Empowering Legacy Reuse with Service Oriented Architecture and Web Services

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SSTC 2009
April 23, 2009

NSD: Navigation Systems Division of Northrop Grumman Corporation

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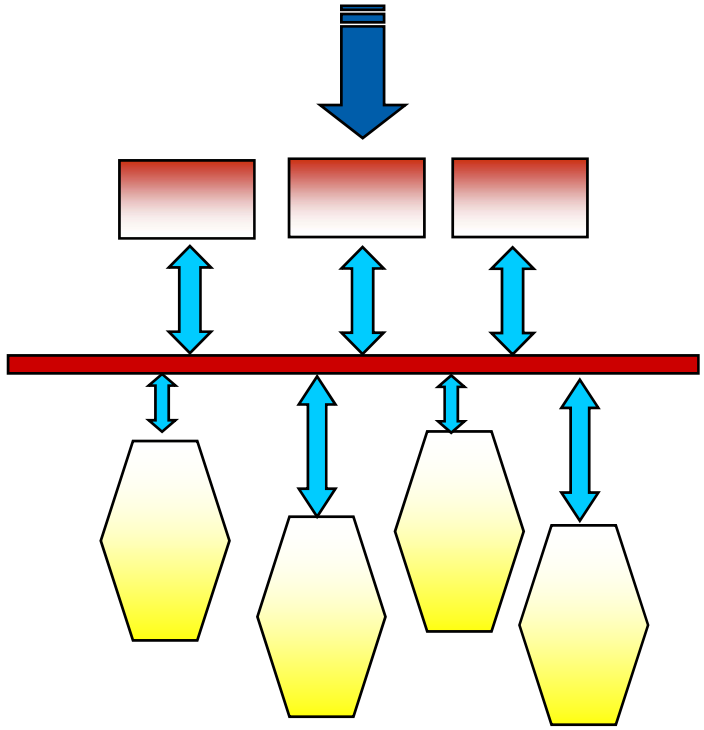

Overview

- **Classic Legacy Reuse Technique**
  - Inherited from earlier languages, platforms, and technologies
  - Represents valuable core technologies and billions of dollars of investment (time and money)
  - Parts of legacy software are routinely reused in new products and systems
  - Demands for new technologies make reuse difficult; often leading to reengineering or *copying* code
- **Motivation for Legacy Reuse**
  - Increase productivity
  - $/SLOC reduced approximately 47% by work avoidance (*IEEE source*)
  - Provide system interoperability

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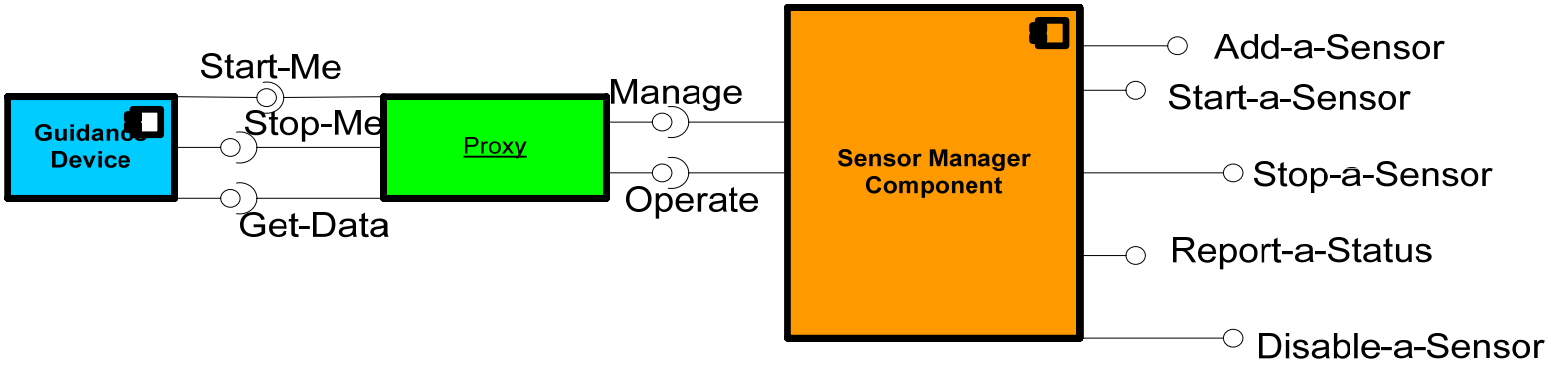
Classic Methods for Legacy Reuse

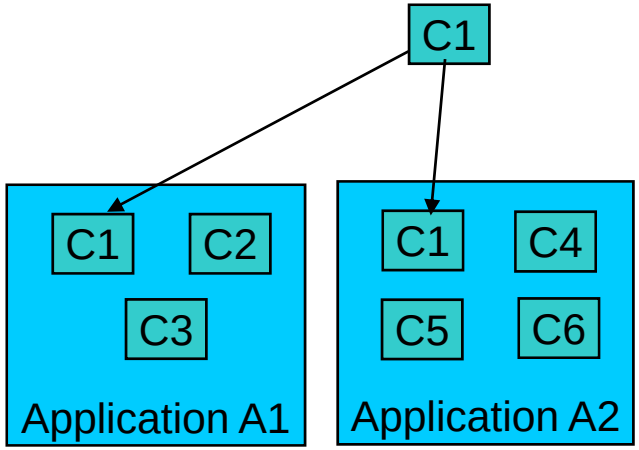
- **Predominate methods for reusing legacy code is by 'copying' code (or code duplication)**
- **Code level reuse is a poor practice**
  - Inflates volume of low-reuse legacy code
  - Must resolve interface differences during integration making it difficult
  - Resolved defects, enhancements, or other changes to the reusable code
    - Require updating multiple copies of the same source code to incorporate changes
    - Creates version control nightmare
    - Not propagated to applications
  - Does nothing to solve the reusability problem

A Better Way - Component Based Reuse

- **Make components out of legacy code**



- **Build new systems with these components**
  - Reuse components across many systems
  - Achieve uniformity in design and interfaces
  - Make “whole” with “parts”



Component Based Design (CBD) and an Architectural Framework

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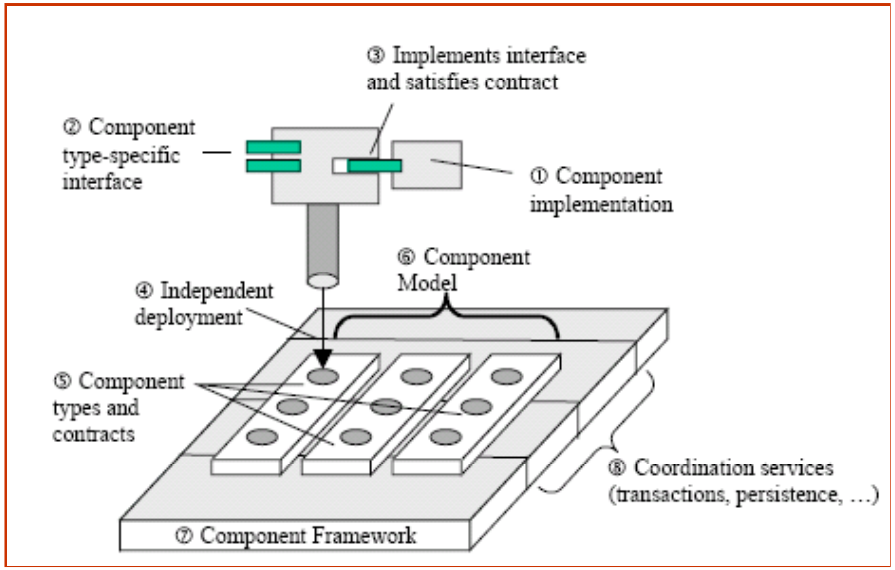
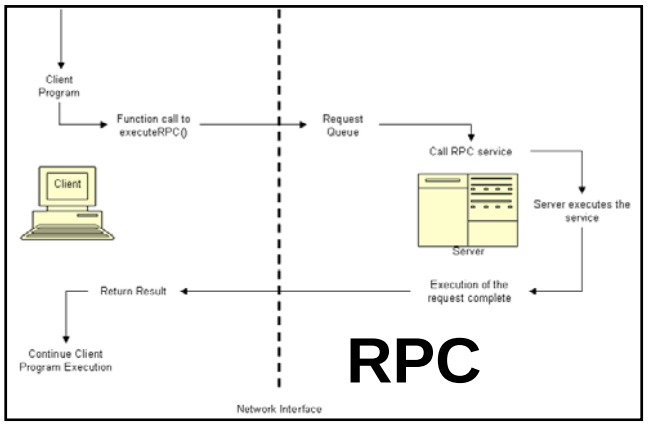
- **Critical Success Factor with CBD**
  - Using a standard software architecture
  - Conformance to component models transforms software implementations into standard architectural implementations
  - Variety of component models available - our solution uses a Service Oriented Architecture (SOA) framework

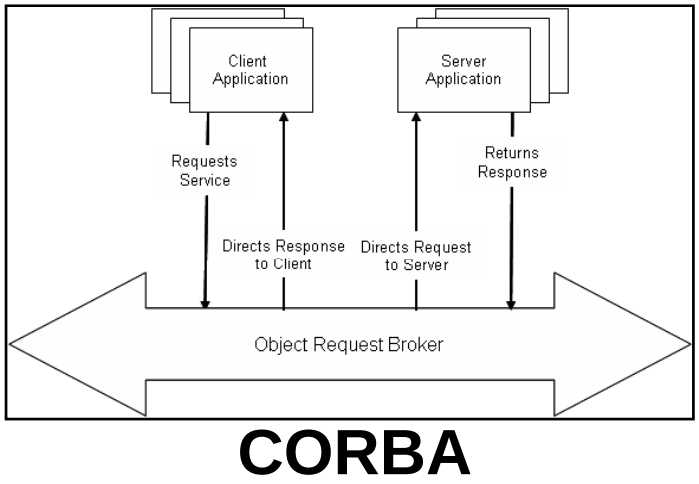


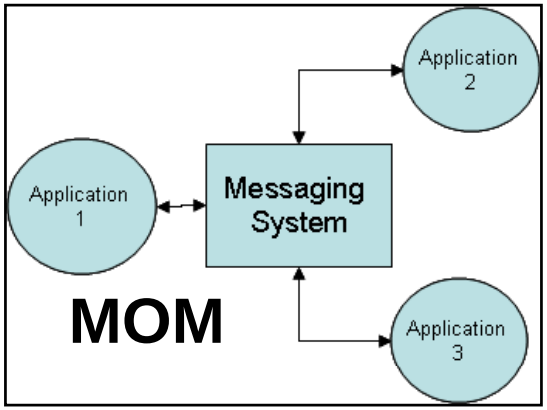
"Technical Concepts of Component-Based Software Engineering"
SW Eng Inst, Carnegie Mellon university

Enabling Technologies

- Interfacing approaches and component models specify how components interact with each other
  - Common Object Request Broker Architecture (CORBA)
  - Message-Oriented Middleware (MOM)
  - Remote Procedure Calls (RPC)
  - Microsoft DCOM and .NET
  - Web Services and J2EE







Enabling Technologies – Service Oriented Architecture (SOA)

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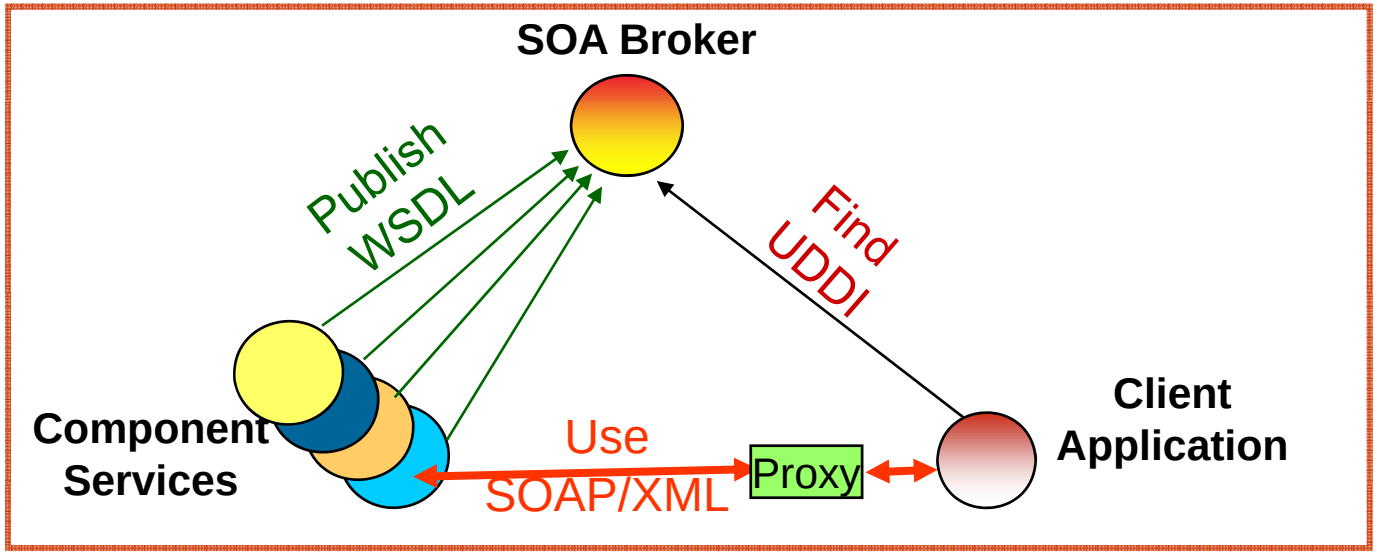
- Gartner: "a style of multi-tier computing that helps organizations share logic and data among multiple applications and usage modes."
- IBM: "an application architecture within which all functions are defined as independent services with well-defined invokable interfaces which can be called in defined sequences to form business processes"
- Us: Standards based reconfiguration of legacy software with standards based interfaces. Motive = Business Agility
  - Configure legacy software into components and publish as a service in an SOA framework

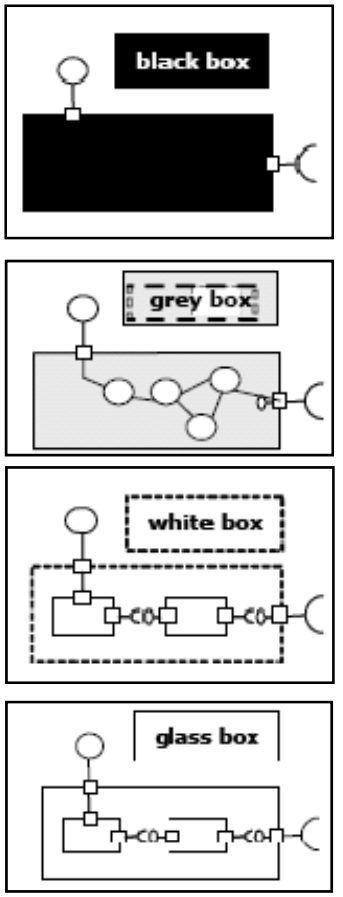


Enabling Technologies

- Service Oriented Architecture (SOA)
  - Principles include encapsulation, abstraction, reusability, autonomy, optimization, discoverability
  - Service provider exposes its interface and information necessary to use the service
  - Web Services implement a SOA
    - SOAP – protocol to exchange XML messages commonly using HTTP; but not necessary
    - More flexible over other interfacing approaches
- Resolve by linking vs. Resolve dynamically?
  - UDDI - Universal Description, Discovery and Integration
  - Discover servers dynamically

Binary Level Reuse

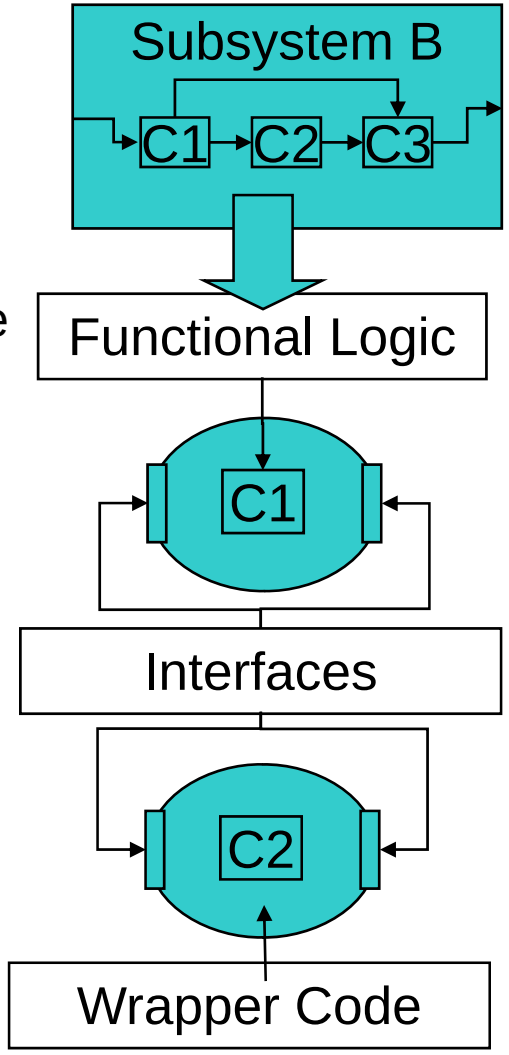
- **Binary (or library) level reuse**
  - Facilitates reuse of the same compiled code from multiple projects without needing access to the source code (examples: Windows DLLs & COM objects)
- **Advantages**
  - Source code and binary version control issues are centralized and not distributed across all users maintaining specialized versions of source or binary
  - Although source code is not available, users can still extend the functionalities of the reused components using wrappers and facades
  - Facilitates Black box reuse of legacy code
    - Turn legacy code into binary reusable components
    - Group related functions into a single component
    - Modularization - make components reusable across different systems
  - Components are “black boxes” to its clients
    - Implementation detail is hidden
    - Interaction via messages



“Component-based Approach and Dependable Systems”
Dept of CS/Eng, Malardalen University

Overview of Solution

- **Basic Methodology**
  - Extract reusable components (C1 and C2) from Legacy Subsystem B
  - Wrap reusable components
  - Develop public interface, protocol, and required message formats to interact with components
    - Platform independent data types
- **C1 and C2 are reusable components**
  - Can be independent or create another composite component
  - Subsystem B as well as other systems can request their services



Overview of Solution - Component Reuse and Extracting Interfaces

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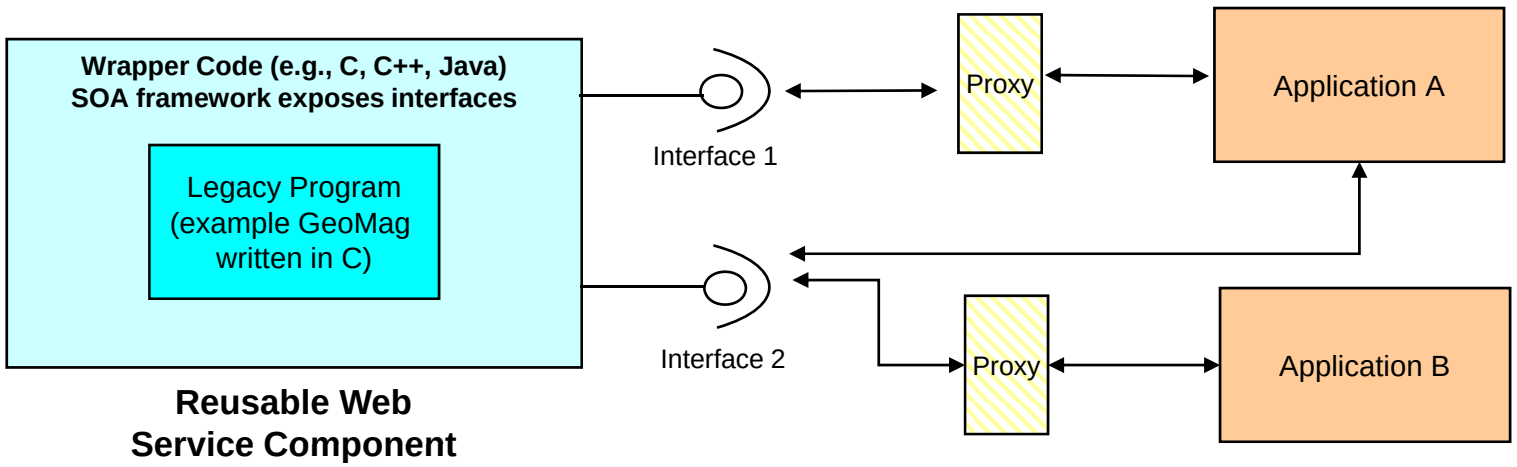
- **Extraction**
  - Identify code of a business operation to determine feasibility of reuse as a public interface
    - Use control and data flow analysis to identify processing and affected data objects.
  - SoftLink process (*Sneed, Harry; Fifth IEEE International Workshop, 2003*)
    - Process for creating Web Services from Legacy Applications
    - Function mining, function wrapping, XML schemas
  - Brute force extraction of reusable functional components from the legacy application
- **Recompose interfaces**
  - Wrap function prototypes in a generic fashion
  - Interface definitions describe how components should be utilized
    - Must be clear, unambiguous, platform independent
    - Web Service Description Language (WSDL)
  - Resolve interface differences with a ‘proxy’ component

Example Reuse Architecture

- Example using a legacy application (GeoMag) written in C that performs various Geodetic calculations, including magnetic variation
- Wrapper code exposes two interfaces (web services)
  - Application A uses both interfaces 1 and 2
  - Application B uses interface 2
- Proxies are used to resolve interface differences



Sample Interface Specification for GeoMag Example

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- Interface for calculating magnetic variation
- Defines inputs and outputs
  - Input: Lat/Long, Altitude, Date
  - Output: Magnetic Variation
- Written in WSDL

GeoMagWSDLOperationRequest (5 parts)

Part Name	Part Element or Type
latitudeDecimalDegrees	xsd:double
longitudeDecimalDegrees	xsd:double
altitudeInHundredsOfMeters	xsd:float
yearInteger	xsd:positiveInteger
monthInteger	xsd:positiveInteger

Add Part | Remove Part

GeoMagWSDLOperationReply (1 part)

Part Name	Part Element or Type
magneticDeclination	xsd:double

Add Part | Remove Part

```
<?xml version="1.0" encoding="UTF-8"?>
<definitions name="GeoMagWSDL" targetNamespace="http://j2ee.netbeans.org/wsdl/GeoM
    xmlns="http://schemas.xmlsoap.org/wsdl/"
    xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:tns="http://j2ee.netbeans.o
    <types/>
    <message name="GeoMagWSDLOperationRequest">
        <part name="latitudeDecimalDegrees" type="xsd:double">
            <documentation>Latitude In Decimal Degrees (-90 to 90)</documentation>
        </part>
        <part name="longitudeDecimalDegrees" type="xsd:double">
            <documentation>Longitude in Decimal Degrees (-180 to 180)</documentati
        </part>
        <part name="altitudeInHundredsOfMeters" type="xsd:float"/>
        <part name="yearInteger" type="xsd:positiveInteger"/>
        <part name="monthInteger" type="xsd:positiveInteger"/>
    </message>
    <message name="GeoMagWSDLOperationReply">
        <part name="magneticDeclination" type="xsd:double"/>
    </message>
    <portType name="GeoMagWSDLPortType">
        <operation name="GeoMagWSDLOperation">
            <input name="input1" message="tns:GeoMagWSDLOperationRequest"/>
            <output name="output1" message="tns:GeoMagWSDLOperationReply"/>
        </operation>
    </portType>
    <binding name="GeoMagWSDLBinding" type="tns:GeoMagWSDLPortType">
        <soap:binding style="rpc" transport="http://schemas.xmlsoap.org/soap/http"
        <operation name="GeoMagWSDLOperation">
            <soap:operation/>
            <input name="input1">
                <soap:body use="literal" namespace="http://j2ee.netbeans.org/wsdl/
            </input>
            <output name="output1">
                <soap:body use="literal" namespace="http://j2ee.netbeans.org/wsdl/
            </output>
        </operation>
    </binding>
    <service name="GeoMagWSDLService">
        <port name="GeoMagWSDLPort" binding="tns:GeoMagWSDLBinding">
            <soap:address location="http://localhost:18181/GeoMagWSDLService/GeoMa
        </port>
    </service>
    <plnk:partnerLinkType name="GeoMagWSDL1">
        <!-- A partner link type is automatically generated when a new port type i
In a BPEL process, a partner link represents the interaction between the BPEL proc
A partner link type characterizes the conversational relationship between two serv
        <plnk:role name="GeoMagWSDLPortTypeRole" portType="tns:GeoMagWSDLPortType"
    </plnk:partnerLinkType>
</definitions>
```

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Advantages of our approach

- **Programmers do not need to know implementation details**
  - Only knowledge of the interface is required
- **Transforms software implementations into architectural implementations (service oriented)**
- **Interoperable between systems and programming languages**
- **Components can be interconnected**
  - A component may rely on many other components
- **Independent deployment**
  - Dependences can be resolved at runtime
  - ‘Broken’ components can be replaced or substituted minimizing system downtime

Validation Through IRAD Prototypes

- The concept has been demonstrated in an IRAD project at NSD and used in several applications involving many different functionalities
  - Interfaced open architecture Air Defense System with Air Battle Management System
    - Integrated non-real time data into real time system
    - Mission Planning, Air Combat Order (ACO), Air Tasking Order (ATO)
  - Integrated ground picture into air picture
    - Red/blue force tracking
    - Enhanced situational awareness

Experience to Date
In IRAD Projects

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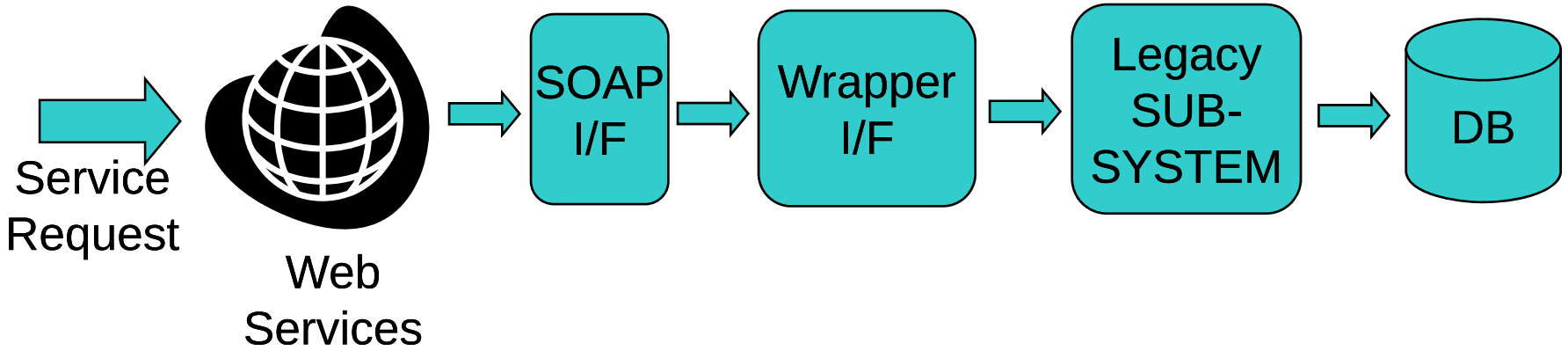
- Developed proxy component for Web Service Interface to open architecture air defense system
- Design Goals
  - Create a robust interface
  - Minimize infrastructure changes to connect system
  - Base the data exchange on XML
  - Support XML API - convert to legacy internal format
- Design Approach
  - Build the interface on SOAP Web services
  - Pass XML data via SOAP transactions



Experience to Date
In IRAD Projects

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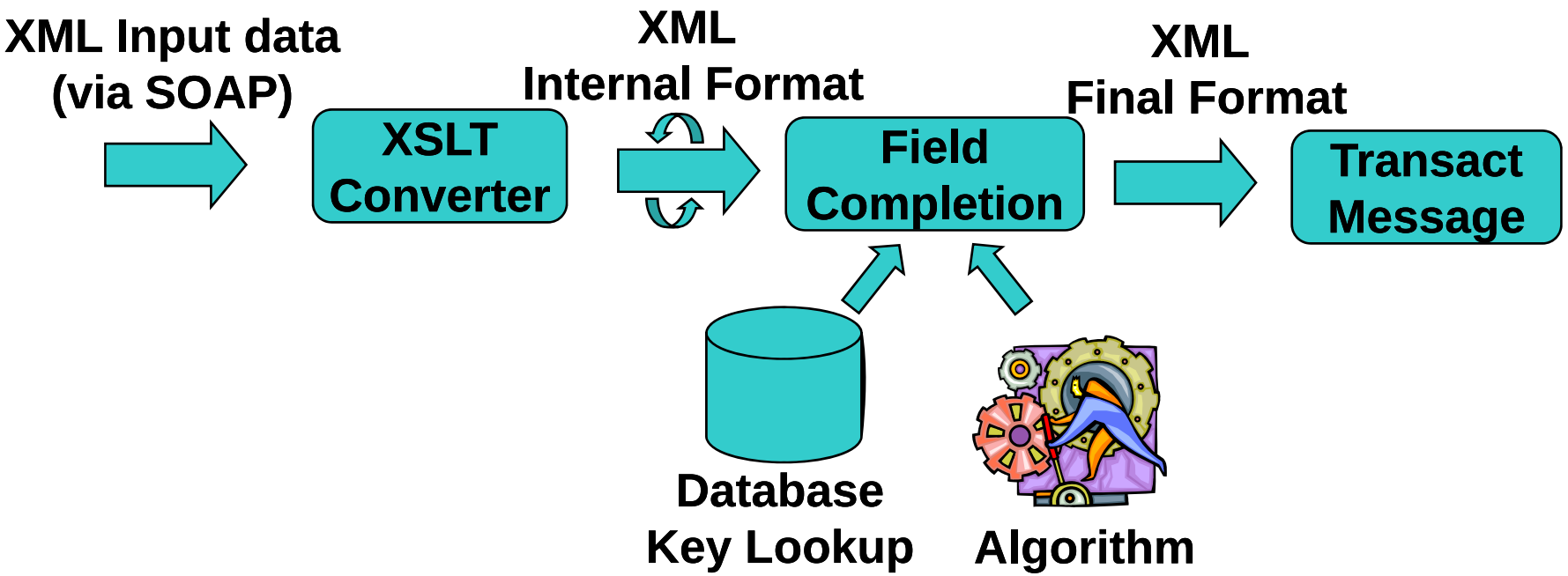
- SOAP Interface Component
  - Interface acts as a proxy
  - Extensible Stylesheet Transformations (XSLT) convert XML to internal format
  - Database and algorithms assist in resolving interface differences (e.g., units, defaults, enumerations)



Experience to Date In IRAD Projects

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- Web Services within Command and Control (C2)
  - Clients can communicate via Web Service to access Track, Unit Task Organization (UTO), and Overlay data
  - Clients are able to create, modify, and delete Track and UTO data
  - Schemas
    - Exchange Track information using Global Command and Control System (GCCS) Tactical Management System (TMS) Track schema
    - Exchange Overlay information using the Defense Information Systems Agency (DISA) XML Overlay schema
- Successfully used Web Service to integrate ground picture from Web Service with air picture
  - Exchange tactical picture in near real time
  - Red/blue force tracking
  - Link-16 messages

Future Considerations

- True web service architecture in a net centric environment
- Dynamic binding

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Summary

- Software reuse has many benefits, specifically at a binary level
- Emerging technologies (e.g., CBD, SOA) can assist in a developing a structured and disciplined architecture for component reuse
- Distributed systems with network centric architectures would greatly benefit by reusing the wealth of legacy code.

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Acronyms

- ACO – Air Combat Order
- API – Application Programming Interface
- ATO – Air Tasking Order
- C2 – Command and Control
- CBD - Component Based Design
- COM – Component Object Model
- CORBA – Common Object Request Broker Architecture
- DISA - Defense Information Systems Agency
- DLL – Dynamic Link Library
- GCCS - Global Command and Control System
- HTTP – Hypertext Transfer Protocol
- IEEE - Institute of Electrical and Electronics Engineers
- IRAD – Internal Research and Development
- J2EE - Java 2 Platform, Enterprise Edition
- MOM – Message-Oriented Middleware
- NSD – Navigation Systems Division of Northrop Grumman Corporation
- RPC – Remote Procedure Call
- SOA – Service Oriented Architecture
- SOAP – Simple Object Access Protocol
- SLOC – Source Lines of Code
- TMS – Tactical Management System
- UDDI – Universal Description, Discovery and Integration
- UTO - Unit Task Organization
- XSLT – Extensible Stylesheet Language Transformation
- XML – Extensible Markup Language
- WSDL – Web Service Definition Language


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DEFINING THE FUTURE
Questions