ORGANIZATIONAL ALIGNMENT THROUGH INFORMATION TECHNOLOGY: A WEB-BASED APPROACH TO CHANGE

Jeffrey H. Smith, William Heinrichs
Jet Propulsion Laborator;y, M/S 602-237
4800 Oak Grove Drive, Pasadena, CA
jeffrey.h.smithl@jpl.nasa.gov

Keywords: **Telecommunications, Automation, Service Delivery, User Interface, Resource Allocation**

ABSTRACT

Growth in demand for the Jet Propulsion Laboratory Deep Space Network, (DSN) has created increased interest in methods and techniques for reducing costs and improving efficiency. Responding to this increased demand, NASA and the Jet Propulsion Laboratory have been striving to enhance the effectiveness and efficiency of delivering telecommunications services while reducing costs.

The implementation of new processes to achieve these objectives requires significant changes to service delivery systems and practices provided by supporting organizations. During the course of this restructuring process, a number of observations about the relationship between process redesign, organizational changes, and the advantages of web-based approaches for software integration were made.

This paper reports on the effectiveness of web-based internet tools and databases to facilitate integration of technical organizations with interfaces that minimize modification of each technical organization. Correspondingly, the use of common web interfaces minimizes the modification, redesign, and cost of existing legacy software projects by enabling interaction with new processes.

A Case Study involving the integration of two services and current software development efforts to enhance the delivery of deep space planetary communications services are described.

INTRODUCTION

There has been considerable interest at NASA in reducing the operating costs of space missions [1, 2, 3]. To this end, the process of delivering telecommunications capabilities has been moving from a paradigm of providing highly customized capabilities to delivering lower cost standardized services. Numerous provider organizations involved in delivering these services have been examining a variety of ways to accelerate the definition of missions, selection of telecommunications services, identification of equipment resources, scheduling resources, and delivering requested services to the project "customers." This study focused on telecommunications service delivery and the integration of provider organizations that supported this process. Many of these organizations provided their services using stand-alone software programs and tools. This paper describes how web-based approaches were used to facilitate the integration of provider services and movement toward a better, faster, and less costly service delivery system.

The extensive installed base of legacy software programs used by provider organizations to support the telecommunications delivery process has been an ongoing barrier to the redesign of the overall system. These software programs represent years of continuous software investment and evolution. Because many of these software programs were customized to provide continuously improving functionality, an approach was needed to minimize changes and thus reduce cost impacts of significant software redesign.

A web-based approach is described for integrating independent software programs. Each organization and

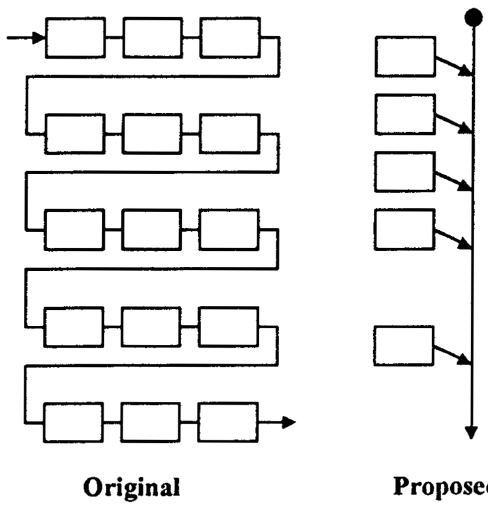

Figure 1. Contrasting Service Delivery Approaches Showing Original and Proposed Architectures

software program had individual requirements and products incompatible with automated information technology systems. Resulting legacy software designs were generally stand-alone and isolated from other programs. Furthermore, each program was part of a series process that could not proceed in a timely fashion until each subtask was completed. This created a labor intensive, slow, and cumbersome process for customers who spent much of their time waiting for all the relevant project information to be "passed around" and for the system to catch up or clear the latest changes.

The challenge was to transform the focus on each of these organizations and their software programs from a development perspective to a "service" perspective with a socket-driven interface for each tool to interact with the larger system. Figure 1 presents a simplified view of the original system and the proposed web-based system.

REDESIGNING THE DELIVERY OF PLANETARY TELECOMMUNICATIONS SERVICES: CASE STUDY

The end-to-end progress of a service request is illustrated in Figure 2. Within the original service delivery process, technical provider organizations and their software programs interacted with each other via electronic mail or telephone to identify the analysts; initiate the required analyses; schedule and perform the work; and deliver the results to the customer and other providers. The old process involved passing a host of documents, data files, voice, and electronic messages back and forth among numerous providers.

Streamlining the process was aimed at simplifying and focusing the minimum required information to deliver service into a web-accessible database that could be processed through the life cycle of a service request. More importantly, the collection of information into a service request provided a container for viewing of all relevant information and status of a request by all interested parties.

A full description of the end-to-end service delivery process is beyond the scope of this paper. However, a Case Study is presented for part of the process that illustrates the concepts and observations of this paper.

The Case Study described herein redesigned 2 parts of the service request process by emphasizing each provider's specific services and products and standardizing those products via a web-based interface. Figure 2 displays the life cycle of a service request. During the service request life cycle, modifications and increasingly detailed information are added to the request. At each step in the process, numerous quantities of data and analysis products are exchanged between a variety of sources. The complexity, magnitude, and frequency of data flows increases as the time approaches for delivery of the tracking service.

Provision of planetary telecommunications services typically begins with definition of the mission phases, events, and service requests. Examples include launch, cruise, maneuver, encounter, landing, and other types of phases. The Resource Mapper Service translates customer service requests into allocated equipment sets that will deliver the service. The Resource Mapper software requests Telecom Service to complete its function. The Telecom Service analyzes the performance of the spacecraft communications system and the ground (Earth) antennas to determine which ground equipment sets are capable of delivering the customer's requested service.

The Resource Mapper service contains information about available equipment items while the Telecom service analyzes the link between the spacecraft and the ground antennas to determine whether communication is feasible. These services are delivered in 3 general steps:

Step 1. Customer selects service and technical parameters
Step 2. Resource Mapper Service identifies candidate equipment sets
Step 3. Telecom Service filters out infeasible equipment sets

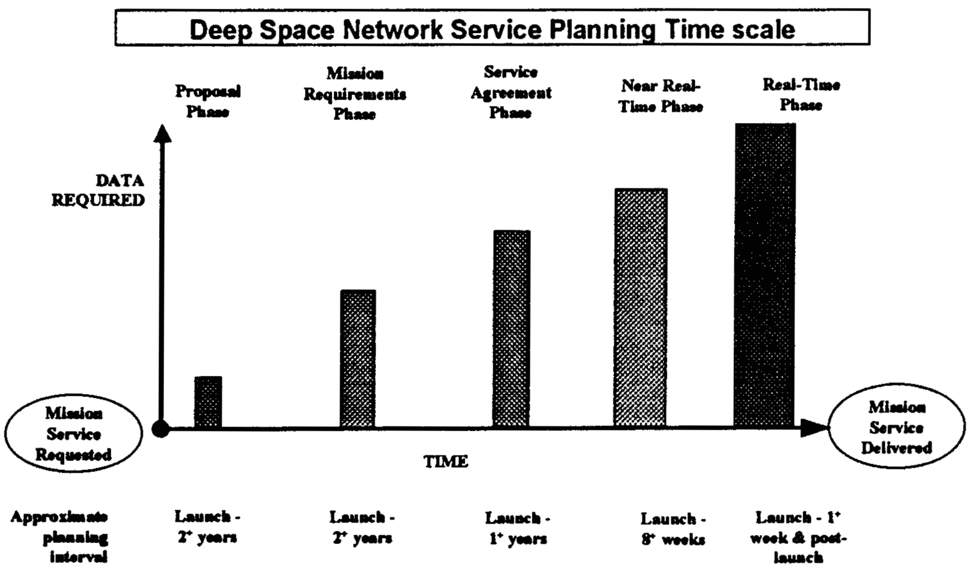

Figure 2. Life Cycle of a Service Request for Planetary Communications

At Step 1, telecommunications services are mapped to multiple technical parameters used to characterize performance (Table 1). The parameters are stored in a web-based mission and asset database for access by mission users and other service providers.

Service selection parameters are used as inputs to the Telecom service link budget analysis model [4]. The service selection parameters are augmented by technical parameters that characterize the performance of a suite of ground antennas [5]. These technical parameters are also stored in the mission and assets database.

Table 1. Step 1 Sample of Technical Parameters

Service Selection Parameters	Units
Radio frequency band	X, S, Ka
Spacecraft transmitter/receiver frequency	MHz
Distance between Earth and the spacecraft:	km
Elevation angle of the ground antenna	degrees
Weather condition assumption	Attenuation model
Command data rate (Maximize)	Bits per second
Spacecraft antenna gain	dB
Spacecraft system noise temperature	Degrees Kelvin
Spacecraft antenna-related losses, dB	dB

Step 2 identifies equipment sets required to complete the communications link. Technical parameters affiliated with each of the equipment items are also stored in the mission and assets database. The Resource Mapper connects each of the feasible antennas to a string of support equipment required to complete the telecommunications link. For example, if the signal is to be transmitted to a spacecraft, there are numerous transmitters available for allocation. If the signal is to be received from the spacecraft, there are numerous receiving antennas on the ground that may be used. The Resource Mapper identifies equipment sets capable of providing the requested service subject to the constraints of equipment performance, availability, and customer specifications. The intersection of the service requirements, feasible antennas, and associated equipment sets are feasible equipment sets capable of providing the requested service. The Resource Mapper Service is hosted on a Windows NT®[1] Server PC using Java J++.

In Step 3, the Resource Mapper Service requests Telecom Service to filter the equipment sets into feasible sets for delivering the requested telecommunications services. The Telecom Service is composed of numerous software models using the MATLAB®[2] language, various data files, and a host of performance data for the ground-based antennas. The entire Telecom Service system of over 1000 files is hosted on a UNIX platform run in batch mode. The inputs to the Telecom Service are the parameters in Table 1 passed via the Service Request and the trajectory files created for the mission (by another service). The output of the Telecom Service is a Data Rate Capability File (DRCF) containing the forecasted performance for each candidate ground antenna over a range of communication data rates for specified start and end times. Developing an interface between the Resource Mapper Service and Telecom Service was initially viewed as an "impossible" task. However, the functional interaction between the services was facilitated using a number of web-based approaches. These included automated analysis tools, on-line databases, and intra-network-based user interfaces.

APPROACH

The approach of this study used web-based browsers, databases, and software wrappers to simplify the integration of dissimilar organizations and software programs. It was clear at the outset, that ground rules were needed because the redesign of the service delivery system was taking place under a reduced budget environment—significant rework of existing software and development of major software startups was not practical. As a result, the aim was to bring existing technologies to bear on the solution approach. Rather than redesigning the Resource Mapper or Telecom services to adapt to a new process, the objective was to provide an infrastructure to enable these (and other) varied services to provide their products with minimal changes.

The systems integration problem was complicated by the presence of multiple, dissimilar computer platforms and operating systems using different computer languages. After extensive review, a two-phase approach was identified that would enable the project to meet its requirements without significant new developments.

In the first phase, web-based browser and database technologies were used to integrate the non-homogeneous information systems in different provider organizations. Different platforms would interface with a server-based mission and assets database providing one center for information—a Service Request. This database contains various data files, database tables, and database systems maintained for all users to access via independent browsers.
The plan for Phase 2 involved using software to "shrink wrap" the object models of each independent provider software program, allowing them to interact with the mission and assets database. The use of Component Object Model technologies was viewed as a long-term goal for evolving software [6]. While the large quantities of legacy software were viewed as an obstacle to COM technologies, the use of interface wrappers would provide a bridge to future COM capabilities. Once each individual service was wrapped in a

[1] Microsoft Corporation

[2] MathWorks, Inc., Natick MA.

workable interface, a future COM module would be developed to interact with the wrapper interfaces.

The approach in this Case Study was aimed at developing a wrapper for the Telecom Service to interface with objects in the Resource Mapper.

After reviewing the input and output requirements of the two services, the complexity of the Telecom Service modules, and development of requirements for the Resource Mapper Service, the approach shown in Figure 3 was developed.

The central file for the interface between the two services was the Data Rate Capability File (Table 2). Each mission completing a Service Request would have a nominal DRCF that would be updated periodically as the mission progressed through its development phase. Rather than repeatedly call the Telecom Service for every change in a Service Request, an automated procedure was developed to update the DRCF when changes were made. As a background process, the Resource Mapper Service revises the Resource Mappings in response to changes to the DRCF. A dynamic linked library was developed to interface the Resource Mapper Service with the DRCF file.

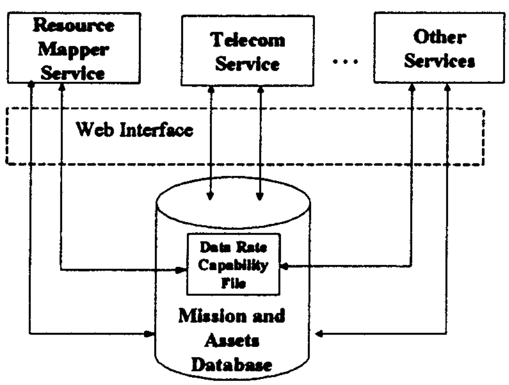

Figure 3. Case Study Architecture

In the future, it is anticipated that additional capabilities will be added in order to update inputs from the Service Request, the Resource Mapper, or from the Telecom Service.

RESULTS

After the DRCF file was incorporated into the interface between the two services, the advantages of automating the transfer of information between providers became apparent. Linkages were then established between the Telecom Service and the mission and assets database. The trajectory files containing fundamental information used by the Telecom Service could also be accessed by other provider organizations. These providers included organizations responsible for View Period Services, Mission Planning Services, Navigation Services, and Spacecraft Design Services. This added connectivity significantly reduces the traffic required to send multiple copies of these files in various formats to other providers. Much of this traffic has been response to changes by one or more of the other providers. Thus, single changes often rippled through the entire system as each provider acquired the latest version of each data set. Instead of constantly passing a variety of obsolete versions, these services could be wrapped in an interface to enable access to the latest version of the data.

An additional benefit was the potential reduction in cost of maintaining the Telecom Service by enabling the capability to access the performance parameter data directly from the mission and assets database where the parameters are maintained. Many of the hundreds of data files required by the Telecom Service contain manually copied values from the database's original source—a series of technical manuals and documents [5]. The need to review and update these data will be eliminated by directly accessing the latest on-line values of the parameters.

DISCUSSION AND OBSERVATIONS

The use of web-based software technologies to facilitate integration of technical organizational processes was demonstrated in the study. The use of interface wrappers for interacting with dissimilar computer architectures, operating systems, and software tools, proved beneficial on both sides of the interface. The requestor of Telecom service was able to view a simple set of inputs and outputs while the provider of service could focus on their service without the necessity of developing burdensome interfaces or rewrites to their code.

The process of wrapping inherited legacy software to interface with newer object models was viewed as the next logical step in the development of a service-based planetary telecommunications system. A key advantage of this process is the ability of each component to evolve at individual rates subject to varying requirements and budgetary constraints.

The next logical step is the development of standardized interfaces for software communication. Defining COM and XML interface standards enable concurrent software development efforts and focusing on internal process improvements versus revising outputs to meet new customer requests.

In closing, a number of observations were drawn:

Process Observations

- ❑ Each service provider should clearly define its products, required inputs, and schedule
- ❑ Functions should be integrated and combined where overlaps exist
- ❑ Simplify multiple versions of basic services to focus on appropriate process owners and reduce duplication
- ❑ Processes should be modified (if possible) to remove barriers to automation
- ❑ Emphasize concurrence versus approval where possible to enhance efficiency of service request throughput time

Web-Related Observations

- Use web-interface and data base technologies to facilitate organizational interfaces between service providers
- The software integration process should focus providers on provider issues--they should not be required to generate tools to compensate for other provider deficiencies
- Adopt standard procedures (libraries) for common interfaces and standardized access to customer service requests

ACKNOWLEDGMENTS

The authors would like to thank Chet Borden and Dean Hardi at JPL for their support. The authors also acknowledge the help of Kar-Ming Cheung and Sil Zendejas whose support enabled elements of this work to be performed. This work was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Table 2. Data Rate Capability File Example

								Canberra	Madrid	Goldstone	Canberra	Canberra	
date/time	calendar	range	range	owlt	lgax	lgaz+	sc ant	elevation	elevation	elevation	max uplnk	max dnlnk	
yyyy-doyThh:mm:ss	date	km	AU	sec	to earth (deg)	to earth (deg)	best LGA	angle (deg)	angle (deg)	angle (deg)bit rate (bps)	bit rate (bps)	bit rate (bps)	
1998-289T00:00:00	10/16/98	141461.5	0.001	0.47	79.99	169.62	(U/L)lgaz-(D/L)lgaz-	10	10	10	2000	28440	More →
1998-290T00:00:00	10/17/98	358308.9	0.002	1.2	86.72	176.41	(U/L)lgaz-(D/L)lgaz-	10	10	10	2000	28440	
1998-291T00:00:00	10/18/98	548242	0.004	1.83	27.61	62.15	(U/L)lgax (D/L)lgax	10	10	10	2000	28440	
More →													

REFERENCES

1. National Aeronautics and Space Administration, Space Operations Management Plan, Document JSC 27527, Lyndon B. Johnson Space Center, Houston, Texas, February 28, 1997.

2. Smith, Jeffrey H., The Challenge of Doing More With Less: Finding the Right Portfolio of Technology Investments, JPL Document No. D-11776, Jet Propulsion Laboratory, Pasadena, California, May 1994.

3. Smith, Jeffrey H., "The New Millennium Technology Program: Streamlining the R&D Planning Process," *Proceedings of the 25th Annual Meeting of the Decision Sciences Institute*, Seattle, WA, 1996, pp. 518-520.

4. Smith, Jeffrey H., "Algorithm for Service Request Processor Antenna Selection Using Mission and Assets Database (MADB) Inputs," JPL IOM 311.8/97-14, Jet Propulsion Laboratory, Pasadena, California, July 28, 1997.

5. TDA, Deep space Network/Flight Project Interface Design Handbook, JPL Document 810-5, Rev. D, Volumes I, II, Jet Propulsion Laboratory, Pasadena, CA, March 29, 1997.

6. Sessions, Roger, COM and DCOM: Microsoft's Vision for Distributed Objects, Wiley Computer Publishing, John Wiley and Sons, New York, 1998.