EXECUTION STRATEGY DEVELOPMENT USING DSM AND BAYESIAN BELIEF NETWORK-VALUE TRANSFORMATION APPROACH

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ABSTRACT
Equilibrium exists when value creation and consumption rates equal each other. Identifying the creation sequence in a sophisticated system will enable us to identify its equilibrium points.

Keywords: Equilibrium, principal circuit, strategy development, axis of symmetry

1 INTRODUCTION
Identifying execution variables dependencies is necessary in managing complex projects, but is it enough to support decision making in a dynamic environment? Understanding how the execution variables, elements, interact with the environment variables is a critical part of the answer. Such understanding will ensure the made decision balances different stakeholders’ requirements, gains and results in a sustainable smooth execution.

If we have a DSM contains 100 elements, DSM size 100 x 100, representing the execution of a project. At which point in the DSM should we start the execution, and which direction should we take? Do DSM’s elements behave the same way through the project execution? To be able to answer these questions we need to view the DSM as a system that transform value in two processes Benefit and Cost as time progress. DSM elements go throughout these processes assuming different states.

2 DSM AS A VALUE TRANSFORMATION SYSTEM
We need to define such a system with the goal of finding the value transformation maximum and minimum points. The following steps are taken:

1. Identifying Principal Loop/Circuit of dependency. This is the longest value transformation path, i.e. value transformation is proportional with time.
2. Logic quantification: DSM is defined as a value transformation system; two random sequences are introduced to represent how DSM elements go through the Benefit and Cost processes.
3. Build state matrix, 3N x N, where logic is replaced with the elements’ state.
4. Analyze the result using Bayesian Belief Network, BBN.

2.1 Identifying principal loop of dependency
Principal loop/circuit of dependency, PC, represents the longest path of a sequential dependency, value transformation. Such path represents how the value is transformed with respect to time. The algorithm used to identify the PC is available in Psm32, http://www.problematics.com

2.2 Logic quantification
DSM could be viewed as a value transformation system where elements go through two processes Benefit and Cost. To be able to represent these two processes, the DSM needs to be split into two layers, B-layer where elements give benefit and C-layer where elements receive cost. In other words DSM is a superposition of two layers B & C placed above each other.

To quantify the DSM logic we need to introduce two random sequences representing the Benefit and Cost. Such sequences could be generated using expansion and contraction mechanisms. One of the reasons these mechanisms were selected is that they work in a similar way to how we build the
dependency among the DSM elements, i.e. elements’ benefits move vertically away from the DSM diagonal; while their costs move horizontally towards the DSM diagonal. B-layer expands while the C-layer contracts to execute the Benefit and Cost respectively.

Imagine an element at the DSM B-layer’s diagonal which is moving perpendicular to and away from it, this is expansion. Contraction, at the C-layer, is the opposite: the element is moving towards the DSM’s diagonal starting from the C-layer’s corners. The system and the mechanisms are shown in Figure 1. In three dimensions a DSM cell is viewed as a tube that takes a benefit from an element, in the B-layer and conveys it to another element in the C-layer. In other words value moves perpendicular to both layers inside the tube.

\[
\text{CON}_p, \text{ Contraction, probability:} \\
\text{CON}_p = P(\text{cf ABCFG}) = P(\text{ABCFG|cf}) \cdot P(\text{cf}) / P(\text{ABCFG}) = 1/18 
\]

-CON\(_p\): Probability of a DSM tube’s end at the C-layer being in Contraction.
-cf: C & F exchanging value with each other, there are always two possibilities i.e. C-F or F-C, P(cf) value is 1/2
-P(ABCFG): Probability of having variable A, B, C, F and G exchanging value without C exchanging value directly with F = 18/20
-P(ABCFG|cf): Probability of having variable A, B, C, F and G having C exchanging value directly with F = 1/10

These figures are easily obtained by counting the DSM cells satisfying the probability conditions.

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\text{EX}_p, \text{ Expansion, probability:} \\
\text{EX}_p = P(\text{cf CDEF}) = P(\text{CDEF|cf}) \cdot P(\text{cf}) / P(\text{CDEF}) = 1/10 
\]

-EX\(_p\): Probability of a DSM tube’s end at the B-layer being in expansion.
-P(cf) value is 1/2 as mentioned previously
-P(CDEF): Probability of having variable C, D, E, and F exchanging value without C exchanging value directly with F = 10/12
-P (CDEF|cf): Probability of having variable A, B, C, F and G having C exchanging value directly with F = 1/6

Table 2. Expansion state probability

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2.3 Elements state matrix

The introduced random sequences reflect two perpendicular axis of symmetry as shown in Tables 1 and 2. Geometrically they are represented as D and Z in Figure 2. Element X crosses axis D while switching from Cost to Benefit and vice versa. Axis Z was introduced to mark the end of fully forming X, i.e. creation as shown in Figure 2. Element crosses axis Z to switch from sending to receiving feedback, this process acts as a stabilizer to the entire system. For this reason Elements state will be calculated using quantum mechanics approach, i.e. represented in a complex form using the tubes’ probability in Tables 1 and 2.

Element State = \( E_s = EX_p + i CON_p \)

-Element in Cost/Benefit: \( E_s = (EX_p^2 + CON_p^2) \)
-Element in C-layer and is not receiving value: \( E_s = CON_p \)
-Element in B-layer and is not giving value: \( E_s = EX_p \)

To balance the element state probability, i.e. Summation of all \( E_s \) equal one, a Creation state was added, CR. This state represents the period when the element is not in any place on the DSM. Geometrically it could be viewed as perpendicular axis to the DSM. Such axis appears when the element, at an equilibrium/starting point, trying to stabilize the system by adding or removing values, i.e. initial or intermediate conditions. Equation (3) shows the element state balance.

\[
EX_p^2 + CON_p^2 + (EX_p^2 + CON_p^2) + CR = 1
\]  

Figure 2. Element X Pre and Post Creation DSM Zones

Our interest is to study the elements before and after creation to identify their equilibrium point, at which the value created is equal to the value consumed. During our analysis we will deal with State as Value. The element state matrix, for a decision making problem is composed of 3N x N+4, while for situation analysis and strategy development is 2N x N+4. The additional 4 variables are added to represent the whole system state, the summation of the elements state matrix rows, and phase.

Part 1, \( N \times N \), Element total state across D axis of Symmetry:

Pre-Creation: \( E_{X,D} = X_b + X_c = I*(EX_p^2 + CON_p^2) \)  

Post-Creation: \( E_{X,D} = X_b + X_c = I*(EX_p^2 + CON_p^2) \)  

Part 2, \( N \times N \), Element total state across Z axis of symmetry:
Above Axis D: \[ E_{S,D} = X_b + X_c = -1 \cdot (E_x \cdot p^2 + C_o \cdot p^2) \]  \hspace{1cm} (6)

Below Axis D: \[ E_{S,2} = X_b + X_c = 1 \cdot (E_x \cdot p^2 + C_o \cdot p^2) \]  \hspace{1cm} (7)

Part 3, N*N, Element CR state:

DSM upper half (above D) = \[ 1 \cdot (1 - (E_{S,D}^2 + E_{S,2})) \]  \hspace{1cm} (8)

DSM lower half (below D) = \[ -1 \cdot (1 - (E_{S,D} + E_{S,2})) \]  \hspace{1cm} (9)

The above 3 matrices, for decision making problems, are stacked above each other and placed next to the system state matrix, 3N x 4. For situation analysis and strategy development problems, elements state matrix was built as a payoff matrix. Element’s state was referenced to other elements’ state.

2.4 Analyzing the results using Bayesian Belief Network, BBN

The tool used for the Bayesian Belief network analysis is Bayesialab 5.0.2, http://www.bayesia.com/en/products/bayesialab.php. The following is a summary of the steps performed to represent the DSM in BBN: (1) data is uploaded using the data-mining tool, (2) the discretization process performed is K-mean, (3) machine learning is applied using “Taboo” or “Sop-EQ” algorithm, and (4) clustering elements using K-means, elements are divided into classes each class is represented by a factor, e.g. F1, F2. The factor was given a title representing its effect on its class. Now we have a BBN with a minimum of 85% contingency table fit for situation analysis and strategy development applications and 80% for decision making.

3 ANALYSIS

The criterion for our analysis is to find equilibrium points, which are the keys to high value and stable execution. Equilibrium points could take one of the following shapes: minima, maxima or saddle point. Figure 3 shows the sign convention and its meaning, our reference is the point of creation which means the element starts to rotate its cost and benefit axis 180 degrees each.

In a Decision Making problem we need to identify the most stable alternative/s with respect to the total system state/value, which is calculated by adding the element state matrix rows. Figure 4 shows the Prisoner Dilemma as an example for decision making problem. The stable solution is F1, green curve, its slope is steeper on the left hand indicating that its minima, equilibrium, was approached from the negative side, uncertainty. This solution is perceived as a risk base alternative and to manage it, mitigate its uncertainty, a trust mechanism is required between the two prisoners in order for them not to tell on each other.
4 CONCLUSION AND RECOMMENDATION

A new approach was used to implement the DSM as a decision making tool using Bayesian Belief Network, BBN. To describe the DSM elements interaction: 1- DSM was considered as a value transformation system, with two axis of symmetry and 2-two random sequences were introduced in the form of contraction and expansion mechanisms. Bayesian law was used to generate the sequences’ probability. Due to DSM symmetry, elements were described in terms of a State using quantum mechanics approach. Elements state were arranged in a matrix and uploaded using data mining in BBN software, where elements were clustered in classes. Each class was represented by factor. Problems solutions were based on identifying equilibrium points in elements state versus the total system state.

DSM and BBN combined together using the proposed algorithm is a powerful tool, The DSM size used in this research was as high as 96 x 96. Using DSM alone is limited to sequencing and managing work iteration. Using BBN alone to model 96 x 96 is too costly, from computation perspective. While the results of the cases modeled in this work do not contradict reality, further research is required to verify the effect of the DSM feedback blocks, size and number, on the BBN accuracy.

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Execution Strategy Development Using DSM and Bayesian Belief Network-Value Transformation Approach

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The Needs

- What is our best strategy to execute projects? Do we have more than one?
- Is it possible to know risk/opportunities at early stage of the project?
- Can we troubleshoot execution problems, pinpoint the driver and make a decision to get the project back on the right track?
- **The above could be achieved if we can describe how DSM elements interact with each other.**

Our Goals and How to Achieve Them

- Logic dependency among elements is built into DSM.
- To achieve our goal we need to quantify this logic dependency.
- Then we can use artificial intelligence, AI, to identify the relation among the elements and how they interact.
- Given the way we build DSM logic, a Bayesian Belief Network, BBN, is a good base for such an AI. However we might have a problem trying to use BBN with feedback loops; i.e. changing direction W.R.T. Time.
- Now we have 2 problems to solve:
  - Feedback loop limitation in BBN.
  - Logic Quantification
- A partial solution to deal with the first problem is to arrange the elements in their longest time sequence, i.e. the principal loop of dependency, PC. The algorithm is available in Psm32, [http://www.problems.com](http://www.problems.com)
Logic Quantification

- To quantify the DSM logic two random sequences were introduced.
- These sequences need to preserve the DSM symmetry, and keep the information integrity.
- One way to think of these sequences is the probability of an element moving across the DSM in two opposite directions while the DSM is building itself, i.e. DSM size changes in the sequence probability calculation.

DSM as a Value Transformation System and Its Axis of Symmetry

- Our goal at this step is to apply the random sequences in a consistent way to preserve the DSM built logic.
- To do that we need to view the DSM as a value transformation system.
- The value transformation is composed of two process Benefit and Cost, corresponds to the vertical and horizontal logic respectively.
- Each element goes through these processes by crossing D-axis of symmetry.
- At Z-axis of symmetry the element rotates its Benefit and Cost axis 180 degree, we call the period of this process creation.
- The position of the element is described using a state in a complex form.
- Our next step is to build a state matrix.
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Difference between Decision Making and Situation Analysis/Strategy Elements State Matrix

- In decision making our interest is finding the best solution and probably ignore the rest of the given alternatives.
- While in situation analysis/strategy our interest is finding how the elements interact with each other, i.e. the path elements take on the DSM.
- Element state matrix for decision making is composed of:
  - N x N Matrix for state across D-axis of symmetry
  - N x N Matrix for state across Z-axis of symmetry
  - N x N Matrix for CR state, it represents any other state not accounted for.
- For situation analysis we build the matrix to depict the path an element would take moving in two opposite direction:
  - N x N each column entry=X_{i}+(X_{1}+X_{-1})
  - N x N each column entry=X_{i}+(X_{1}+X_{-1})

Where X_{i/\pm} is the summation of the element post-/pre-creation state

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Analysis Case # 1
Prisoner Dilemma

- **Elements:**
  - P1 does not Tell
  - 6 Months Sentence-P2
  - P2 does not Tell
  - 6 Months Sentence-P1
  - Free-P2
  - P2 Tells the Truth
  - Free-P1
  - P1 Tells the Truth
  - 5 Year Sentence-P1
  - 5 Year Sentence-P2
  - 10 Year Sentence-P1
  - 10 Year Sentence-P2

- Note: Zero’s shown in the DSM mean logic one.
Prisoner Dilemma
Element State Matrix

Added variables to represent the system:
• Phase
• Net Value: summation of the elements state.
• Pos. Value: the positive component of the net value.
• Neg. Value: the Negative component of the net value.

Prisoner Dilemma
Bayesian Belief Network, BBN

“F1: P1 & P2 Do not Tell”, green curve, is the stable solution.

F2: EQ Value, blue curve above, is a factor representing the system variables Class. When it equals zero it sets the system to equilibrium.
### Analysis Case # 2

#### 500 S&P

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#### Element State Matrix

**500 S&P**

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\text{Analysis Case # 2} & \text{500 S&P} & \text{Element State Matrix} & \text{INVEST ON VISUALIZATION} & \text{INVEST ON VISUALIZATION} & \text{13th International DSM Conference 2011- 11} & \text{13th International DSM Conference 2011- 12} & \text{199}
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Analysis Case # 2
500 S&P BBN

Model results close to equilibrium state

Actual Data: Global indices,
The data span the period from Dec 2007 to Jan 2011.
Conclusion & Further Development

- DSM logic was quantified using two random sequences, and elements state matrix was built.
- There is high potential of using this approach especially when there is no available data, or in a complex situation.
- The way the state matrix is built is being optimized to suit different type of problems, e.g. decision making, situation analysis..
- Part of the current work is to fine tune the modeling parameters in BBN.