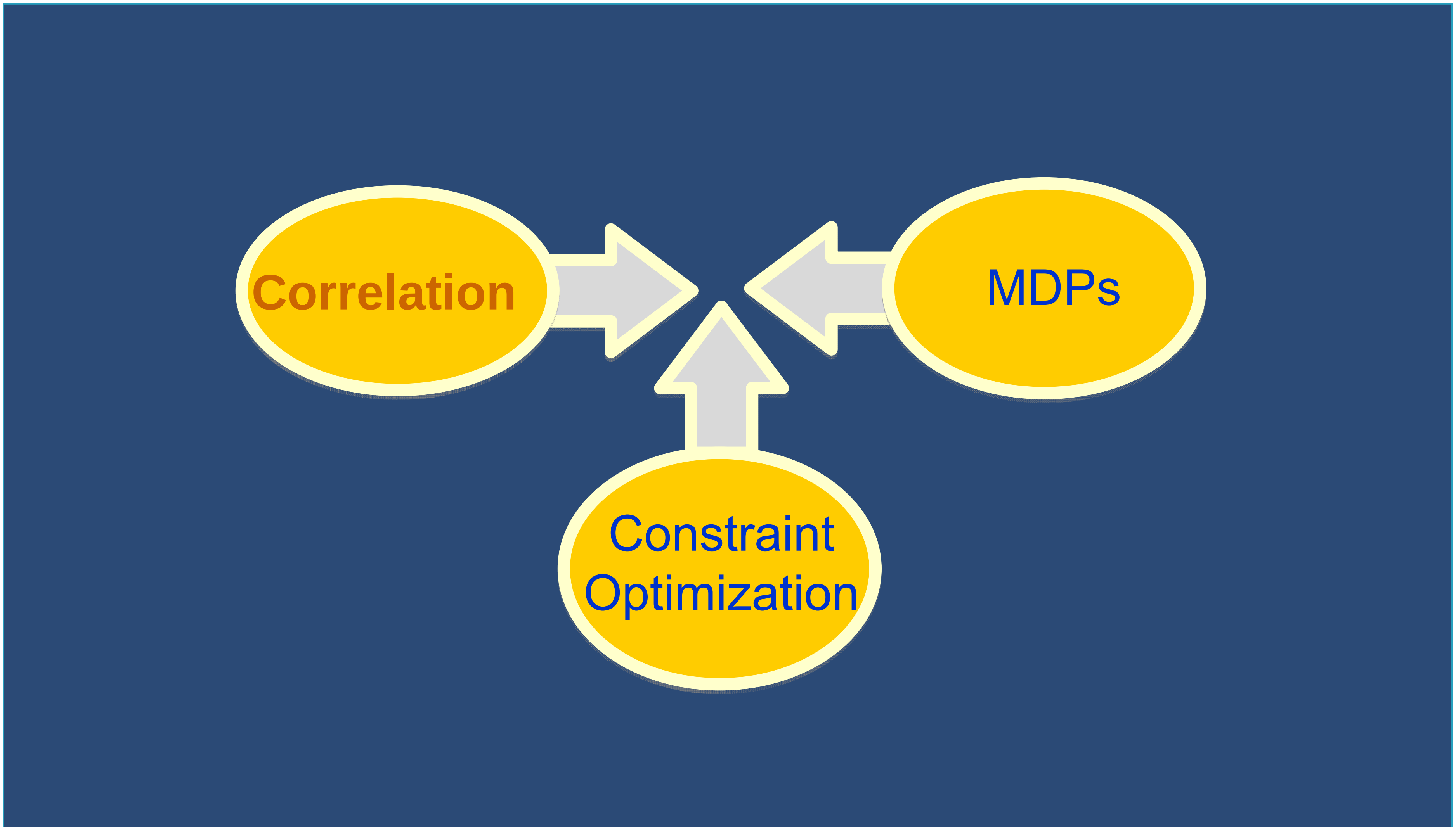


2006

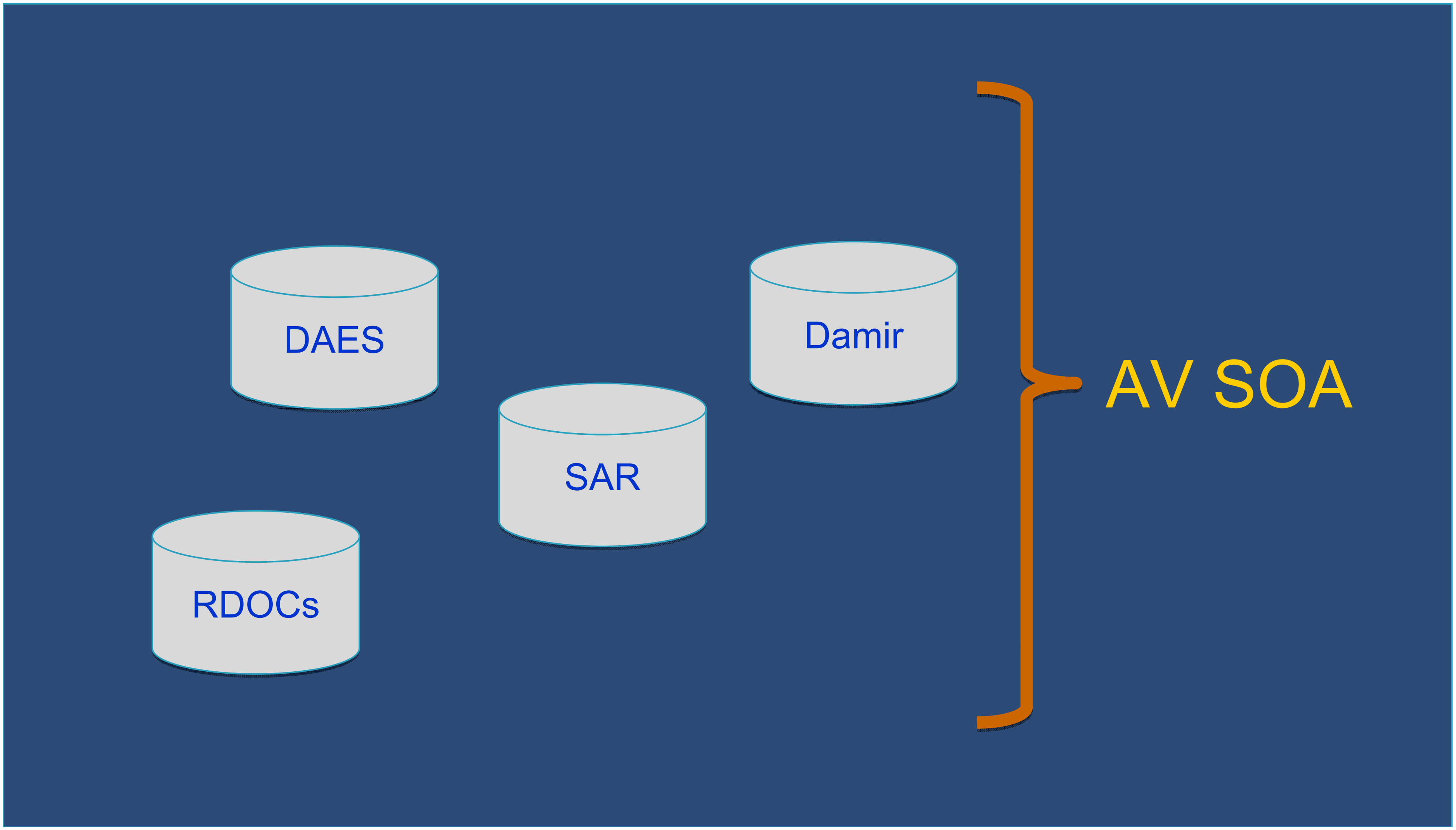


2007

Nonlinear and Linear Methods



Datasets



Variables

Data Exchange

Interdependencies

APB Schedule ::
APB Performance Breaches ::
APB RDT&E Breaches ::
PAUC Breaches

Total Cost Variance ::
Engineering Cost Variance ::
Schedule Cost Variance ::
Estimation Cost Variance ::

Percent Cost Growth

Preliminary Results: Correlation Coefficients

Program Manager's Perception of Data Risk (2005-2007)

Self

Engineering Cost Variance	-.08*
Performance Breaches	.11*
RDT&E Breaches	.13**

Downstream

Total Cost Variance	-.12**
Engineering Cost Variance	-.22**
Estimation Cost Variance	-.11*
Performance Breaches	.13**
RDT&E Breaches	.09*
PAUC Breaches	.12**

Correlation

Correlation Coefficients

Preliminary Results :: Lagged by One Year

Sender APB Performance Breaches ::

Downstream RDT&E Breaches .07*

Sender Total Cost Variance ::

Downstream Schedule Cost Variance .09*

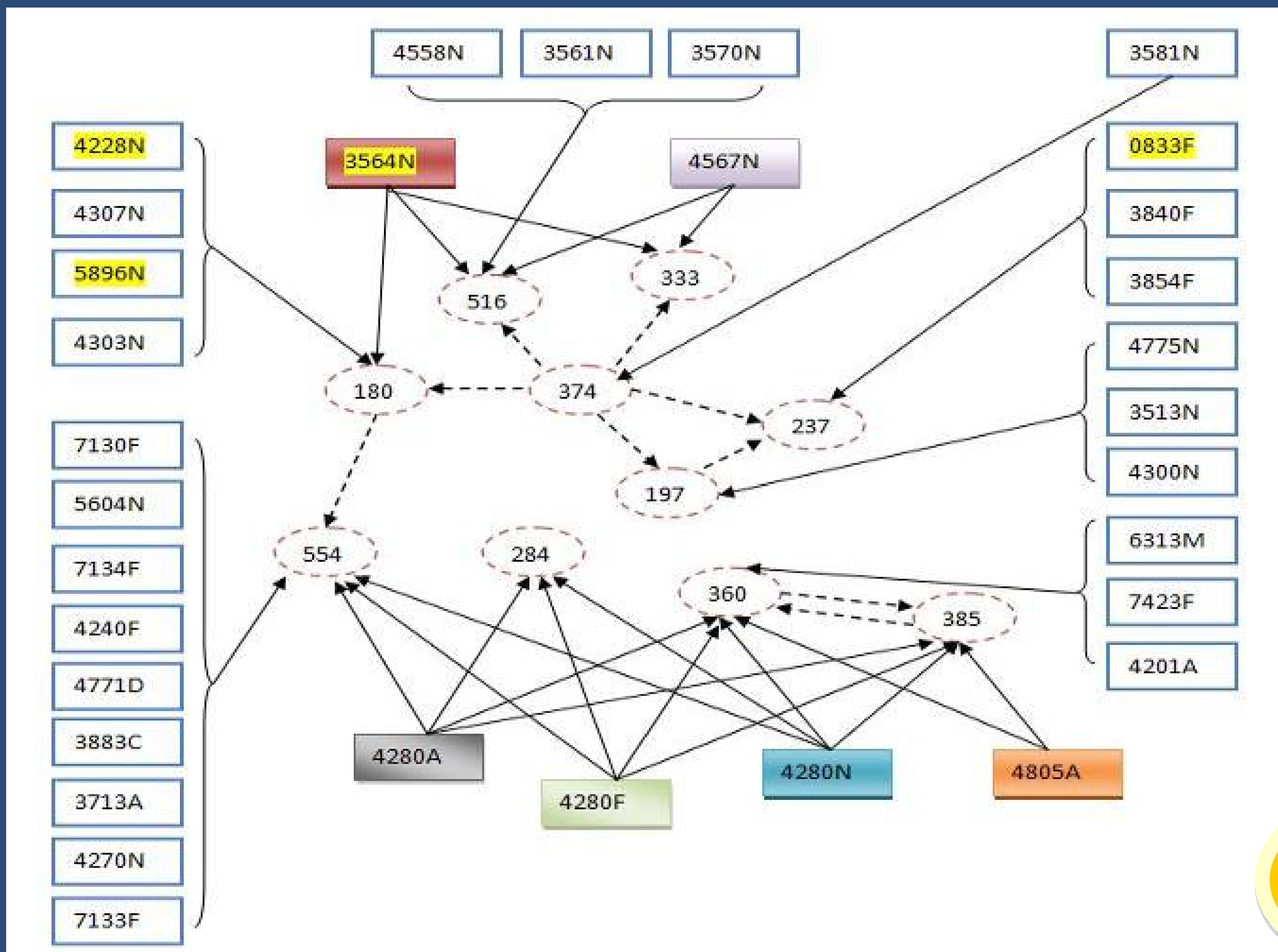
Sender Engineering Cost Variance ::

Downstream Percent Cost Growth .12**

Upstream Influence on Downstream Programs

Correlation

Network of 10 nodes in 2006



MDP

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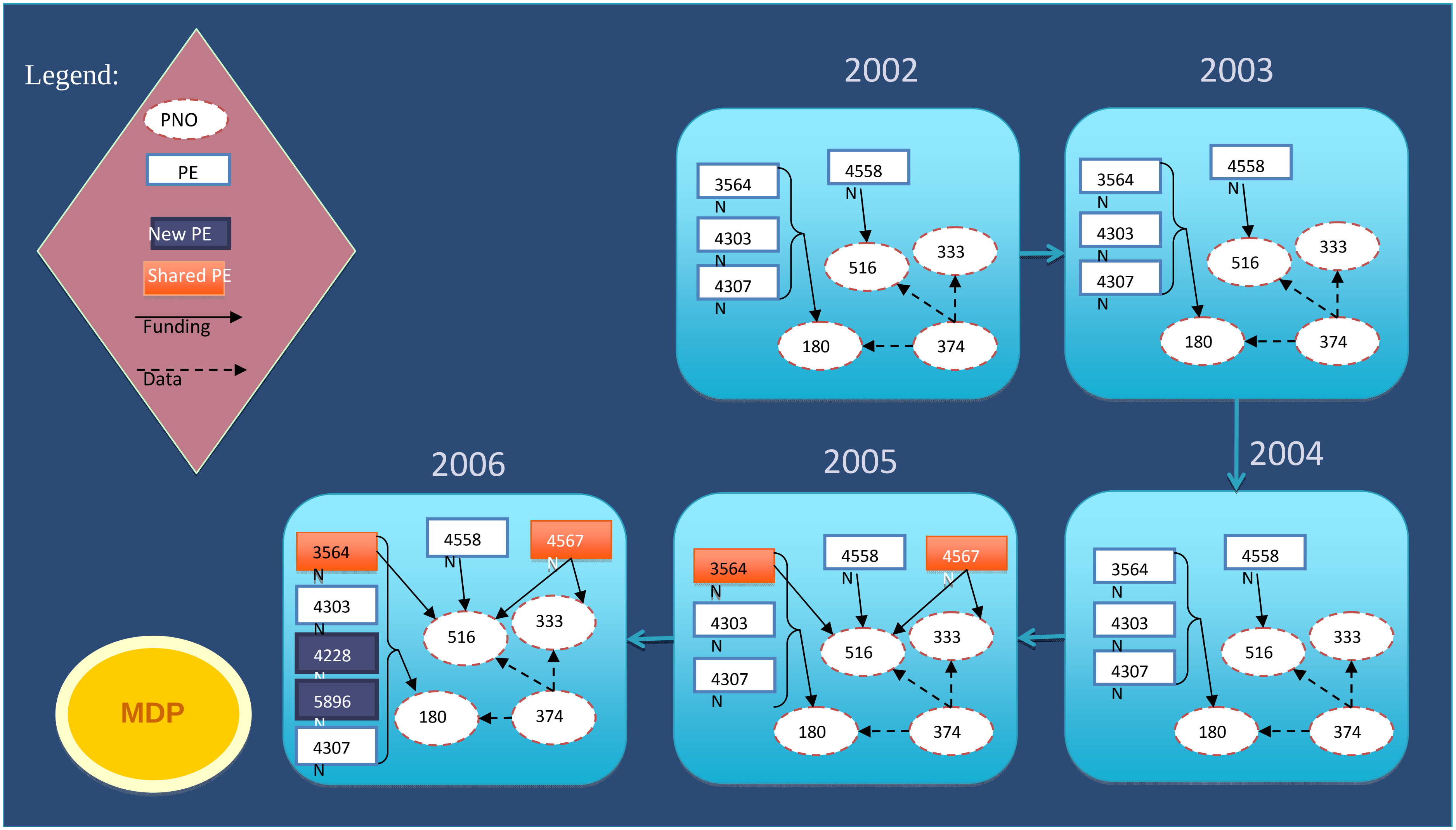
Network Evolution over Time

From the perspective of PNO 180



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Markov Decision Processes

R ... ty is key.

... nes over time to support

MDP ... sequential decision making.

Computing optimal p ... gramming will
support non-myopic d

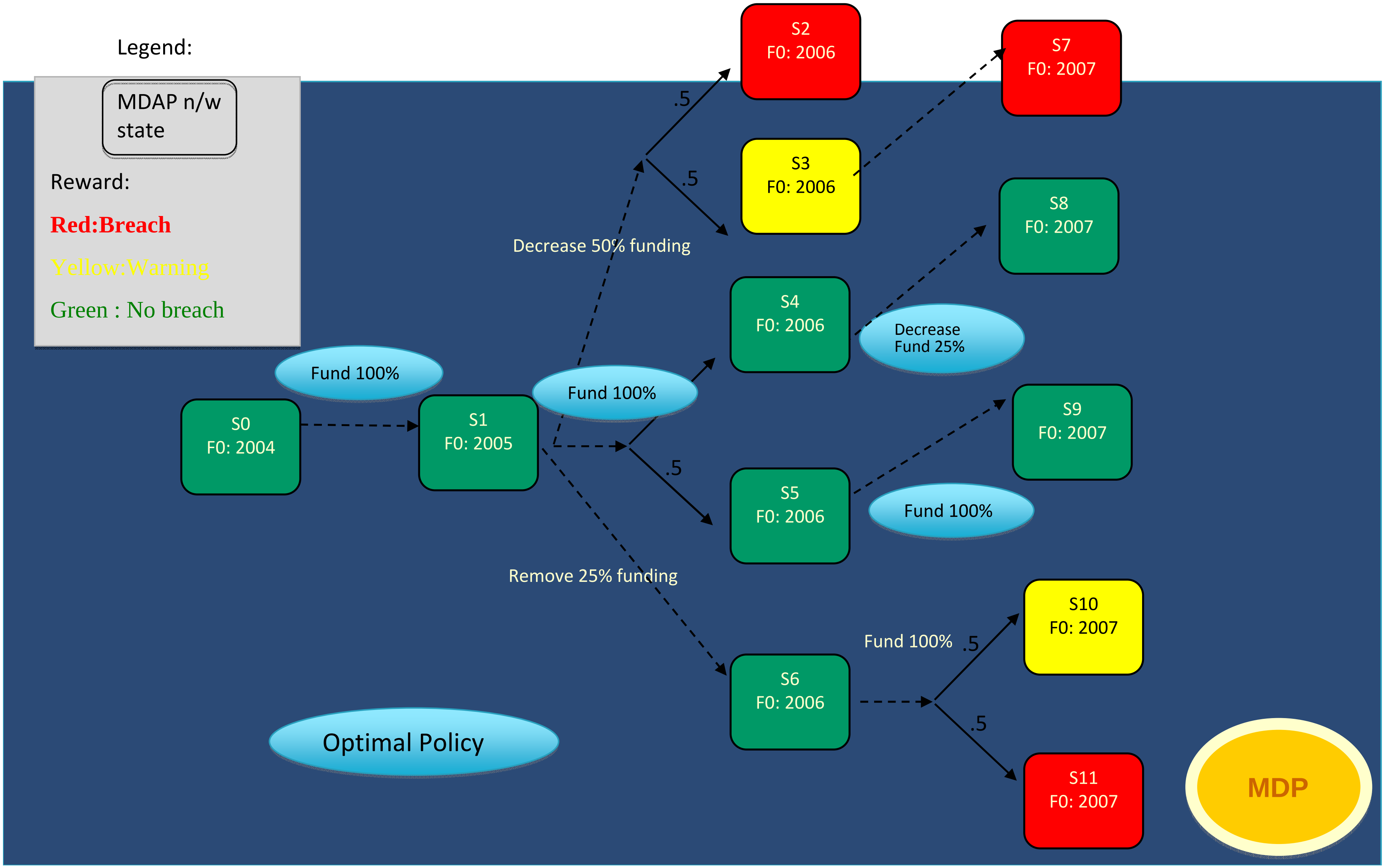
Interested in studying the effects of subtle changes on the overall behavior of the MDAP network !

First order and second interdependencies among MDAPS

And sequential effects!

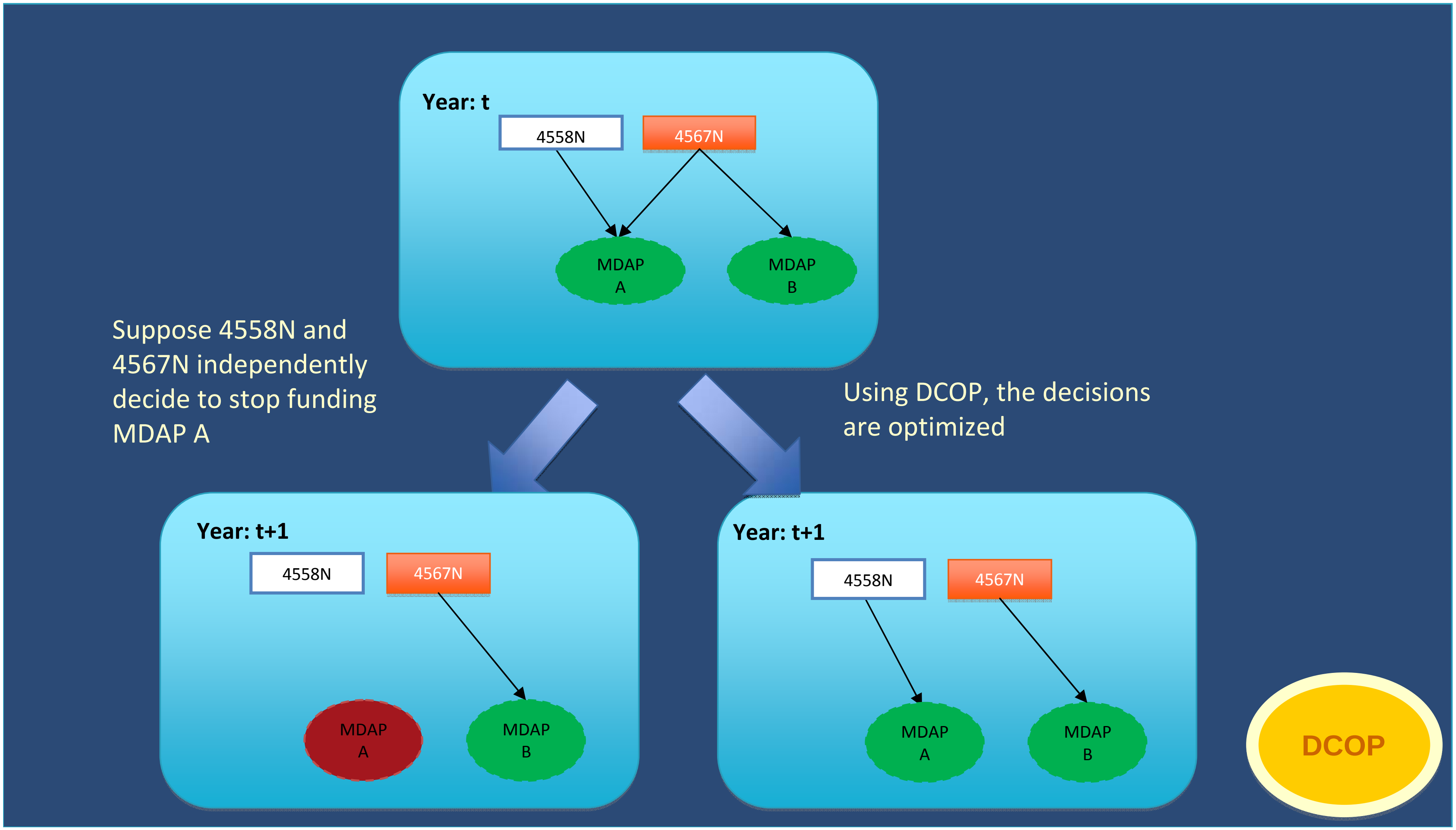
MDP

Sample MDP of a MDAP network



Distributed Constraint Optimization

Study effect of distributed "What if" questions on MDAP n/w



Data Acquisition Road Blocks

Missing Data in a 10 node network

- PAUC data from 2002 to 2006 is incomplete:
  For e.g. Data for critical node PNO 374 is missing.

- Funding proportion data from 2004-2007 is incomplete:
  PNO 180 only has 2005-2007 data.

- ~ 40% of "PNO spending under PE" data in this set not available.

Next Steps

• Map program interdependence to reveal the directionality of the influence of cause-effect relationships	✓ *Add 2008 - 2009*
• Test the cascading risks that upstream programs exert on downstream programs in light of data and funding exchanges	✓ *Test 2005 - 2009*
• Test the extent to which the cost overruns & schedule delays of upstream programs cascade on to interdependent downstream programs	✓ *Test 2005 - 2009*
• Employ the findings to make recommendations on potential governance mechanisms that may prove capable of mitigating the risks of interdependencies	✓ *December*
• Provide a research code book of acquisition data elements for future research efforts	✓ *December*

Back up Slides

Markov Decision Process (MDP) model

MDP Factored State Features:

- F0: Year
- F1: Current PNO ID and % change in its PAUC
- F2: Set of PE(s) funding PNO
- F3: Engineering cost variance
- F4: Schedule cost variance
- F5: Estimation cost variance
- F6: PEs with funding relationships and PAUC % change
- F7: PEs with data relationships and PAUC % change

MDP

MDP model

Action, Transition, Reward

- Action space: Cross product of diversity features
    - <Total # of PES> X <# of funding services>
    - Other diversity features being studied are level of funding; command levels; # of intl partners; joint requirements.
- Transition Probabilities: Obtained statistically from generalizations of past data from 2002-2007
- Reward Function: Based on Nunn – Mccurdy breach threshold
    - Red: PAUC% >15%;
    - Yellow: 5% -15%
    - Green: PAUC %< 5%

MDP

Reward transition for PNO 180

Distributed Constraint Optimization

Given:

- Variables {x1, x2, …, xn},
- Finite, discrete domains D1, D2, … , Dn,
- For each xi, xj, valued constraint fij: Di x Dj $\rightarrow$ N.

Goal:

- Find complete assignment A that maximizes/minimizes F(A) where, F(A) = S $f_{ij}(d_i,d_j)$, $x_i \leftarrow d_i, x_j \leftarrow d_j$ in A

MDP

Value of Information in Decision Networks

Supporting Joint decision making by multiple Program Managers

Value of Computation

- Captures the value of being able to know "not only additional uncertainties but also additional decisions already made by other team members" before making some other decisions in the team decision situation.

Influence diagram

- Generalization of a Bayesian network
- Structured to accommodate team decision situation where incomplete sharing of information among team members can be represented and solved very efficiently.