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Decision Support for

Value Analysis and the Scheduling of Veteran's Health Care

NBS Enterprises, LLC Proprietary

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SYNOPSIS

The Department of Veterans Affairs (VA) is faced with the escalation of warriors in need of regular and special health care. The Iraq and Afghanistan conflicts have produced several veterans whose records must be processed with a further need to schedule care within the context of limited resources. To minimize the impact of these issues, the VA has initiated the use of mission planning software tools and the establishment of systems analysis These efforts comprise management cost accounting, health information, patient characteristics and resource availability. In order to respond to asynchronous change and evolving requirements, each of these disparate data sources is in a constant state of flux. Because of system dynamics, additional techniques are required to provide management courses of action while scheduling resources and services in a timely manner.

Answers to near unlimited queries by a staff operating without automated decision support require several days and in some cases, answers are never forthcoming. Scheduling of services cannot be achieved in a static environment. Rather, value analysis of the VA health care enterprise must be correlated with optimal scheduling software so that enhancements to overall performance are continually visible to managers and their planning staff.

NBS Enterprises (NBS) is foremost in the development of management decision aids. We are able to associate dashboard data from disparate sources such as databases for patient records, personnel, and resource specifics and availability.

The NBS decision support system (DSS) capabilities:

- Associated dashboards and planning guidelines
- Optimal scheduling of services and analytical forecasting
- Interactive "what-if" analysis
- Traceability of the decision support process
- NBS algorithms and value analysis software are fully developed producing great savings in costs and times required for enterprise enhancements.

PROBLEM STATEMENT

The Department of Veterans Affairs is responsible for health care management and the scheduling of patient care. Further, improvements and incremental builds for the enterprise are to be justified with extensive quantitative computations. Multiple variables are considered with disparate databases as there sources. All manual processing is time consuming and costly in terms of labor hours. There is a need to optimize the use of resources when managing the operations of the Integrated Health Care System. Directors or operations necessarily must speed up the processes and decision making relative to the use of resources, especially in light of increasing demands of patient requests and the pressures on budgeting.

PROBLEM SOLUTION

The NBS Enterprises (NBS) software tool suite provides an automated decision support system (DSS) that improves the effectiveness of health care managers by associating multiple variables and developing courses of action automatically.

NBS is uniquely able to draw on its experience from the intelligence and war-fighting worlds to address the problem for health administrators using its decision support system.

SCHEDULING

Scheduling of patient services is accomplished in the context of value analysis, which is addressed in Section 4.0. Scheduling of appointments and services is impacted upon by asynchronous events. These events might arise from emergency procedures or by the sudden development of high-priority patient requirements. Veterans travel to various locations in the continental US placing additional strains on availability of resources and services.

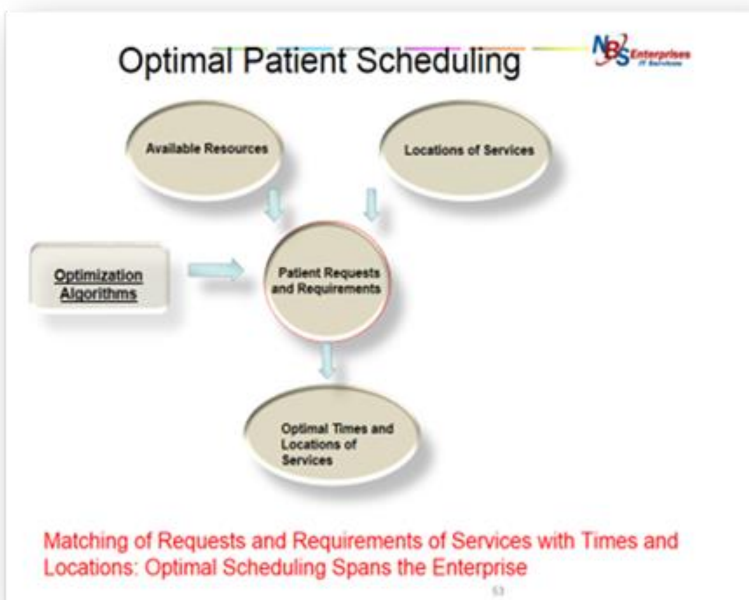

Figure 1

Figure 1 shows the interactions of data that contribute to scheduling. Patient requests arrive continually and are matched with available facilities and resources. Portions of all dashboard sources are inserted into optimization algorithms, which generate courses of action. A manual attempt to streamline a complex system, which encapsulates numerous procedures, usually proves to be fruitless. The interactions of scheduled and asynchronous services require automated techniques that associate performance, value analysis, and optimization.

VALUE ANALYSIS

To fully understand the impact of operational functions and the dynamics of an implemented or proposed systems, modeling and simulation are necessary to compute performance statistics for all of the system artifacts. Further, the impacts of current and forecasted technologies need to be assessed. Numerous tools and simulation languages are available for applications. However, a commercial-off-the-shelf (COTS) tool which encapsulates the capabilities to generate both performance calculations and the optimal disposition of system components is not available on the open market. The NBS paradigm and software tool suite not only derives performance statistics and optimizes the disposition of resources, but it also provides analytical forecasting and value analysis.

Applications of the NBS approach produce the answers to system administrator questions, namely:

- "How well does the enterprise, its systems and its components function (performance analysis)?"
- "How can we improve operations (optimization)?"
- "What is the value of a new technology (component performance in the context of the enterprise)?
- What is the risk of a program change?
- What are overall risk factors and how can they be mitigated?
- "How do we plan for the future (analytical forecasting and the transition from as-is to to-be)?"

Qualitative representations are transferred to quantitative models, expediting analysis and producing a rationale for change. The NBS approach, which has been shown to be accurate and effective, enhances a health care enterprise in an innovative manner, not evident in current management systems tools. NBS applications act as a complete guide for system and enterprise changes while displaying guidance for management decisions.

Capabilities and possible mission applications:

- Comprehensive models of the enterprise: personnel, facilities, processes, technology,
- information technology systems, patient care and satisfaction, costs, schedules, risks.
- Performance analysis: throughput, utilization of resources, bottlenecks, waiting times.
- Optimization: means of enhancements to the concept of operations and procedures.
- Risk assessment: assurance of continuity of operations.
- Cyber security: protection of patient records and mission plans.

- Technology: cost effectiveness in a systems sense.
- Personnel: Matching of skills to mission tasks.
- Association of operations measurements with mission performance.
- Prioritization of incremental builds and program enhancements.
- Optimal scheduling of patient care.
- Analytical forecasting and the development of courses of action.

The NBS tool suite architecture is noted in Figure 2. Data from various dashboards are integrated and processed by a mathematical baseline supported by a collection of algorithms. Performance analysis, optimization and forecasting are produced resulting in the development of courses of action (COA). The COA provide quantitative guidance for patient scheduling and enterprise development.

The existing tool suite is interactive. Results are represented in minutes or seconds of computational times so that operational and management decision support exists in a near continuous manner.

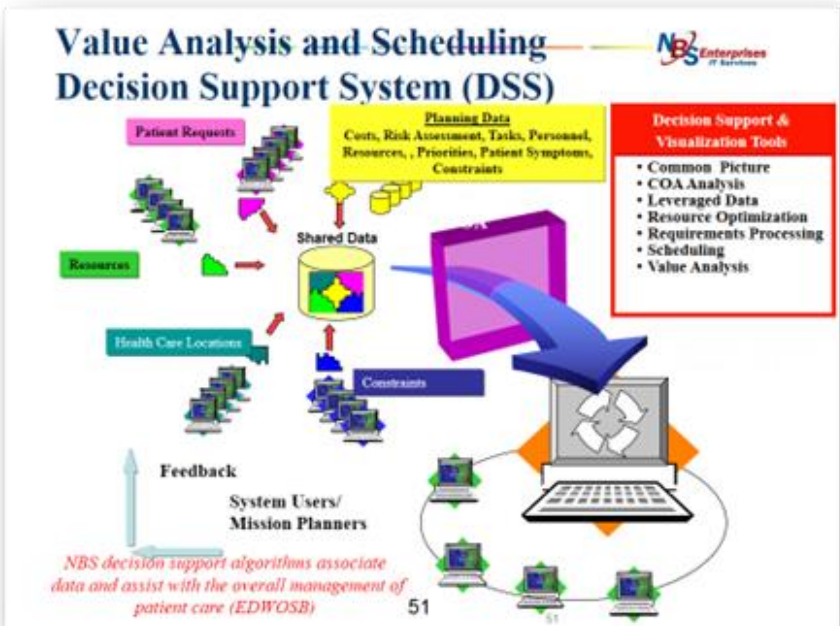

Figure 2

APPENDIX A: MODELS AND ALGORITHMS

BACKGROUND

The NBS tool suite, when applied, reduces mission times, overall costs and in many cases saves lives (TLC). It has been applied successfully to a variety of complex systems, including the Dynamic Battle Management (DBM) System, supply distribution in the battlefield, and the optimal allocation of weapons and platforms to targets in an air defense environment. The tool suite encapsulates a general purpose problem solver that employs one network representation to permit the association of multiple variables, performance computations, optimization and value analysis (Figure A1). A Petri net, which is the primary representation of the tool suite, is a directed graph and a rule-based system. Optimization and variable balancing are always accomplished in the context of a systems model. Only one measure of system effectiveness is optimized while all system variables are balanced to best achieve an objective. The variables represent competing measures of performance such as minimum expense to prepare for patient services versus quality of care. Either costs or quality are emphasized, or combinations of the two are obtained. Several measures of performance are integrated into a singular system measure of effectiveness.

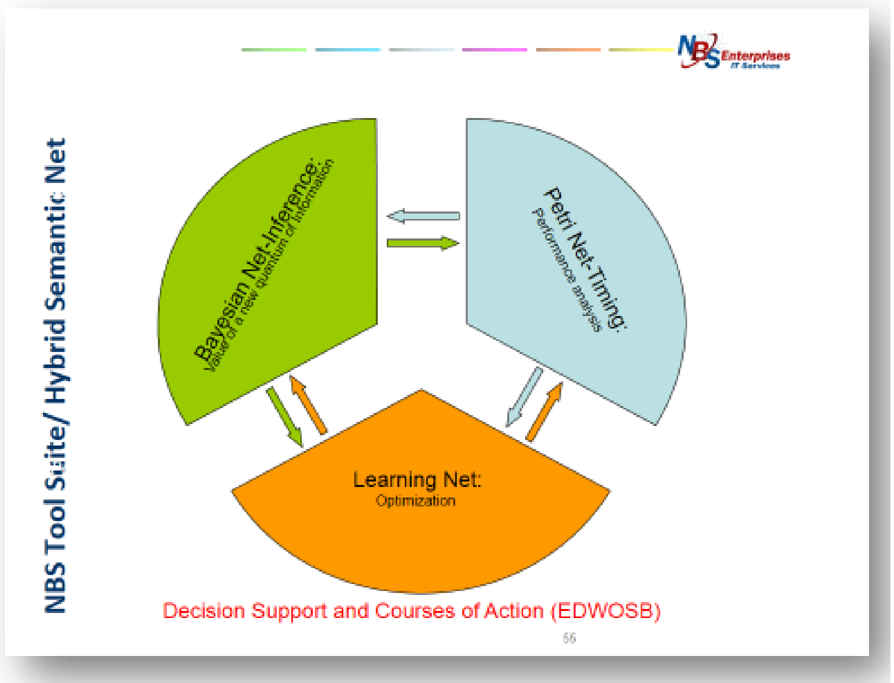

Figure A1 Hybrid Semantic Net and Tool Functionality

DATA TRANSFORMATIONS, SEMANTIC NETS AND ASSOCIATIONS

Data streams exist in various forms such as voice, text, video, and digital formats. Each data source is transformed into a common representation scheme. Relevant data are extracted to form a separate, structured database operated on by a unique set of metadata. The metadata transforms dashboards into a format that can be used for modeling purposes. A set of associations is developed for all disparate data structures. Dependencies with other associations are identified and are inserted into a context model, which represents an entire scenario of interest: assets, timelines, and dependencies. The context model is exercised producing performance statistics and impact analysis. In addition to the general context model, optimization algorithms are appended. The additions address specific issues such as the transition of patient requests into service requirements. Based upon the results of analysis and optimization, a course of action, with a rational for selection, is presented for consideration to a decision maker.

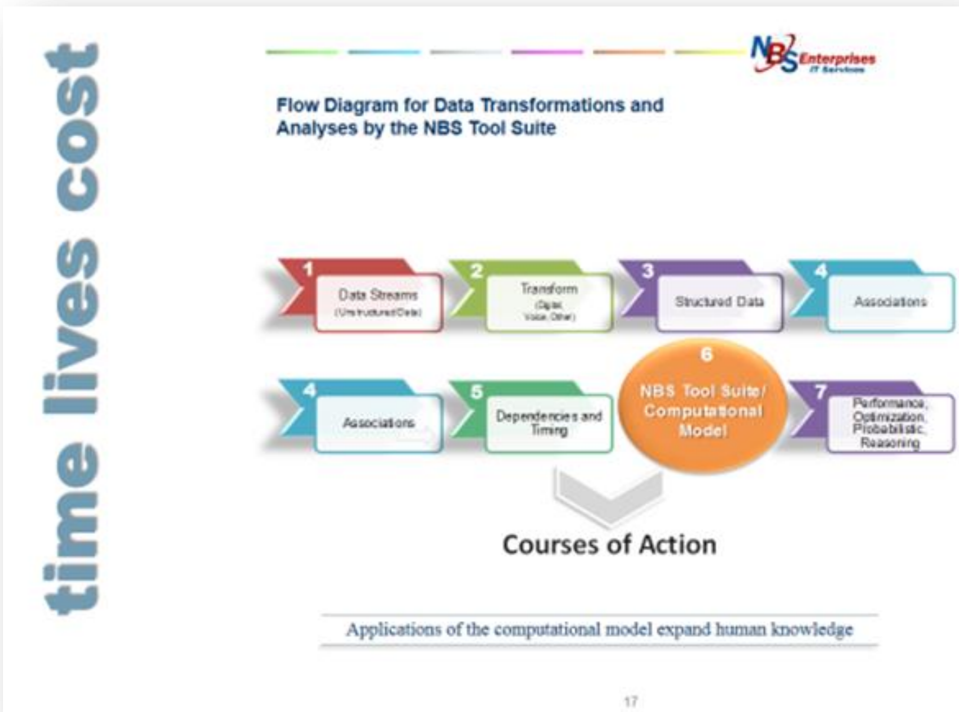

Figure A 2 Analytical Flow

Performance Modeling

The motivation to use Petri nets as a prime representation scheme results from their power to act as a rule-based system and to be transferred easily into an analytical model or a simulation language.

Figure A 3 depicts the evolution from a system architecture to a Petri net and finally to a model that computes performance statistics. Initially, as noted in Figure A 3, models are tested by developing challenge cases and comparing automated solutions to those generated manually. After thorough testing, the models are used for real-time computations in dynamic environments. The Petri net backbone is then expanded by the super positioning of neural nets and Bayesian nets. One representation network has the potential to step through the triad of Figure A 1, producing performance statistics, optimization and value analysis. By correlating execution time and variance with each event, a total systems model is produced. The model is run to compute typical statistics such as response times, queue lengths, utilizations and throughputs.

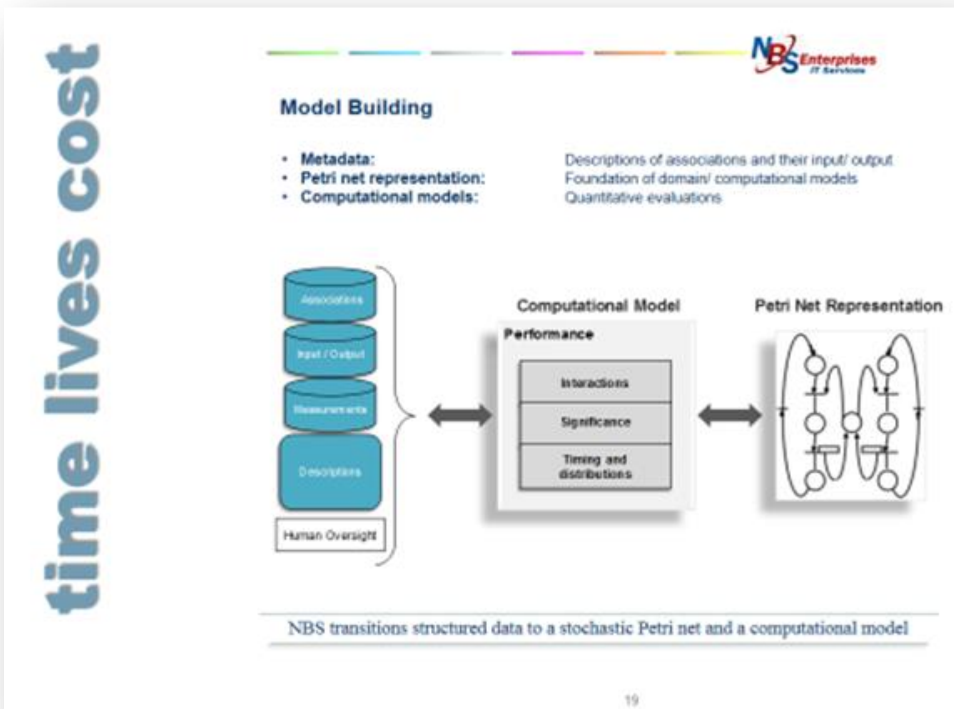

Figure A 3 Model Building

Neural Nets and Optimization

The back propagation technique for neural nets is used for pattern recognition and other learning schemes. The incrementally changed weights associated with network links typically represent correlation statistics. For the composite TLC nets, the weights in addition, signify performance statistics generated by a Petri net computation. For example, if an analyst is optimizing a communications flow, the weights indicate the quantities or latency by message type that are transmitted through each link and node. Back propagation is conducted in response to performance calculations until a "best" solution for message routing is achieved. An objective function might be the total latency of all messages in a network.

INFORMATION INCREMENT AND VALUE ANALYSIS

The utility of Bayesian nets and statistical inference have been described by Judea Pearl: Probabilistic Reasoning in Intelligent Systems, Morgan Kaufman. The Pearl text is considered as a seminal description of statistical fusion and the representation scheme for networks of inference. Although of great value, Bayesian nets have two deficiencies:

- Independence of events must be assumed
- Time is not represented

The TLC approach is to transition Bayesian nets to Petri nets, which are directed graphs comprising conditions, transitions/ events and connecting links. By superimposing Bayesian nets onto Petri nets, the representation becomes time related and the assumption of event independence is removed. The computational results provide a time-related, worth computation of an increment of knowledge.

APPENDIX B: MODELING RESULTS

A simple problem to demonstrate the optimal assignment of resources follow in this section. Because of space limitations we do not show the results of more complex situations whereby several constraints imposed upon a health care enterprise are addressed, nor do we show any associations of events using semantic nets.

First, we consider a simple example case whereby 10 resource locations are available to serve 10 patient requests. Four health care units are available to accomplish services

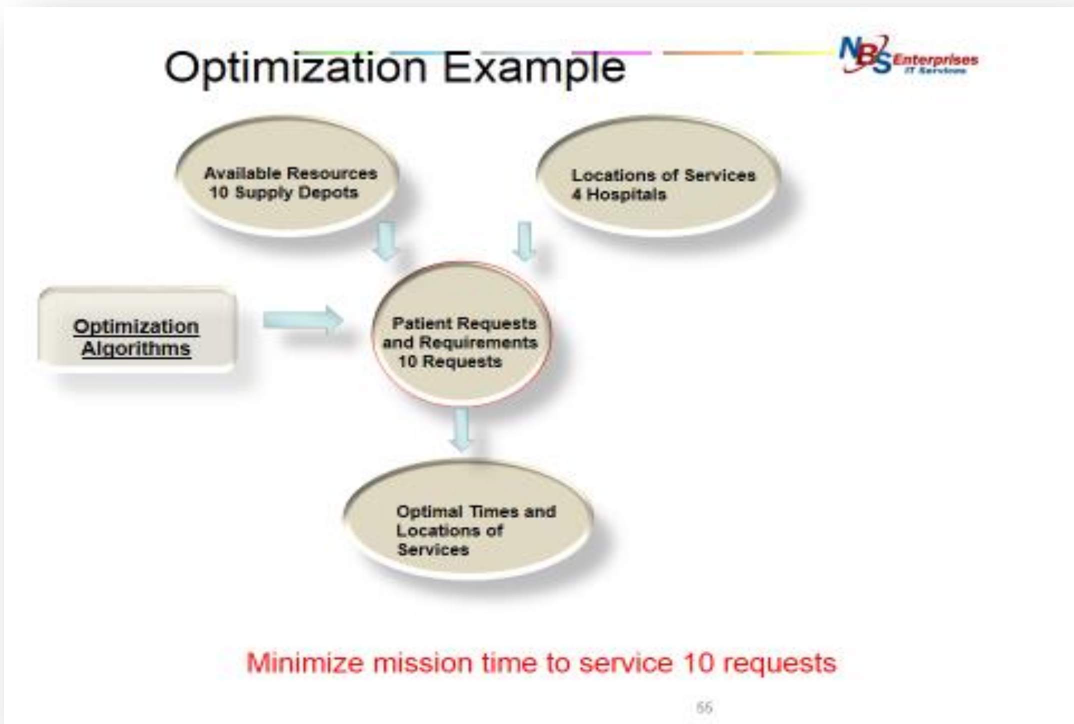

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Figure B 1

To initiate an optimization process, various sources of data are required. Figure B 2 shows the amount of time necessary for supply depot number 1 to delivery necessary resources for each of the health care units. A similar matrix exists for each of the supply depots. For an actual case, resources will comprise equipment, personnel and other necessities. Some resources might be collocated with a health care unit. The numbers are noted only as an example and have no operational significance.

Figure B 2: Delivery Time (Hours)

Resource Delivery Times for Supply Depot Number 1

Health Care Unit \ Request Number	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	4	4	3	5	6	7	8	8	6	5
3	5	2	4	4	4	3	7	7	8	9
4	6	5	3	7	8	10	11	12	13	14

For every requests, a health care exhibits a time to service. Every location and requests have a unique service. Because of queuing times (times waiting for service), not every requests is assigned to a location with a minimum service time. Further, the optimization process considers both service time and time to deliver resources.

Figure B 3: Service Time (Hours)

Health Care Service Time for Each Type of Request

Health Care Unit \ Request Number	1	2	3	4	5	6	7	8	9	10
1	10	12	3	4	5	6	7	8	9	10
2	9	14	3	5	6	7	8	8	6	15
3	8	12	4	4	4	3	7	7	8	9
4	7	5	3	7	8	10	11	12	13	14

Initially, supply depots and health care centers are assigned to each request in an arbitrary manner. Figure B 4 shows the location of arbitrary assignments.

An integer is inserted in the matrix to indicate an assignment. For instance, requests one, two and three are assigned to health care site number one.

A similar matrix exists for the supply depots. Using the two matrices, the total time for each request, which comprises delivery time and service time, is added to the total mission time. For the arbitrary assignments, total mission time is 128 hours. The mission time does not denote the time when all processing begins until its end. Rather, it indicates the times required to service all requests. The time from beginning to end of services can of course be provided and used as a measure of effectiveness.

Figure B 4: Arbitrary Request Distribution

Distribution for Each Type of Request

Request Number		1	2	3	4	5	6	7	8	9	10
	1	1	1	1							
Health Care Unit	2				1	1	1				
	3							1	1		
	4									1	1

After processing by the NBS tool suite, a new distribution of requests to supply depots and health care sites is computed. For the optimal distribution, the total mission time has been reduced to 77 hours. This is a reduction of 40 percent.

Figure B 5: Optimal Request Distribution

Distribution for Each Type of Request

Health Care Unit / Request Number	1	2	3	4	5	6	7	8	9	10
1	1	1							1	
2			1				1	1		
3				1						1
4					1	1				

Mission objectives can be changed, such as when multiple health care procedures are necessary for a patient requests. Multiple resources, perhaps located at different depots, might also be required. Essentially any reasonable measure of effectiveness or sets of constraints can be acted upon by the tool suite. For the simple example displayed above, less than one-second of computational time is required on a laptop computer. For hundreds of requests, solutions are available in less than one minute.

The intent of this example is not to provide an exhaustive explanation of assignment optimization. Rather, the objective is to outline the process employed to develop optimal assignments. Comprehensive demonstrations are available for the NBS tool suite.