Acquisition Strategies for Service-Oriented Architected Spacecraft Command and Control Systems

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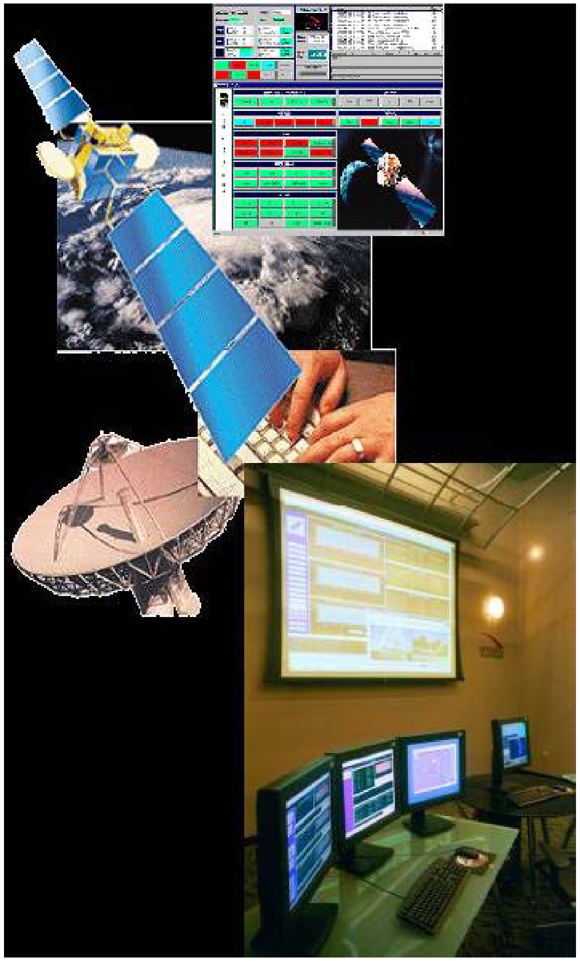
Assuring Space Mission Success

Introduction

- Trend for Service-Oriented Architecture (SOA) being embraced by space community
- CCSDS has published draft standards for a SOA based Spacecraft Command and Control Systems
- Programs such as GPS in process of acquiring a SOA based Command and Control System
- Challenges exist for the acquisition organization
- Strategies to address challenges



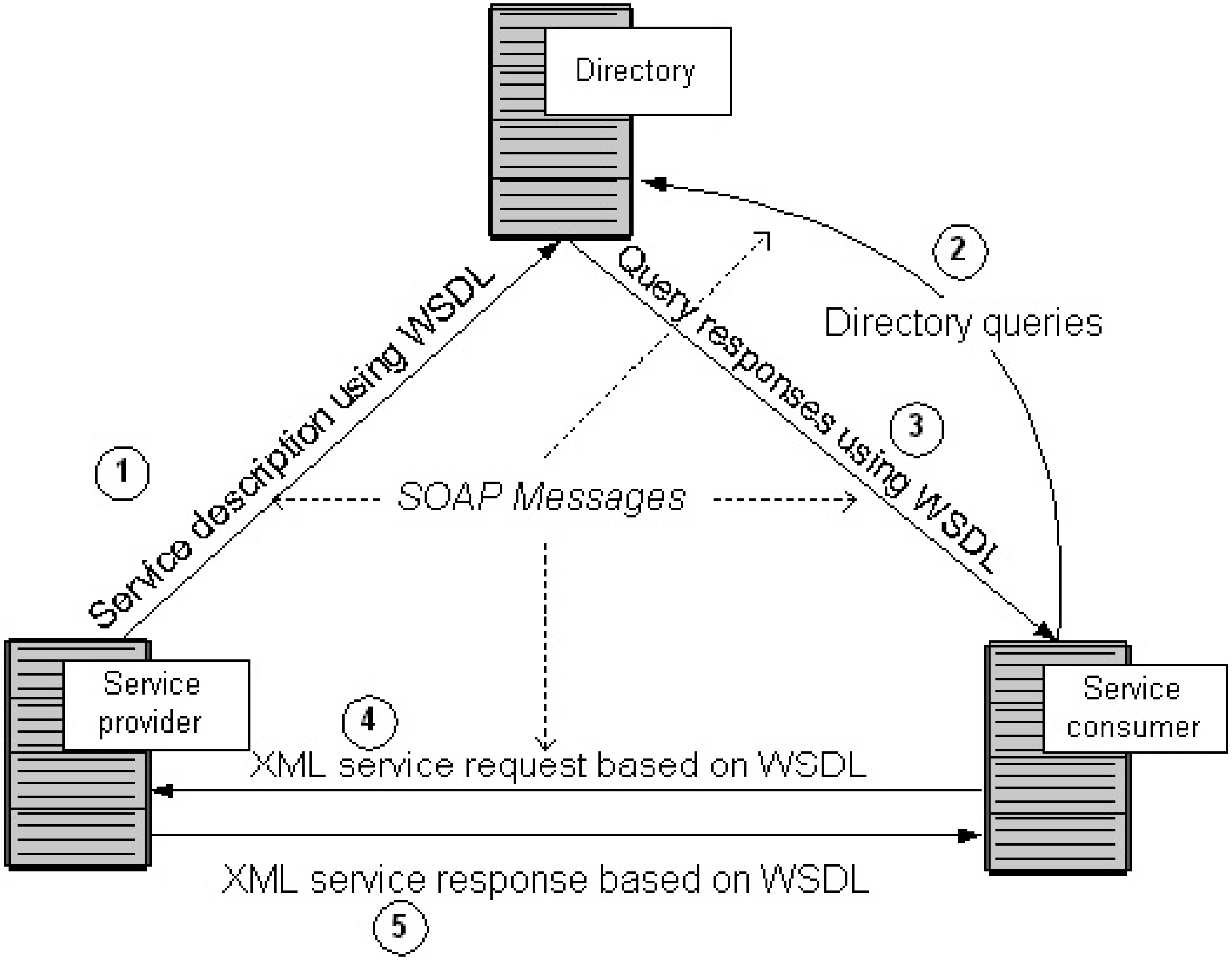
SOA Defined

- A paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains

- It provides a uniform means to offer, discover, interact with and use capabilities to produce the desired effects consistent with measurable preconditions and expectations

- In its simplest form, a Service-Oriented Architecture is a collection of services
  - Services are defined as intrinsically unassociated units of functionality, which have no calls to each other embedded in them

EXAMPLE SOA using Web Services


Directory
1
Service description using WSDL
2
Directory queries
Query responses using WSDL
3
SOAP Messages
Service provider
Service consumer
4
XML service request based on WSDL
XML service response based on WSDL
5

Barry, Douglas K., *Web Services and Service-Oriented Architectures: The Savvy Manager's Guide*, Morgan Kaufmann Publishers, San Francisco, CA, 2003, p. 23

Spacecraft Command and Control Services

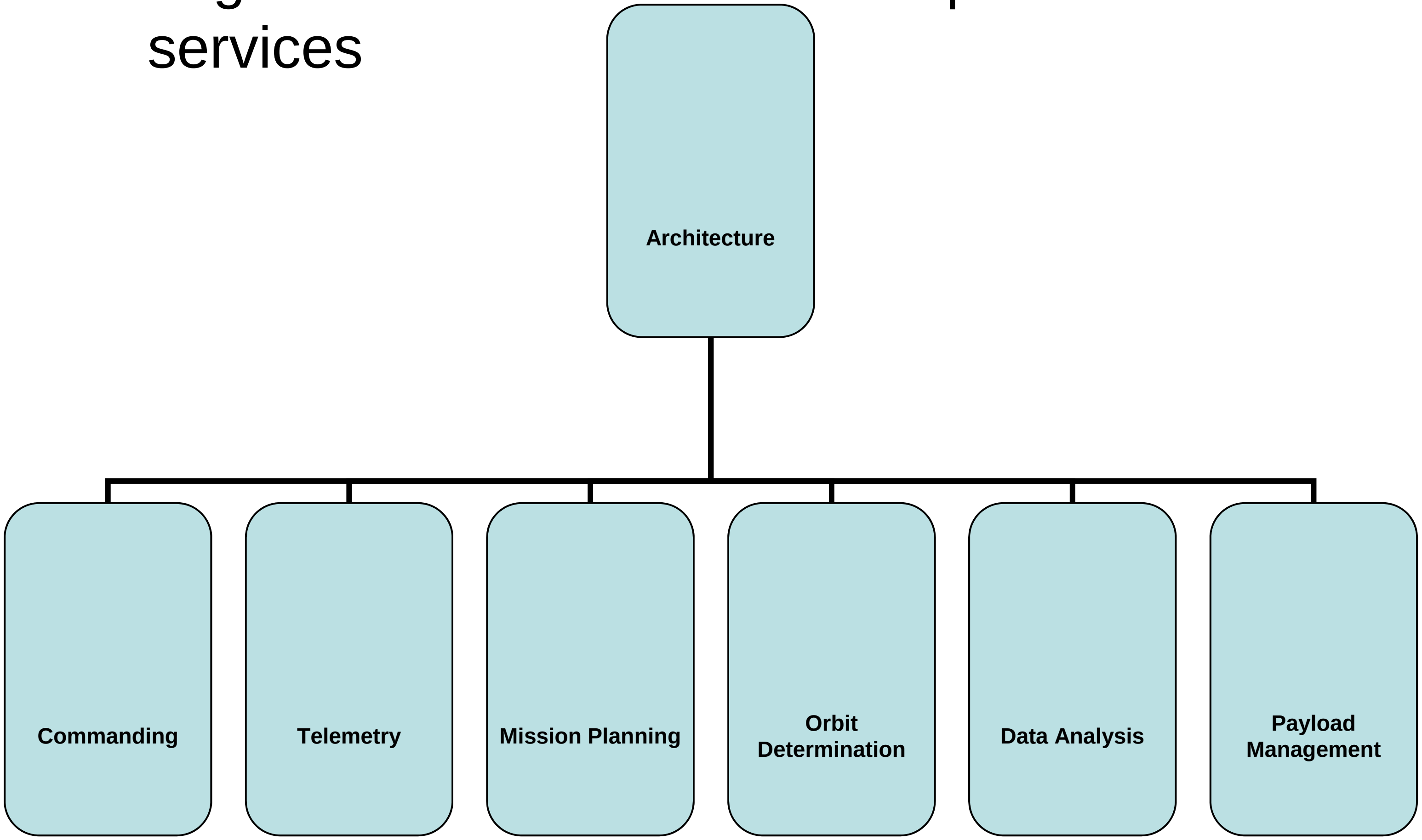
- Mission Planning
- Spacecraft Commanding
- Telemetry Processing
- Orbit Determination and Analysis
- Payload Management
- Simulation
- Procedure Development and Execution
- Data Analysis

Challenges

- Developing the Right Set of Requirements
  - Need to adapt requirements to available products and services
- Developing a System Architecture that is Compatible with Diverse Products
  - Large effort required to standardize product interfaces as well as keeping system secure
- Integrating Many Diverse Products
  - Allocating sufficient time and resources to this effort may require rework of existing scheduling models.

Strategies

- Organize the team around the products or services



Strategies

- Developing the "Right Set" of Requirements
  - Keep system requirements at a high level
  - Specifying too much detail in the system requirements limits the solution set and makes decomposing the requirements very difficult, causing redundancy at lower levels.
  - Prototype often to test out the feasibility of requirements with regard to goals, risk and stakeholder buy-in
  - Involve the end users in prototype demonstrations
  - Prioritize the requirements from most to least mission critical
  - Delay the establishment of the requirements baseline until the necessary prototyping is completed

Strategies

- Developing a System Architecture that is Compatible with Diverse Products
  - Designate a dedicated group to define or oversee the selection of the middleware or communication protocol
  - Describe the architecture in the simplest means possible
  - Define performance and security requirements up front
  - Perform trade studies while prototyping various architectures against defined criteria
  - Select products and vendors that can easily conform to selected architecture
  - Maximize use of COTS and/or reuse and legacy software when possible

Strategies

- Integrating Many Diverse Products
  - Allocate at least 50% of the development schedule to integration and test
  - Develop a formal plan for integration and test and adhere to it
  - Ensure that best practices and standards are used while executing integration and test
  - Use proven test methods and certified test equipment
  - Employ an independent test organization to verify the functionality

Software Acquisition – Capability Maturity Model*

- 5 levels
  - Initial – Ad hoc acquisition process
  - Repeatable – Processes are in place to plan, manage, evaluate and transition the product
  - Defined – Acquisition process is documented and standardized
  - Quantitative - Detailed measures of the acquisition processes and processes are collected
  - Optimizing - Continuous process improvement is fostered by quantitative feedback from the process

*** Software Acquisition Capability Maturity Model (SA-CMM) Version 1.03**
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Software Acquisition – Capability Maturity Model*

- Process Areas
  - Level 1 – Initial: None
  - Level 2 – Repeatable
    - Software Acquisition Planning
    - Solicitation
    - Requirements Development and Management
    - Project Management
    - Contract Tracking and Oversight
    - Evaluation
    - Transition to Support

*** Software Acquisition Capability Maturity Model (SA-CMM) Version 1.03**
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Software Acquisition – Capability Maturity Model*

- Process Areas (continued)
  - Level 3 – Defined:
    - Process Definition and Maintenance
    - User Requirements
    - Project Performance Management
    - Contract Performance Management
    - Acquisition Risk Management
    - Training Program Management
  - Level 4 – Quantitative:
    - Quantitative Process Management
    - Quantitative Acquisition Management
  - Level 5 – Optimizing:
    - Continuous Process Improvement
    - Acquisition Innovation Management

*** Software Acquisition Capability Maturity Model (SA-CMM) Version 1.03**
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Software Acquisition – Capability Maturity Model - Tailored

- If Level 2 add “Acquisition Risk Management” and “User Requirements”

- Merge “Requirements Development and Management” and “User Requirements” into one process area

- Inform end user of acquisition strategy

- Hold off on placing the requirements under change control until the necessary prototyping is done

- Performance and security requirements should be established early and placed under change control before the prototyping effort begins

Conclusions

- A SOA based system offers multiple benefits
  - Interoperability, reusability, expandability, maintainability
  - Cost reductions and improved service to users
- Challenges to acquisition organization can be overcome by:
  - Involving the end user early
  - Adapting requirements to products
  - Prototyping before baselining requirements
  - Selecting vendors that will bear the cost of standardization
  - Tailoring Software Acquisition – Capability Maturity Model