Service Oriented Software for Modern Fusion Experiments

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Introduction

WHAT MAKES A MODERN FUSION EXPERIMENT DIFFERENT?
- Steady state plasma!
- Plasma physics driven control!
- Largely automated analysis!
- Huge effort but still with technical risks (W7-X quench, ITER disruptions)

=> Lunar probe approach: Do the best with all data!

WHAT IS A SERVICE?
Keywords: Service oriented (SO*), Software as a Service (SaaS)

WHY DO WE NEED SERVICES?
Where you already use them and what you gain!

WHAT ARE THE PRESENT CODAC PLANS?
The route to structured SOA
Example: W7-X Automated Data Analysis

The key in all analyses!!!
W7-X Automated Data Analysis & Modelling

Finite $\langle \beta \rangle$ plasma + bootstrap current (VMEC + WebService based parallel extender)

Prediction of divertor heat loads
What is a Service?

IN GENERAL:
It is a task, that somebody else can do for you!
(e.g. serving a cup of coffee, cleaning your office, sheet of paper with Poincare ...)

IN FUSION:
Typically some expert calculation (theory), some particular data analysis (exp.), ..!
(e.g. mapping, IDA, magnetostatics, power deposition ...)

IN INFORMATION TECHNOLOGY:
For computers it is basically a remote procedure call!

PROVIDED BY:
Experts and their computers (using their favorite language and OS)!

DEFINES:
Interfaces!!!!

REPRESENTS:
Software Components
How to use a Service

Your Application

Load
Receive
Search & Receive
Bind

Service Description <File>
Service Description <Web Server>
Service Description <Registry>

Some Action

This machine has service functionality, e.g. calculation of Stellarator fields

Use it <Function Call>
How to Define a Service

Like a precise(!) contract:
(automated code generation)

Definition of interfaces:
- Data Structures
- Operations
- Input and output messages

Frameworks / Standards
CORBA, COM, ICE ... ,REST
W3C WebServices

Stateful or stateless?
(Does the service have some memory?)

At present we (CoDaC) believe in the future of (stateful) W3C WebServices!

WebServices are part of MS.NET!
The W3C Standard: WebServices
The contract

<?xml version="1.0" encoding="UTF-8"?>
<wsdl:definitions name="W7X">
  <xsd:schema
    xmlns:xsd="http://www.w3.org/2001/XMLSchema">
    <xsd:complexType name="CoilInfo">
      <xsd:sequence>
        <xsd:element name="name" type="xsd:string"></xsd:element>
        <xsd:element name="Units" type="xsd:string"></xsd:element>
        <xsd:element name="minCurrent" type="xsd:double"></xsd:element>
        <xsd:element name="maxCurrent" type="xsd:double"></xsd:element>
        <xsd:element name="Windings" type="xsd:int"></xsd:element>
      </xsd:sequence>
    </xsd:complexType>
    ...
  </xsd:schema>
  ...
</wsdl:definitions>

Definitions
Data Types
Messages
Operations
Protocol:
typ. SOAP
Service location

Barth Seminar, 23.04.2008
How to Employ WebServices

**Server Side**

**Building the client code:**

- WSDL file
  - Stub Compiler: WSDL -> Source Code
  - Compiler: Source Code -> Executable

**User Side**

**Running the client code:**

- Executable: Run
  - Service request: SOAP Message
  - Service response: SOAP Message

- Server Function: Run
Example: W7-X Field & Vessel Service
(Visual Studio C#.NET Express)
Service Oriented Fusion Initiative
Part of the SEED Project

Comprises 5 frameworks:

**SOFI:**
*Service oriented fusion initiative*, NetDisponent, LoadProbes, WSBroker

**MINERVA:**
General Bayesian modelling framework, representing Bayesian graphs

**CDB:**
Database representing all experiment relevant meta information

**OPTIMIZATION PACKAGE:**
With many exchangeable algorithms

**FUNCTIONS:**
Usage of real mathematical functions instead of data representation
Where SOFI Helps: Weaker Code Dependencies

Large Application

Application with some libraries

Each addition of features adds further Libraries

Some libraries are under development

Number of dependencies grows

Application complexity is limited
Where SOFI Helps:
Application Service + Multi-Facette User Interface

Core Application Services

Helper Services

Thin (GUI) Service Client
- Console Application
- Eclipse Plugin
- Matlab
- C#.NET, WinForms

One application, many user interfaces!
Example: Tiny Console Application  
(Line of Sight Intersection Test)

Fast intersection tests \((10^5/s)\) of this complex structure!

No dependencies to any complex program library, only to standard system libraries!

```
werner@pcwerner:~/afs/soft/i386_linux26/src/hairdryer/vesselintersector> ldd intersector
linux-gate.so.1 =>  (0xffffe000)
libstdc++.so.5 => /usr/lib/libstdc++.so.5 (0x4003e000)
libm.so.6 => /lib/tls/libm.so.6 (0x400fc000)
libgcc_s.so.1 => /lib/libgcc_s.so.1 (0x4011f000)
libc.so.6 => /lib/tls/libc.so.6 (0x40127000)
/lib/ld-linux.so.2 (0x40000000)
```
W7 Code – PIES Service
WebServices for Parallelisation

W7 Application
@home

PIES Service@Greifswald
(function parallelExtender)

PIES Services@Garching
(function singleExtender)

Sends grid points + equilibrium file
Distributes points
collect results & reports progress

$10^5$ B(r) calculations,
Surface integral takes 2 s
2-3 days computation
only 15 min. with Parallel WebServices!

Data Analysis Application
(calculation of coil signals)

112 CPUs
Where you(!) already use WebServices
Multi-facetted Application

Project Professional

Project Web Access

PSI
(WebService Interface)

MS Project Server 2007

SAP Connector
(tecneos)

SQL DB

http://svproject2/PWA/_vti_bin/psi/Project.asmx?wsdl
(Service Description)
CoDaC Plans

**CREATION OF SERVICES:**
- W7-X Poincare & Vessel Structure (service works, prototype use)
- Parallel Extender Service for VMEC & PIES (service works, prototype, however routinely used)
- Service Maintenance (next master’s thesis)

**QUALIFICATION OF SERVICE TECHNOLOGY:**
- Performance
- Reliability
- Scalability
- Maintainability
- Security?

**W7X-SOA STRUCTURE (CONTROL, DAQ, ANALYSIS, MODELLING, PUBLISHING):**
- Global service structure plans
- Definition of hardware nodes
- Network structure and transfer rates
- Enterprise service bus
Wendelstein 7-X Service Landscape (old slide)

- Application “W7”
  - Magnetic. Config.
  - Slowing Down...

- Application “LoWendel”
  - Plasma Radiation
  - Field Line Diffusion

- Application “W7-WS”
  - Linux, C++, Qt

- Plugin “W7-WS”
  - Win, Unix, Eclipse, Java

- Application “W7.NET”
  - Win .NET, C#, WinForms

- Module “W7.m”
  - MatLab, Java

- CDB
- PoolCare
- Signal Proc.
- Digital Int.
- Vessel/Limiter
- NetDisponent
- WS-Broker
- W7 Tools
- NBI
- Birth Profile
- Particle Tracer
- Legacy Codes
- VMEC
- MAG3D
- Diagnostic
- Forward Func.
- PIES Equilibrium

- CoDaStation “Wdia”
  - User Analysis Function

- Tiny Application “Intersector”
  - Intersection of Sightlines

- Integrated Data Analysis

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Service Oriented Architecture, Structured SOA
(IBM’s Redbook on SOA Foundation)
THANKS!