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Computationally Derived Models of Adversary Organizations

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Abstract—**An extension to the lattice algorithm for designing decision-making organizations subject to cultural constraints is presented. Hofstede dimensions have been used to incorporate cultural attributes in the design process in the form of constraints on the allowable interactions within the organization. An example is used to illustrate the approach.**

***Index Terms*—Organization Design, Petri Nets, Cultural Dimensions, Decision Maker**

I. INTRODUCTION

The effort to model organizational behavior with mathematical models has a long history. The groundbreaking work of Marshak & Radner [1] looked at the communications between organization members; today we would call this connectivity and associated information flows. Drenick [2] proposed a mathematical theory of organization in which a number of fundamental system theoretic ideas were exploited to draw insights for the design of organizations consisting of members who process tasks under time constraints – a form of Simon's [3] bounded rationality. Levis [4] and his students developed a discrete event dynamical model and a set of rules that governed the allowed interactions – whether they represented forms of information sharing or of commands. This model, expressed mathematically in the language of Colored Petri Nets [5], allowed the design of organizational architectures that could meet accuracy and timeliness constraints while not exceeding the workload limitations of the decision makers. Essentially, the organization members conducted information processing and decision making tasks, often supported by decision support systems in order to reduce workload, while increasing accuracy and timeliness of the organizational response [6].

The basic model of the single decision maker evolved over time in order to accommodate more complex interactions and allow for different types of internal processing by the organization members[7]. The early focus was on small teams in which several members needed to be organized to perform a demanding, time-sensitive task.

The objective was to achieve organizational performance without causing excessive workload that would lead to performance degradation.

A key objective, relating structure to behavior, meant that the structure and attributes of the simulation models must be traceable, in a formal way, to the architecture design. Hence the use of the term "executable" model which denotes that there is a formal mathematical model used for simulation with characteristics that are traceable to the static designs. The mathematical model can also be used for analysis, i.e., properties of the model and performance characteristics can be determined from the mathematical description. A wealth of theoretical results on discrete event dynamical systems, in general, and Colored Petri nets, in particular, can be applied to the executable model.

More recently, the problem of modeling adversary organizations about which we may have limited information has received renewed attention. Adversaries may have differences in equipment or materiel, differences in command structures, differences in constraints under which they can operate, and, last but not least, differences in culture. The differences in equipment and in operational constraints can be handled easily in the existing modeling framework. Differences in command structures require some additional work to express these differences in structural and quantitative ways. The real challenge is how to express cultural differences in these, primarily mechanistic, models of organizations.

Other considerations that drive the design problem are the tempo of operations and whether the adversary has an explicit organization, as a military force would have, or an implicit one, as a loosely coupled terrorist organization may have. This work focuses on the ability to introduce attributes that characterize cultural differences into the mechanistic model for organization design and use simulation to see whether these parameters result in significant changes in structure. The objective, therefore, is to relate performance to structural features but add attributes that characterize cultural differences. Specifically, the attributes or dimensions defined by Hofstede [8] are introduced in the design process in the form of constraints on the allowable interactions within the organization.

In Section II, the modeling approach is described briefly since it has been documented extensively in the literature. In Section III, the Hofstede dimensions are introduced and then applied to the organization design algorithm. In Section IV, an illustrative example is presented. In the final section, advantages and shortcomings of this approach are discussed.

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II. THE DECISION MAKER MODEL AND ORGANIZATIONAL DESIGN

The five-stage interacting decision maker model [7] had its roots in the investigation of tactical decision making in a distributed environment with efforts to understand cognitive workload, task allocation, and decision-making. The five-stage model allows the algorithm in each stage to be defined and makes explicit the input and output interactions of the decision maker with other organization members or the external environment. It also has a well-defined algorithm for characterizing workload. This model has been used for fixed as well as variable structure organizations [9].

The five-stage decision maker (DM) model is shown in Figure 1. The DM receives signals from the external environment or from another decision maker. The Situation Assessment (SA) stage represents the processing of the incoming signal to obtain the assessed situation that may be shared with other DMs. The decision maker can also receive situation assessment signals from other decision makers within the organization; these signals are then fused together in the Information Fusion (IF) stage to produce the fused situation assessment. The fused information is then processed at the Task Processing (TP) stage to produce a signal that contains the task information necessary to select a response. Command input from superiors is also received. The Command Interpretation (CI) stage then combines internal and external guidance to produce the input to the Response Selection (RS) stage. The RS stage then produces the output to the environment or to other organization members.

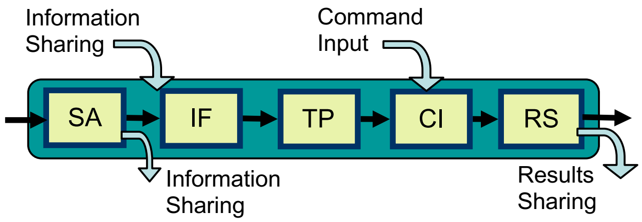

Fig. 1. Model of the Five-Stage Decision Maker

The key feature of the model is the explicit depiction of the interactions with other organization members and the environment. These interactions follow a set of rules designed to avoid deadlock in the information flow. A decision maker can receive inputs from the external environment only at the SA stage. However, this input can also be another decision maker's output. A decision maker can share his assessed input with another organization member; this is depicted as an input to the IF stage when the decision maker is receiving a second input. This input must be generated from another decision maker and can be the output of the SA or RS stage. In the CI stage, the decision maker can receive commands. This is also internally generated and must originate from another decision maker's RS stage. Thus the interactions between two decision makers are limited by the constraints enumerated above: the output from the SA stage, can only be an internal input to another decision maker's IF stage, and an internal output from the RS stage can only be input to another decision maker's SA stage, IF stage, or CI stage.

The mathematical representation of the interactions between DMs is based on the connector labels e_i, s_i, F_{ij}, G_{ij}, H_{ij} and C_{ij} of Fig. 2; they are integer variables taking values in {0, 1} where 1 indicates that the corresponding directed link is actually present in the organization, while 0 reflects the absence of the link. These variables can be aggregated into two vectors **e** and **s**, and four matrices **F**, **G**, **H** and **C**. The interaction structure of an n-decision-maker organization may be represented by the following six arrays: two n x l vectors **e** and **s**, representing the interactions between the external environment and the organization:

$$\mathbf{e} = [e_i], \quad \mathbf{s} = [s_i] \quad \text{for i } 1, 2, \dots, n$$

and four n x n matrices **F**, **G**, **H** and **C** representing the interactions between decision makers inside the organization. Since there are four possible links between any two different DMs, the maximum number of interconnecting links that an n-decision-maker organization can have is

$$k_{max} = 4n^2 - 2n$$

Consequently, if no other considerations were taken into account, there could be $2^{k_{max}}$ alternative organizational forms. This is a very large number: 2^{90} for a five-person organization.

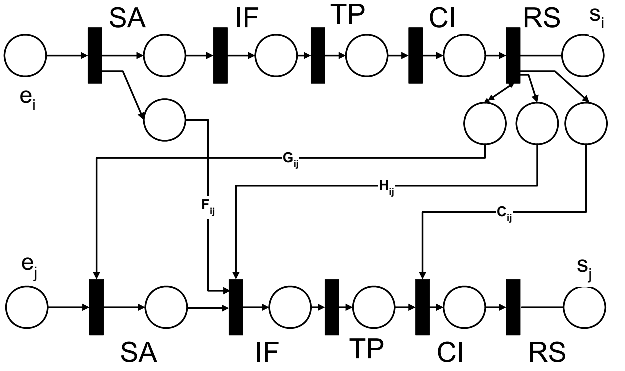

Fig. 2. One-sided Interactions Between Decision Maker i and Decision Maker j

In the Petri net representation of the DM model, the transitions stand for the algorithms, the connectors for the precedence relations between these algorithms, and tokens for the messages that flow between the DMs. If the tokens need to be distinct, i.e., carry information, then a Colored Petri net representation is used. Other organization components can be modeled using the same basic five-stage model, but eliminating one or more of the stages. For example, a processor that receives sensor data and converts it to an estimate of a vector variable can be modeled by a single SA transition, while a data fusion algorithm can be modeled by an IF transition. With this model of the organization member and its variants used to model other components, it is now possible to formulate the problem of designing decision-making organizations.

III. THE LATTICE ALGORITHM

The analytical description of the possible interactions between organization members forms the basis for an algorithm that generates all the architectures that meet some structural constraints as well as application-specific constraints that may be present. The set of structural constraints rules out a large number of architectures. The most important constraint addresses the connectivity of the organization - it eliminates information structures that do not represent a single integrated organization.

Remy and Levis [10] developed an algorithm, named the Lattice algorithm, that determines the maximal and minimal elements of the set of designs that satisfy all the constraints; the entire set can then be generated from its boundaries. The algorithm is based on the notion of a simple path - a directed path without loops from the source to the sink. Feasible architectures are obtained as unions of simple paths. Consequently, they constitute a partially ordered set. The algorithm receives as input the matrix tuple
{**e, s, F, G, H, C**} of dimension n, where n is the number of organization members.

There are some structures corresponding to combinations of interactions between components that do not have a physical interpretation; e.g., DMs can exchange information - F_{ij} and F_{ji} can coexist - but commands are unilateral- either C_{ij} or C_{ji} or none, but not both. Those structures should be eliminated, if realistic organizational forms are to be generated. The structural constraints define what kinds of combinations of interactions need to be ruled out. A set of four different structural constraints is formulated that applies to all organizational structures being considered.

R1 A directed path should exist from the source to every node of the structure and from every node to the sink.

R2 The structure should have no loops; i.e., the organizational structures should be acyclical.

R3 There can be at most one link from the RS stage of a DM to each one of the other DMs; i.e., for each i and j, only one element of the triplet $\{G_{ij}, H_{ij}, C_{ij}\}$ can be nonzero.

R4 Information fusion can take place only at the IF and CI stages. Consequently, the SA and RS stages of each DM can have only one input.

Constraint R1 eliminates structures that do not represent a single integrated organization and ensures that the flow of information is continuous within an organization. Constraint R2, allows acyclical organizations only.[1] Constraint R3 states that the output of the RS stage of one DM or component can be transmitted to another DM or component only once: it does not make much sense to send the same information to the same decision maker at several different stages. Constraint R4 prevents a decision maker from receiving more than one input at the SA stage. The rationale behind this limitation is that information cannot be merged at the SA stage; the IF stage has been specifically introduced to perform such a fusion.

Any realistic design procedure should allow the designer to introduce specific structural characteristics appropriate to the particular design problem. To introduce user-defined constraints that will reflect the specific application the organization designer is considering, appropriate 0s and ls can be placed in the arrays {**e, s, F, G, H, C**. The other elements will remain unspecified and will constitute the degrees of freedom of the design. The complete set of constraints is denoted by **R**.

A feasible structure is one that satisfies both the structural and the user-defined constraints. The design problem is to determine the set of all feasible structures corresponding to a specific set of constraints. Note that this approach is not, by design, concerned with the optimal organizational structure, but with the design of a whole family of feasible structures. At this stage, we are only concerned with the structure and information flows, i.e., the development of the set of feasible organizational forms. This set will become the admissible set in the problem of incorporating cultural constraints.

The notion of subnet defines an order (denoted $\leq$) on the set of all well defined nets of dimension n. The concepts of maximal and minimal elements can therefore be defined. A maximal element of the set of all feasible structures is called a maximally connected organization (MAXO). Similarly, a minimal element is called a minimally connected organization (MINO). Maximally and minimally connected organizations can be interpreted as follows. A MAXO is a well defined net such that it is not possible to add a single link without violating the set of constraints **R**. Similarly, a MINO is a well defined net such that it is not possible to remove a single link without violating the set of constraints **R**. The following proposition is a direct consequence of the definition of maximal and minimal elements: For any given feasible structure P, there is at least one MINO P_{min} and one MAXO P_{max} such that $P_{min} \leq P \leq P_{max}$. Note that the net P need not be a feasible. There is indeed no guarantee that a well-defined net located between a MAXO and a MINO will fulfill the constraints **R**, since such a net need not be connected. To address this problem, the concept of a simple path is used.

The following proposition characterizes the set of all feasible organizational structures: P is a feasible structure if and only if P is a union of simple paths, i.e., P is bounded by at least one MINO and one MAXO. Note that in this approach the incremental unit leading from a feasible structure to its immediate super-ordinate is a simple path and not an individual link. In generating organizational structures with simple paths, the connectivity constraint R1 is automatically satisfied.

The Lattice algorithm generates, once the set of constraints R is specified, the MINOs and the MAXOs that characterize the set of all organizational structures that satisfy the designer's requirements. The next step of the analysis consists of putting the MINOs and the MAXOs in their actual context to give them a physical instantiation. If the organization designer is interested in a particular (MINO, MAXO) pair because it contains interactions that are deemed desirable for the specific application, he can further investigate the intermediate nets by considering the chain of nets that is obtained by adding simple paths to the MINO until the MAXO is reached.

This methodology provides the designer of organizational structures with a rational way to handle a problem whose combinatorial complexity is very large. Having developed a set of organizational structures that meets the set of logical

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[1] This restriction is made to avoid deadlock and circulation of messages within the organization.

constraints and is, by construction, free of structural problems, we can now address the problem of incorporating attributes that characterize cultures.

IV. MODELING CULTURAL ATTRIBUTES

Hofstede [8] distinguishes dimensions of culture that can be used as an instrument to make comparisons between cultures and to cluster cultures according to behavioral characteristics. Culture is not a characteristic of individuals; it encompasses a number of people who have been conditioned by the same education and life experience. Culture, whether it is based on nationality or group membership such as the military, is what the individual members of a group have in common [11].

To compare cultures, Hofstede originally differentiated them according to four dimensions: *uncertainty avoidance (UAI)*, *power distance (PDI), masculinity-femininity (MAS),* and *individualism-collectivism (IND).* The dimensions were measured on an index scale from 0 to 100, although some countries may have a score below 0 or above 100 because they were measured after the original scale was defined in the 70's. The original data were from an extensive IBM database for which 116,000 questionnaires were used in 72 countries and in 20 languages over a six-year period. The hypothesis here is that these dimensions may affect the interconnections between decision makers working together in an organization.

The power distance dimension can be defined as "the extent to which less powerful members of a society accept and expect that power is distributed unequally" [8]. An organization with a high power distance value will likely have many levels in its hierarchy and convey decisions from the top of the command structure to personnel lower in the command structure; centralized decision making. Organizations with low power distance values are likely to have decentralized decision making characterized by a flatter organizational structure; personnel at all levels can make decisions when unexpected events occur with no time for additional input from above.

Uncertainty avoidance can be defined as "the extent to which people feel threatened by uncertainty and ambiguity and try to avoid these situations"[8]. An organization which scores high on un- certainty avoidance will have standardized and formal procedures; clearly defined rules are preferred to unstructured situations. In organizations with low scores on uncertainty avoidance, procedures will be less formal and plans will be continually reassessed for needed modifications. Klein et al. [12] hypothesized that during complex operations, it may not be possible to specify all possible contingencies in advance and to take into account all complicating factors.

The trade off between time and accuracy can be used to study the affect of both power distance and uncertainty avoidance in the model [13]. Messages exchanged between decision makers can be classified according to three different message types: information, control, and command ones [14]. Information messages include inputs, outputs, and data; control messages are the enabling signals for the initiation of a subtask; and command messages affect the choice of subtask or of response. The messages exchanged between decision makers can be classified according to these different types and each message type can be associated with a subjective parameter. For example, uncertainty avoidance can be associated with control signals that are used to initiate subtasks according to a standard operating procedure. A decision maker with high uncertainty avoidance is likely to follow the procedure regardless of circumstances, while a decision maker with low uncertainty avoidance may be more innovative. Power distance can be associated with command signals. A command center with a high power distance value will respond promptly to a command signal, while in a command center with a low power distance value this signal may not always be acted on or be present.

V. USING CULTURAL CONSTRAINTS

Cultural constraints help a designer determine classes of similar feasible organizations by setting specific conditions that limit the number of various types of interactions between decision makers. Cultural constraints are simply represented as interactional constraint statements. Four types of interactions have previously been defined (information sharing represented by matrix F, control represented by matrix G, result sharing represented by matrix H, and command represented by matrix C). The upper bounds, lower bounds and constants of an interactional constraint statement can take a value between 0 or the number of fixed-type interactions allowed by user-defined requirements (which ever is higher) and the maximum number of interactions allowed by user-defined requirements for a given problem, and are formulated using a group's cultural score. An approach for determining the values of these constraints has been developed by Olmez [14]. The constraints are obtained using a linear regression on the four dimensions to determine the change in the range of the number of each type of interaction that is allowed.

$$dY = c + \alpha(PDI) + \beta(UAI) + \gamma(MAS) + \delta(IND)$$

where Y is #F or #G or #H or #C

Example:
$\#F \leq 2$, $\#G = 0$, $1 \leq \#H \leq 3$, $\#C = 3$

The methodology to obtain the solution space given a set of user-defined constraints and cultural constraints using an extended lattice algorithm called C-Lattice is presented next.

C-Lattice Algorithm: The Lattice Algorithm allows the automatic generation of candidate structures based on a set of user and structural constraints. If the cultural constraints can be included in the problem statement in a manner similar to the structural constraints, then the lattice structure of the solution space will be preserved and an extended version of the Lattice algorithm may be used to generate structures that satisfy the additional cultural attributes. Since the cultural constraints impose limits on the number of interactions between the decision makers, they are placing additional structural constraints on the solution space. Hence the constraints R1 to R4 specified in [10] can be extended to include the cultural constraints R5 to R8. For example, for the cultural constraint statement give earlier, they become:

- R5: The number of F type interactions must be between 0 and 2
- R6: The number of G type interactions must equal 0
- R7: The number of H type interactions must lie between 1 and 3
- R8: The number of C type interactions must equal 3.

The flowchart in Fig. 3 explains the generation of the culturally constrained solution space.

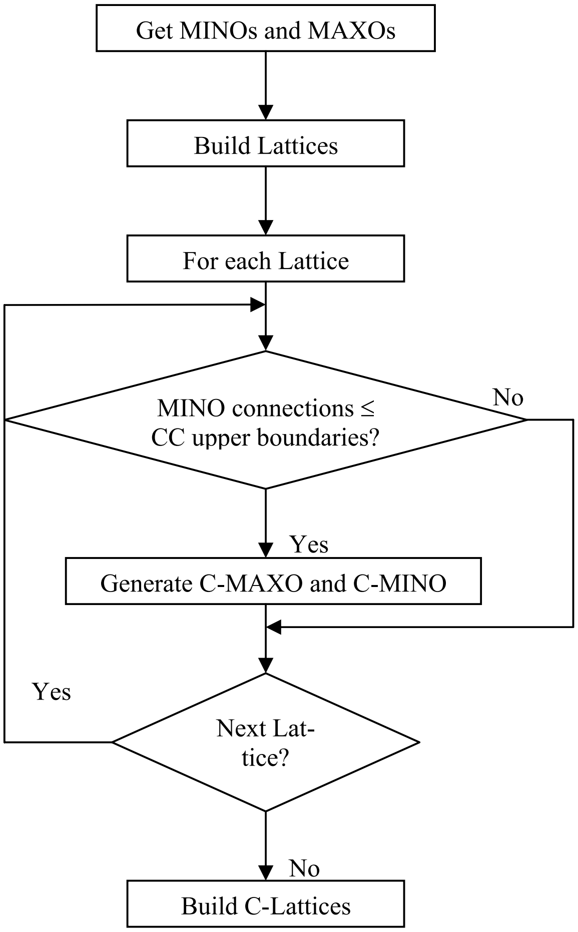


Fig. 3 Flowchart for culturally constrained solution space

MAXOs and MINOs are generated using the same algorithm described in [10]. The "Build Lattices" step checks if a MINO is contained within a MAXO. If it is, then the MINO is connected to that MAXO and forms a lattice. For each lattice in the solution space, we check the MINO to see if it violates the cultural boundaries. For example, if the number of F type interactions in the MINO is two and the maximum allowable by the cultural constraints is only one, then the MINO does not satisfy the cultural attributes and since the MINO is the minimally connected structure in that lattice, no other structure will satisfy the constraints. Hence the lattice can be discarded. If the MINO does pass the boundary test, then simple paths are added to it to satisfy the cultural constraints R5 to R8. The corresponding minimally connected organization(s) is now called the C-MINO(s) (culturally bound MINO). Similarly, by subtracting simple paths from the MAXO, C-MAXO(s) can be reached. The step "Build C-Lattices" connects the C-MINOs to the C-MAXOs. The advantage of using this approach is that the designer does not have to know the cultural attributes at the start of the analysis. He can add them at a later stage. This also enables him to study the same organization structure under different cultures. Also previously designed organization structures can now be analyzed in new light using cultural attributes.

Adversarial modeling using CAESAR III: The proposed algorithm is illustrated using a hypothetical example of an adversarial organization. The simulations were performed using a new application called CAESAR III developed in System Architectures Lab at GMU. CAESAR III is used for the design of information processing and decision making organizations at the operational and tactical levels; it takes into consideration cultural differences as required by the designer.

The scenario reads as follows: Intelligence from the field has informed Blue that the adversary (Red) has organized a force to conduct operations in a distinct part (a province) of the Area of Responsibility. Intelligence has also indicated that the leadership consists of six persons with the command structure as shown in Fig. 4. The Field Intelligence Officers have different areas of responsibility.

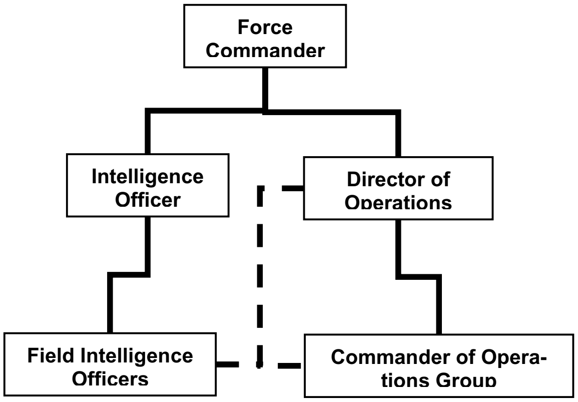


Fig. 4 Command Relationship Chart for Red

The cultural constraints for the two countries are also known.

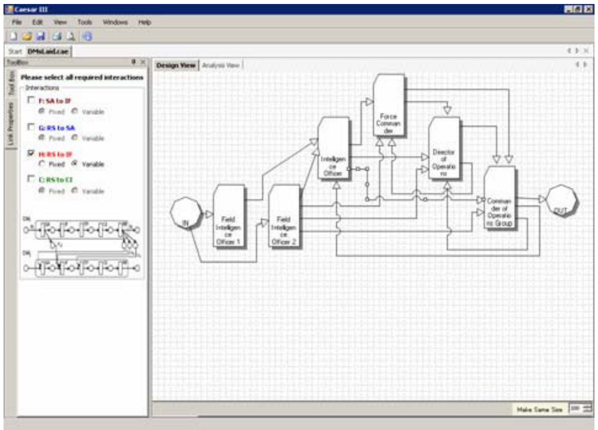
	#F	#G	#H	#C
Blue	2	0	1-3	2-3
Red	2-4	0	1-5	2-4

Given the scenario and the cultural attributes of Red and Blue, can one infer the possible organizational structure of the Red Force and its information exchanges so that Blue can focus its ISR assets to the right targets?

Based on the command relationship chart, one can deduce the number of decision makers (six in this case) and also specify the interactions between them;

- The Field Intelligence Officers interact with the environment and send their Situation Assessment to the Intelligence Officer.
- The Intelligence Officer fuses this information and sends his Assessment to the Force Commander.
- Based on the information received, the Force Commander directs the Director of Operations to develop a Course of Action
- The Director of Operations in turn directs the Commander of Operations to develop and execute a plan based on the COA.
- The variable links have been introduced into the problem based on the type of interactions that usually exist in command and control organizations. They may or may not exist in the Red group. Cultural attributes will be used to determine probable links.

This can be represented in block diagram form as shown in Fig. 5. This information can also be represented in matrices form as shown below where '1' represents a fixed type interaction and 'x' represents a variable type interaction (Fig. 6).



Please select all required interactions
Interactions
☐ F: SA to IF
● Fixed ○ Variable
☐ G: RS to SA
● Fixed ○ Variable
☑ H: RS to IF
○ Fixed ● Variable
☐ C: RS to CI
● Fixed ○ Variable

Fig. 5 Block Diagram of the Organization as seen in the CAESAR III GUI

The resulting universal net is shown in Fig. 7. Running the lattice algorithm without introducing the cultural attributes at this point helps design all feasible organizational structures that meet the specific constraints of the problem. The resulting solution space has a single lattice bounded by one MINO and one MAXO. Figure 8 shows the partially expanded solution space.

Applying Red's cultural attributes to the solution space places further constraints on the number of allowable interactions and helps determine the (plausible) organizational structures that Red may be employing. The resulting solution consists of one MINO and 3 MAXOs and is shown in Fig. 9.

$$e = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 0 \end{bmatrix} \quad s = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$F = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & x & x & x \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad G = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$H = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & x & x \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & x & 0 & 0 \\ 0 & 0 & x & 0 & x & 0 \end{bmatrix} \quad C = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & x \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Fig. 6 Matrix representation of the design problem

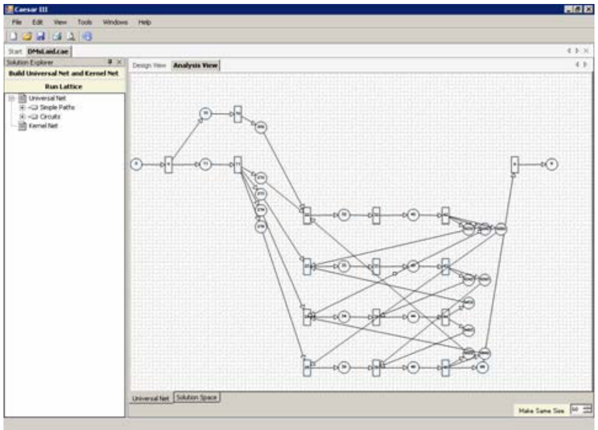


Fig. 7 Universal Net

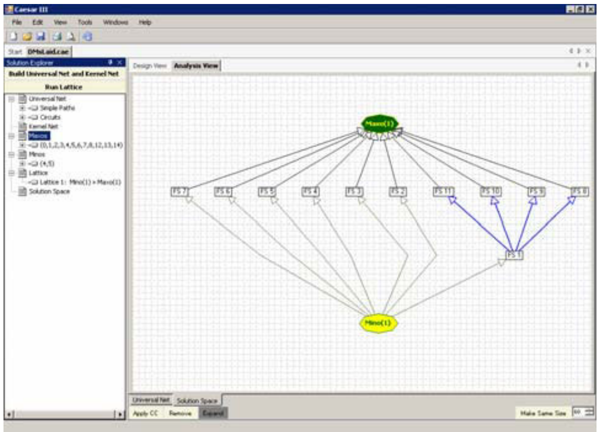


Fig. 8 Partially expanded solution space

The C-MAXOs and the C-MINOs lie within the MAXOs and the MINOs, i.e., the culturally bound solution space is contained in the un-constrained solution space.

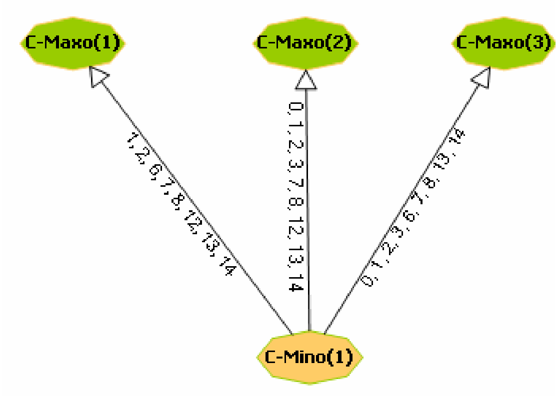


Fig. 9 Culturally Constrained Solution Space for Red

An expanded lattice is shown in Fig. 10. All the structures that lie between a C-MINO and a C-MAXO satisfy the cultural constraints. The actual Petri nets corresponding to the C-MINO and C-MAXOs are shown in Figs. 11 to 14.

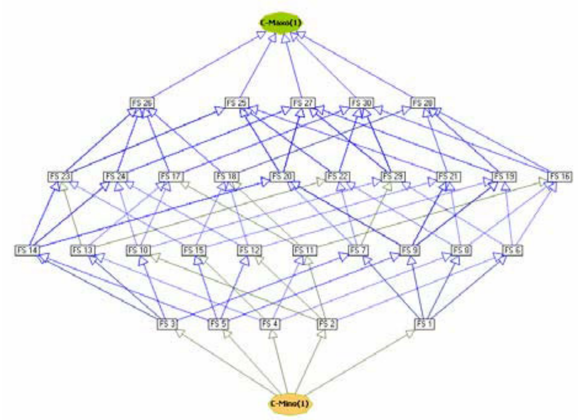


Fig. 10 Expanded Lattice Structure from C-MINO(1) to C-MAXO(1) for RED

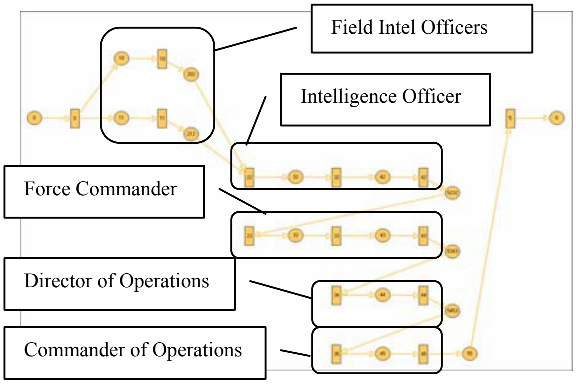


Fig. 11 C-MINO(1) for Red

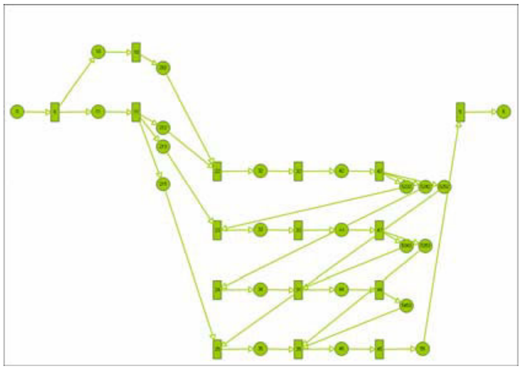


Fig. 12 C-MAXO(1) for Red

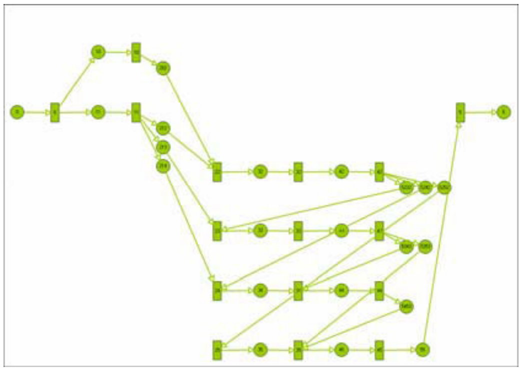


Fig. 13 C-MAXO(2) for Red

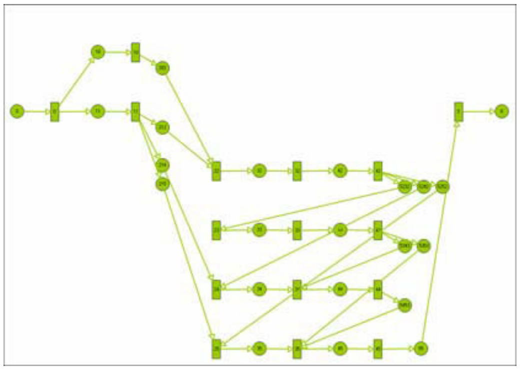


Fig. 14 C-MAXO(3) for Red

Applying Blue's cultural attributes to the original problem results in only one C-MINO and one C-MAXO. The corresponding expanded lattice is as shown in Fig. 15.

The actual Petri net corresponding to the C-MAXO is shown in Figure 16. The C-MINO for Blue is the same as the C-MINO for Red.

Since the constrained solution space for Red has only one C-MINO, which is connected to all the three C-MAXOs, the C-MINO represents the set of interactions that must be present in all the structures that satisfy the cultural attributes of Red. Further analysis of this structure can help identify the high value ISR targets. In cases where there are more than one C-

MINOs, identifying the interactions that are common to all the C-MINOs will indicate which areas to target for ISR activities.

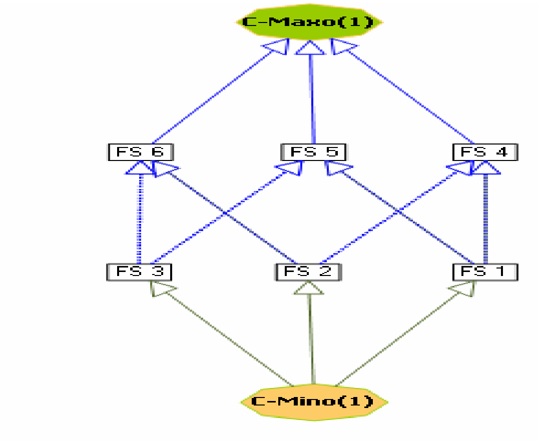


Fig. 15 Expanded Lattice Structure from C-MINO(1) to C-MAXO(1) for Blue

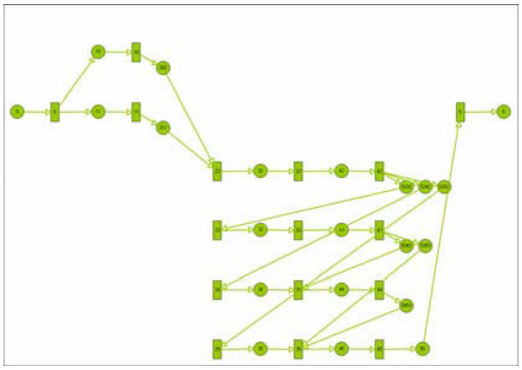


Fig. 16 C-MAXO(1) for Blue

Looking at the solution spaces for the two cases, it is easy to see that the cultural attributes do play a role in the final structure of the decision-making organizations and can provide valuable insight into possible structures that may be used by an adversary.

CONCLUSION

A previously developed methodology for the computational design of information processing and decision making organizations has been enhanced to include cultural constraints that affect the choice of organizational structures. While the Hofstede cultural dimensions have been used, other cultural metrics can be used to derive the cultural constrains R5 to R8. A simple example illustrates the approach. Current effort is focused on enhancing the variable structure and adaptive structure algorithms to incorporate cultural constraints. This is only the first step toward including cultural attributes and behaviors in the computational modeling of adversary organizations. The paper only addresses the question of whether there is a way to incorporate such attributes in existing computational models. The Hofstede dimensions were originally derived from comparable employee groups of a multinational organization known at that time for its strong corporate culture. The assumption here was that military organizations (Army, Navy, Air Force) have strong common cultures across nations and that their differences can be explained in part by such dimensions as those proposed by Hofstede. Much work is needed to examine these assumptions and test the models.

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