A Decision Support System for Managing a Diverse Portfolio of Technology Resources: Automated Resource Allocation of Deep Space Network Equipment

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BACKGROUND

Growth in demand for planetary telecommunications for the Jet Propulsion Laboratory (JPL) Deep Space Network (DSN) has levied increased emphasis on reducing costs and improving efficiency. Responding to this increased demand to meet the needs of space science missions, JPL has been moving forward with a combination of technology and process management improvements aimed at streamlining the delivery of telecommunications services and the process by which customers obtain those services.

This paper describes an automated decision support system designed to facilitate the management of a continuously changing portfolio of technologies as new technologies are deployed and older technologies are decommissioned. This decision support system maintains the inventory and status of all schedulable DSN equipment for the purpose of automated resource allocation. Within the decision support system is an equipment resource database needed to derive resource allocations from requested services. The equipment resource database will manage all schedulable DSN equipment while other software will perform automated resource allocation to determine whether the ground equipment is capable of, and available for, scheduled tracking of a spacecraft. During the initial design of the system, a number of issues were identified.

DISCUSSION OF ISSUES

Because the process for delivering telecommunications services spans multiple organizations, processes, data repositories, and software application programs, it was not surprising to find a number of issues facing the development of a simple equipment inventory and status database to support technology management. For the most part, these issues can be viewed as disconnects and barriers to automation of the technology management, scheduling, and resource allocation processes. The issues spanned four main areas.

1. Change management

Changes to equipment in the DSN Complexes are generally discovered "after-the-fact" by schedulers. Scheduler's routinely select equipment based on manually created, and arcane "configuration codes." These configuration codes are manually modified, rescheduled, and then resubmitted. Changes to the mix of hardware at the DSN Complexes are performed independently of the scheduling function and formal notification of equipment changes is not consistent.

2. Deficiencies in equipment performance characteristics

Some equipment resources are identical in capability but used in different ways for different services. Because a service is a combination of equipment hardware and technical parameter settings, it can be necessary to distinguish between identical equipment units due to subtle differences in hardware performance. Much of this information is not captured in electronic form. Fine tuning of equipment also affects various equipment technical parameters.

3. Tracking of equipment additions and deletions

   The process for equipment changes is not clearly defined. Dates of equipment availability are not readily accessible and there is no central repository for control of DSN schedulable equipment inventory. As a result, equipment changes or substitutions are detected late in the delivery process.

4. Control of equipment changes

   There is no "control document" for equipment inventory and there is no single "owner" of the inventory process and its control. Controlling changes is an ad hoc, negotiable, open-ended process that needs to be formalized for automation purposes. Uncertainties in equipment changes are reflected in the scheduling function since equipment may or may not be available when scheduled. This is due to lack of timely and centralized information about equipment status. The DSN Complexes maintain files that list local inventories (mixed cryptically with non-schedulable equipment), are stored in file form (not a database), and do not identify planned, decommissioned, or to-be-removed items.

FINDINGS

To address these issues a prototype equipment inventory and status database was developed to test the feasibility of a decision support system for this application. The database identifies the equipment by type and instance. For example an "antenna" is a type of equipment resource whereas "DSS14" uniquely identifies the 70m antenna at the Goldstone, California Deep Space Communications Complex. The identification of unique equipment facilitates scheduling of common equipment that may be used in different ways by capturing subtle performance characteristics.

Table 1 illustrates a partial listing of DSN equipment showing instances of equipment for the 3 DSN Complexes. Blanks indicate no equipment at the designated location.

CONCLUSIONS

During the course of this study a number of conclusions were drawn.

1. A decision support system for automated resource allocation of DSN equipment requires an accurate representation of the resources and their availability. An on-line equipment database is an enabling component for basic automation of key scheduling and resource allocation functions.

2. Management of the diverse portfolio of technologies in the DSN requires a representation of equipment to a level sufficient to capture both functional and performance attributes. In addition, the mixture of new technology deployments for testing existing operational equipment and planned decommissioning of equipment indicates a need for automatically updating the resource allocation system when equipment technologies are changed.

3. Management of the technology portfolio can help integrate the user organizations using an on-line database. The database can be updated by a technology manager on the development side of the organization and equipment changes or notifications of outages can be updated by an operator on the DSN Complex side. Project or Mission users could access the inventory and its status at any time.

Table 1. Partial Equipment Resource Inventory and Identifiers

(S.L.N; S=subsystem; L=location; N=unit serial number)[1]

Goldstone	Status	Canberra	Status	Madrid	Status
ANT.DSS13.1	R&T				
70m Subnet		**70m Subnet**		**70m Subnet**	
ANT.DSS14.1	Op	ANT.DSS43.1	Op	ANT.DSS63.1	Op
BVR.DSS14.1	Op	BVR.DSS43.1	Op	BVR.DSS63.1	Op
KBND.DSS14.1	Op	KBND.DSS43.1	Op	KBND.DSS63.1	Op
LFET.DSS14.1	Op	LFET.DSS43.1	Op	LFET.DSS63.1	Op
LFET.DSS14.2	Op	LFET.DSS43.2	Op	LFET.DSS63.2	Op
MDA.DSS14.1	Op	MDA.DSS43.1	Op	MDA.DSS63.1	Op
NAR.DSS14.1	Op	NAR.DSS43.1	Op	NAR.DSS63.1	Op
RCV.DSS14.1	TBR	RCV.DSS43.1	TBR	RCV.DSS63.1	TBR
RCV.DSS14.2	TBR	RCV.DSS43.2	TBR	RCV.DSS63.2	TBR
SRA.DSS14.1	Op	SRA.DSS43.1	Op	SRA.DSS63.1	Op
STWM.DSS14.1	Op	STWM.DSS43.1	Op	STWM.DSS63.1	Op
STWM.DSS14.2	Op	STWM.DSS43.2	Op	STWM.DSS63.2	Op
TXHS.DSS14.1	Op	TXHS.DSS43.1	Op	TXHS.DSS63.1	Op
TXHX.DSS14.1	Op				
TXLS.DSS14.1	Op	TXLS.DSS43.1	Op	TXLS.DSS63.1	Op
TXLX.DSS14.1	Op				
XTWM.DSS14.1	Op	XTWM.DSS43.1	Op	XTWM.DSS63.1	Op
XTWM.DSS14.2	Op	XTWM.DSS43.2	Op	XTWM.DSS63.2	Op
		UCONE.DSS43.1	Op		
34mHEF Subnet		**34mHEF Subnet**		**34mHEF Subnet**	
ANT.DSS15.1	Op	ANT.DSS45.1	Op	ANT.DSS65.1	Op
BVR.DSS15.1	Op	BVR.DSS45.1	Op	BVR.DSS65.1	Op
MDA.DSS15.1	Op	MDA.DSS45.1	Op	MDA.DSS65.1	Op
NAR.DSS15.1	Op	NAR.DSS45.1	Op	NAR.DSS65.1	Op
RCV.DSS15.1	TBR	RCV.DSS45.1	TBR	RCV.DSS65.1	TBR
SFET.DSS15.1	Op	SFET.DSS45.1	Op	SFET.DSS65.1	Op
SHMT.DSS15.1	Op	SHMT.DSS45.1	Op	SHMT.DSS65.1	Op
SRA.DSS15.1	Op	SRA.DSS45.1	Op	SRA.DSS65.1	Op
		STWM.DSS45.1			
TXLX.DSS15.1	Op	TXLX.DSS45.1	Op	TXLX.DSS65.1	Op
XHMT.DSS15.1	Op	XHMT.DSS45.1	Op	XHMT.DSS65.1	Op
XTWM.DSS15.1	Op	XTWM.DSS45.1	Op	XTWM.DSS65.1	Op
34mBWG Subnet		**34mBWG Subnet**		**34mBWG Subnet**	
ANT.DSS24.1	Op	ANT.DSS34.1	Op	ANT.DSS54.1	Op
BVR.DSS24.1	Op	BVR.DSS34.1	Op	BVR.DSS54.1	Op
MDA.DSS24.1	Op	MDA.DSS34.1	Op	MDA.DSS54.1	Op
SHMT.DSS24.1	Op	SHMT.DSS34.1	Op		
SRA.DSS24.1	Op	SRA.DSS34.1	Op	SRA.DSS54.1	Op
TXLS.DSS24.1	Op	TXLS.DSS34.1	Op		
XTWM.DSS24.1	Op			XTWM.DSS54.1	Op
		TXLX.DSS34.1	Op	TXLX.DSS54.1	Op
		XHMT.DSS34.1	Op		
34mBWG Subnet		**34mBWG Subnet**		**34mBWG Subnet**	
ANT.DSS25.1	Op				
BVR.DSS25.1	Op				
KBND.DSS25.1	Op				
MDA.DSS25.1	Op				

[1] R&T: Research and Testing; Op: Operational equipment; TBR: To be removed in the future; Plan: To be installed in the future; Decom: Decommissioned (unused).

4. Additional benefits may accrue to other processes as a result of on-line equipment status. Examples include telecommunications analysis tools, sequence generation tools, the metric predictions process, and reliability and maintenance functions.

5. Centralization of equipment information with designated responsibilities is needed to enable automated resource mapping and scheduling for reliable resource allocation.

In summary, the development of an automated decision support system for DSN resource allocation requires enabling database technology. The benefit of such a database to manage the portfolio of equipment resources is amplified by the current expansion of network technologies. The initial deployment of an equipment status database provides a wedge into development of a fully automated deep space telecommunications network. A challenging task is the restructuring of existing manual processes into a new model for resource allocation. Discussion of this effort is left for the next phase of this study.

ACKNOWLEDGMENTS

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