AN OSI ARCHITECTURE FOR THE DEEP SPACE N1O'WORK

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ABSTRACT

The flexibility and robustness of a monitor and control system arc a direct result of the underlying inter-processor communications architecture. A new architecture for monitor & Control at the Deep Space Network Communications Complexes has been developed based on the Open System Interconnection (0S1) standards. The suitability of 0S1 standards for DSN M&C has been proven in the laboratory. '1 'he laboratory success has resulted in choosing an OS]-based architecture for 1) S-13 M&C. DSS-13 is the, DSN experimental station and is not part of the "operational" DSN; it's role is to provide an environment to test new communications concepts can be tested and conduct unique science experiments. Therefore, DSS-13 must be robust enough 10 suppor [operational activities, while also being flexible enough to enable experimentation. This paper describes the M&C architecture clc.vc.loped for 1)SS-13 and the results from system and operational testing.

Keywords: 0S1, Monitor& Control, GOSI P, Deep Space. Network

1. INTRODUCTION

The flexibility and robustness of a monitor and control system arc a direct result of the underlying inter-processor communications architecture. The Monitor and Control (M&C) system for the Deep Space Network Communications Complexes (DSCC) is based on an architecture developed 10 years ago -- before the advent of the international standards that exist today. As a result, the existing M&C architecture is difficult 10 operate, main tain, and update.

The emergence of the Open Systems Interconnection (OSI) standards and the concept of an open systems architecture hold great promise for providing improved operational environments. The application of OSI-based commercial products to support inter-processor communications is expected to improved inmr-operability while resulting in substantial cost savings. The Government Open Systems Interconnection Profile, (GOSIP), a mandatory Federal Information Processing Standard (FI I'S) for all new computer systems, was adopted to provide computer security for all government systems and to promote the development of OSI technology in the commercial arena,

"1 'he. problems that face the. DSN arc assessing the applicability of the 0S1 standards for DSN systems and identifying migration paths from the existing systems to C)S1-based systems. To determine whether the 0S1 standards were capable of meeting the needs of the 1)SN, an 0S1 testbed was developed to investigate the process control standards (M MS/MAP). The testbed consisted of three elements: the Very Long Baseline Interferometry (V1 .BI) subsystem, the power meter, and the monitor & control computer. The goal of the. testbed was to establish client-server relationships between M&C and the two subsystems across a 1.AN, to create a client-server relationship between the. two subsystems, and to assess performance. '1 'he. testbed was highly successful and the. results indicated that an OSI-based architecture was feasible for DSN Station M&C [Ref. 1].

The success of the OS I-based approach resulted in its selection as the M&C architecture for DSS - 13 -- an experimental Deep Space Station in the DSN. I)SS-13 is not part of the regular operational DSN. Rather, i t serves two purposes: as a test-bed for new concepts in deep space communications, and as a resource for performing unique science experiments. DSS-13 consists of a new .34-Meter Beam Wave Guide Antenna, two advanced receivers, Weather Stat ion, Total Power Radiometer, Microwave S witch Controller, VLBI Wide Channel Band System, Water Vapor Radiometer, Data Handler, and the. Monitor & Control System. The goal for 1992 is to develop, install, and test an operational M&C System to support 1) S- 13 operations and experimentation using this core set of equipment. This paper will describe the architecture of the. DSS-13 M&C system, discuss how the 0S1 standards were applied, and provide results from systems and operational testing Of the M&C sy stem.

2. 1)S S-13 MONITOR & CONTROL SYSTEM ARCHITECTURE

Deep Space Station 13 (1>SS-13) is an experimental beam waveguide antenna used by the DSN to investigate the applicability of Ka-Band deep space. communications. The core subsystems in place at 1)SS-13 are a mixture of several generations of communications and radiometric instruments. The one characteristic they all shared at the beginning of the DSS - 13 M&C development was that all subsystems were designed to work assuming the. presence of a dedicated operator per subsystem. The success of the 0S1 testbed activity led to the concept of centralized M&C at 11 - 13 using 0S1 standards and commercial- off-the-shelf (COTS) hardware and software. The goal set for [h for the DSS-13 M&C team was 10 design, develop, integrate, test, and turn over to operations a centralized M&C system capable of supporting the Ka-Band Link Experiment (KABLE) using only one operator in slightly over one year.

The resulting M&C system is described in the following section. We also present a section on our approach to using the. 0S1 standards, and the current status.

2,1 Station Monitor& Control System

The 1)SS-13 Station Monitor & Control System consists of a central ized monitor and control station (referred to as the Station M&C subsystem - SMC), the M&C interfaces present in each of the. subsystems that are part of the DSS - 13 core equipment, and the Local Area Network (LAN) which connects them all to each other. A block diagram of the DSS-13 configuration is given in Figure 1. The functional goals [Ref 2] of the M&C system are:

1. Provide a centralized M&C facility which will enable a single operator to operate all the equipment necessary to support KABLE.
2. Enable the. SMC operator to perform any operations function for the subsystem through the SMC
3. Provide a means of distributing support data (for example, predict files) to the. subsystems from the SMC
4. Provide a graphical user interface which can be tailored by station personnel to meet their operational needs.
5. Provide a means of recording and logging all operational functions, monitor data, and event not ices.
6. Provide an open systems environment capable of supporting automation

The SMC system constraints were:

1. It must be flexible: enable new subsystems 10 be added quickly, easily, and inexpensively. Since DSS-13 is an experimental station, the ability to bring out new equipment, quickly connect to core equipment, and test out new concepts is an important part of its function.
2. It must be reliable: SinceIXiS-13 is also, in a limited sense, an operational station, the. M&C system had to be able to routinely support operations functions
3. It must comply with the, Government Open Systems Interconnection Profile (GOSIP)

2.2 Approach

The development of subsystems for 1)SS - 13 was well underway when the. c.once.pt of implementing a centralized M&C strategy at the. station was adopted. Our approach to developing the SMC was highly influenced by the need to "retrofit" these subsystems with the capability to be operated over a computer network. In some cases, this was straightforward, in others, it required a significant effort on the part of both the, M&C and the. subsystem development teams. In order 10 remain cost effective, our design decisions had to work with the. existing hardware and software environments used by the subsystems with little or no nmlific.alien. The following sections describe the basic design decisions made and their impact on the. ovc.rail system effort,

2.2.1 MMS

The Manufacturing Message Specification (MMS) protocol was chosen as the. standard on which to base 1)SS-13 M&C. MMS is an application layer protocol designed for process control. The 0S1 testbed activity demonstrated the solid match between the services offered by MMS and those required to support M&C operations functions, Table 1. Rascal on the commercial availability of products, the decision was made to implement the system using MMS over a Token Bus LAN. This decision enabled us to take advantage of the development work already done in the 0S1 Testbed and to begin immediate procurement of the necessary hard ware[1].

[1] Plans are already in place to replace the Token ~~Ring~~ with an ethernet.
Bus

Functional Requirement	MMS Services
Context Management	Initiate Conclude Cancel Abort
Client-Server Relationship	Initiate/Conclude Request Initiate/Conclude indication Initiate/Conclude Response Initiate/Conclude Confirm
Distribution of Support Files	copy Obtain Open Read Close Rename Delete
Directives, Displays, Events, Alarms	MMS Variable Access Read/Write Variable Information Report Get Attributes Define Type Delete Type est.

Table 1. M&C Functional Requirements vs MMS Services

2.2.2 Common Software and Environment

Our approach centered on quickly standardizing a common language and operating system (in our case MS DOS and MS C, current versions). These were chosen because they several of the subsystems were already using them, and because MMS products existed for these environments. The common software needed by each subsystem to form the interface between MMS and their applications was developed and integrated by the M& C team. In some cases, this required translating from one version of the C compiler to another, in other cases, it involved finding compatible products for other environments (e.g. Basic, UNIX). The integration effort was, at times, painful due to the "after-the-fact" decision to use a centralized M& C approach. The local control interfaces needed to be re-engineered, additional data structures were required to support additional feedback needs, and code had to be optimized to meet operating system memory size limitations.

2.2.3 Data Dictionary/Table

The primary interface between M&C and the individual subsystems is through the Data Dictionary. The Data Dictionary provides a listing of all the variables (used to send control information and monitor health, status, and performance) needed to run a subsystem. M&C contains a complete listing. Each of the subsystems contains a complete table of their own variables as well as additional data structures to provide specific information from other subsystems. The table-driven nature of the architecture enables rapid addition, deletion, and other changes and makes adding new subsystems relatively straightforward.

2.2.4 User Interface

The Dexterity[2] commercial user interface package was used to provide the SMC user interface. Draft displays were generated by the SMC team and given to the DSS-13 operators. They were trained in the use of the Dexterity package and began developing their own displays. in the DSS-13 environment where the. types of activities being supported can change, on a regular basis, it is very important for the, operators to have the ability to tailor old displays and build new ones to meet their needs. Because of the open system architecture, data could easily be accessed through the data dictionary and displays incorporating a variety of parameters assembled without a software development effort being needed.

[2] Trademark, Nucleus Software Systems, Ltd

3. STATUS

The overall configuration for 1> S-13 is shown in 1 'igure 1. The M&C system is currently being tested with all of the major subsystems required for KABLE operations. 1)evelopment of the SMC began in October 1991, system integration with the DS S- 13 subsystems in July 1992, and the station will be operational in order to support KABLE in January 1993. During the one-year development effort, two new subsystems, the Station Data Recorder and the High Resolution Microwave Survey (HRMS) gateway were added.

The HRMS gateway was developed to provide. an interface which allowed the experiment to control station equipment over the M&C LAN when the previously planned direct connection was deemed unfeasible at the last minute. The subsystem was developed, integrated, and tested in under 4 months and supported the HRMS kickoff on October 1?., 199?. The flexibility of the DSS-13 M&C architecture in responding to short fuse customer requests resulted in a successful experiment. In addition, the DSS - 13 oJw.raters developed a display which allowed them to monitor the station equipment while it was under the control of the experiment and were able to detect a serious anomaly in time for the experiment to fix it during the actual experiment.

4. SUMMARY

'l"IIC1XS-13 experience in the application of OSI standards to support M&C has been extremely successful. The chosen standard, MMS, meets the functional needs of the station and provides a level of flexibility and responsiveness previously unknown in that environment, The architecture is robust enough to meet current operational needs and flexible enough to provide an migration path for new subsystems.

The experience has also highlighted some important lessons learned on the application of COTS hardware and software and the importance of good systems engineering and configuration control. As a "breadboard" for a M&C system for the operational subnetworks of the DSN, the 1)SS-13 M&C System has provided valuable insights and a proof of feasibility for the overall architecture.

5. ACKNOWLEDGMENTS

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7. ACRONYMS

COTS	Commercial Off the Shelf
1)SCC	1 Deep Space Communications Complex
DSN	Deep Space Network
DSS	Deep Space Station
FIPS	Federal Information Systems Processsessing Standards
GOSIP	Government Open Systems Interconnection Profile
HRMS	High Resolution Microwave Experiment
1s0	international Standards Organization
KABLE	Ka-Band Link Experiment
LAN	Local Area Network
MA}'	Manufacturing Automation Protocol
M&C	Monitor & Control
MMS	Manufacturing Message Specification
0s1	Open Systems Interconnection
SMC	Station Monitor & Control
TDA	Telecommunications and Data Acquisition
VLBI	Very Long Baseline Interferometry

DSS-13 MONITOR & CONTROL