Data Management Support for Product Lifecycle Management*

Walid G. Aref (PI, Computer Science, Purdue)
Jingfeng Yan (Student RA, Computer Science, Purdue)
Vijay Srinivasan (Dr., IBM)

Product Lifecycle Management (PLM)

- Trends or Challenges of PLM
  - Data
  - Services
- New Technologies for PLM
  - RFID
  - SysML
  - ESB
  - Distributed Catalog

What is PLM?

- process of managing the entire lifecycle of a product from its *conception*, through *design* and *manufacture*, to *service* and *disposal*
- Motivation of PLM
  - Meet customer needs throughout the entire product lifecycle
  - Gain market advantage

PLM Infrastructure

- Data Management Perspective
  - Data
    - Collection
    - Storage
  - What can we do over the data?

  Services and Workflow
    - Sharing
    - Retrieval

Trends or Challenges of PLM

- Data
  - Heterogeneous data storage platforms
    - Comes from global or internationalized production and commerce
  - Data type and operation
    - 3D model object data search
    - 3D model object dependent relationship
  - Explosive massive data collection

Trends or Challenges of PLM (cont'd)

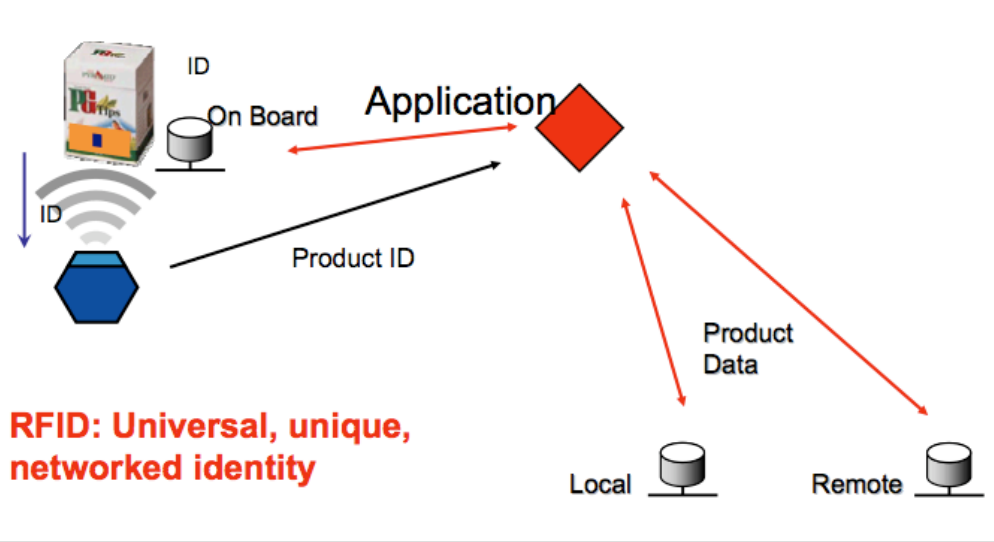
- Services
  - Service discovery
    - Handle new services (register)
    - Search services to build workflow
  - Workflow
    - BEPL is now a business process modeling language that is executable, which could transfer the state.
    - Semantics of workflow: could be domain specific
    - Automated workflow: build workflow to dynamically fit for the business requirements

New Technologies

- Radio-frequency identification(RFID)
- System Modeling Language (SysML)
- Enterprise Service Bus (ESB)
- Distributed Catalog

RFID

- A mean to automatically identify objects
  - More and more adopted by manufactures and transporter
  - RFID Elemenent
    - Tags
    - Reader
- Networked RFID



RFID Roles

- Unique identifier to an object (product)
- Helper to input data to database
- With help of network RFID and Object Naming Service (ONS)
  - Easy to retrieve data from different data sources
  - To apply in different phases of product lifecycle

SysML

- What is SysML?
  - A domain-specific modeling language for systems engineering applications
    - Modeling
      - Supports the specification, analysis, design, verification and validation.
    - Systems
      - include hardware, software, information, processes, personnel, and facilities.
- Unambiguous Language for engineers
- Keep semantics in different perspectives by diagrams

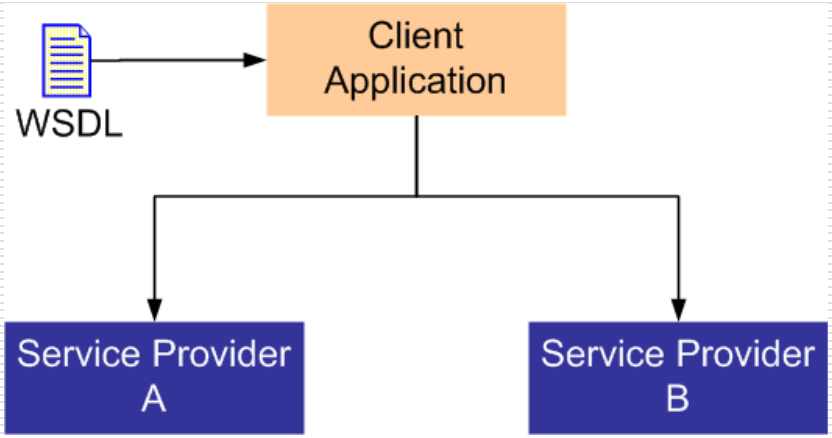
SysML Roles

- Intermediate formal language for maintain the modeling semantics between CAD/CAM and object modeling (dependency and other relationship)
  - It bridges the knowledge between
    - Engineers
    - Engineers and data service developers, who can exploit formalized information to define data and service schema

ESB

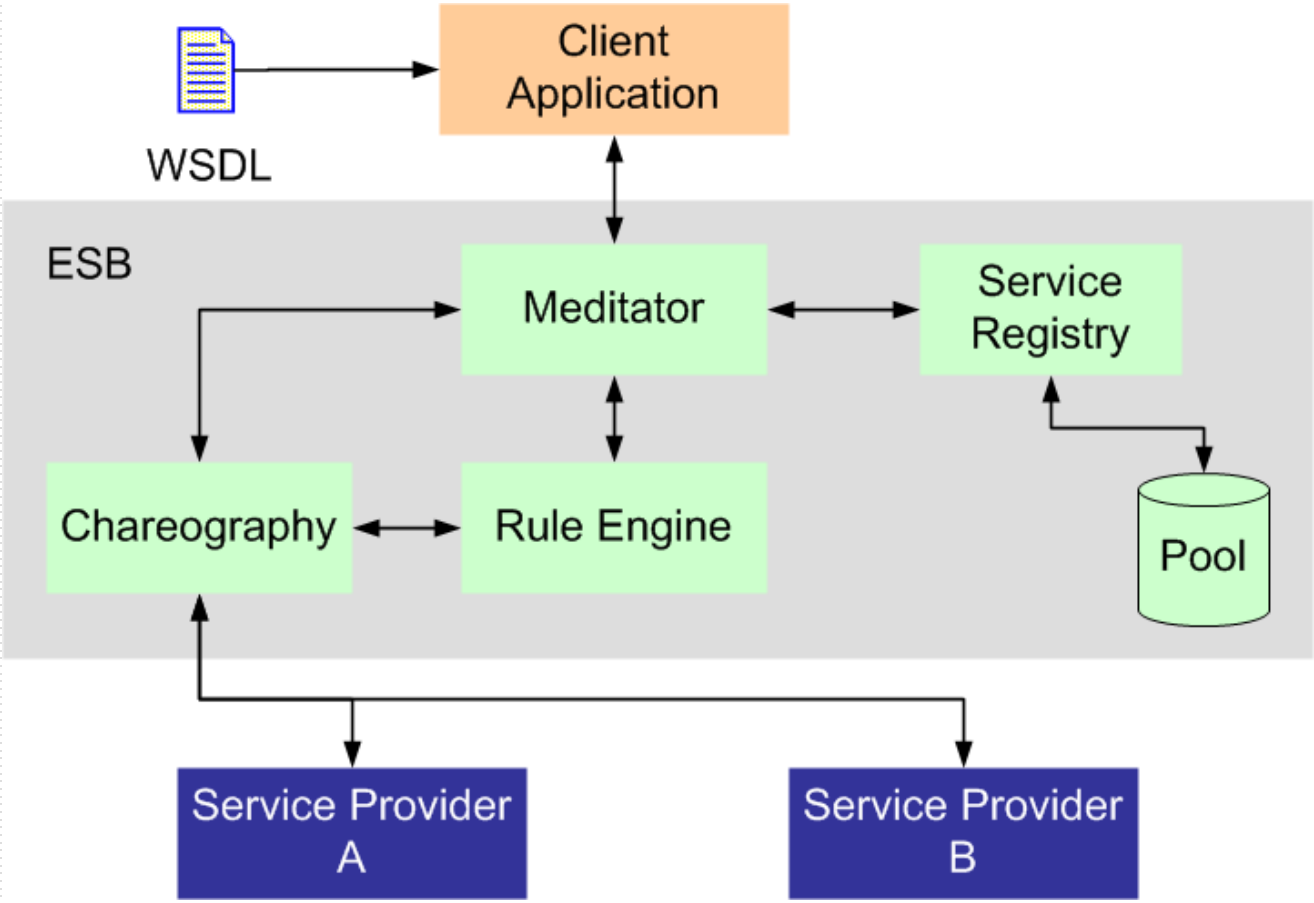
- What is ESB?
  - provides an abstraction layer on top of an implementation of an enterprise message system which allows integration architects to exploit the value of messaging without writing code.
  - It is one of topologies of Enterprise Application Integration (EAI). The other topology is hub.

Motivation of ESB



- Heavy load for developers of client application
  - Service discovery
  - Combine different service
  - Understanding business process

Typical Major ESB Components



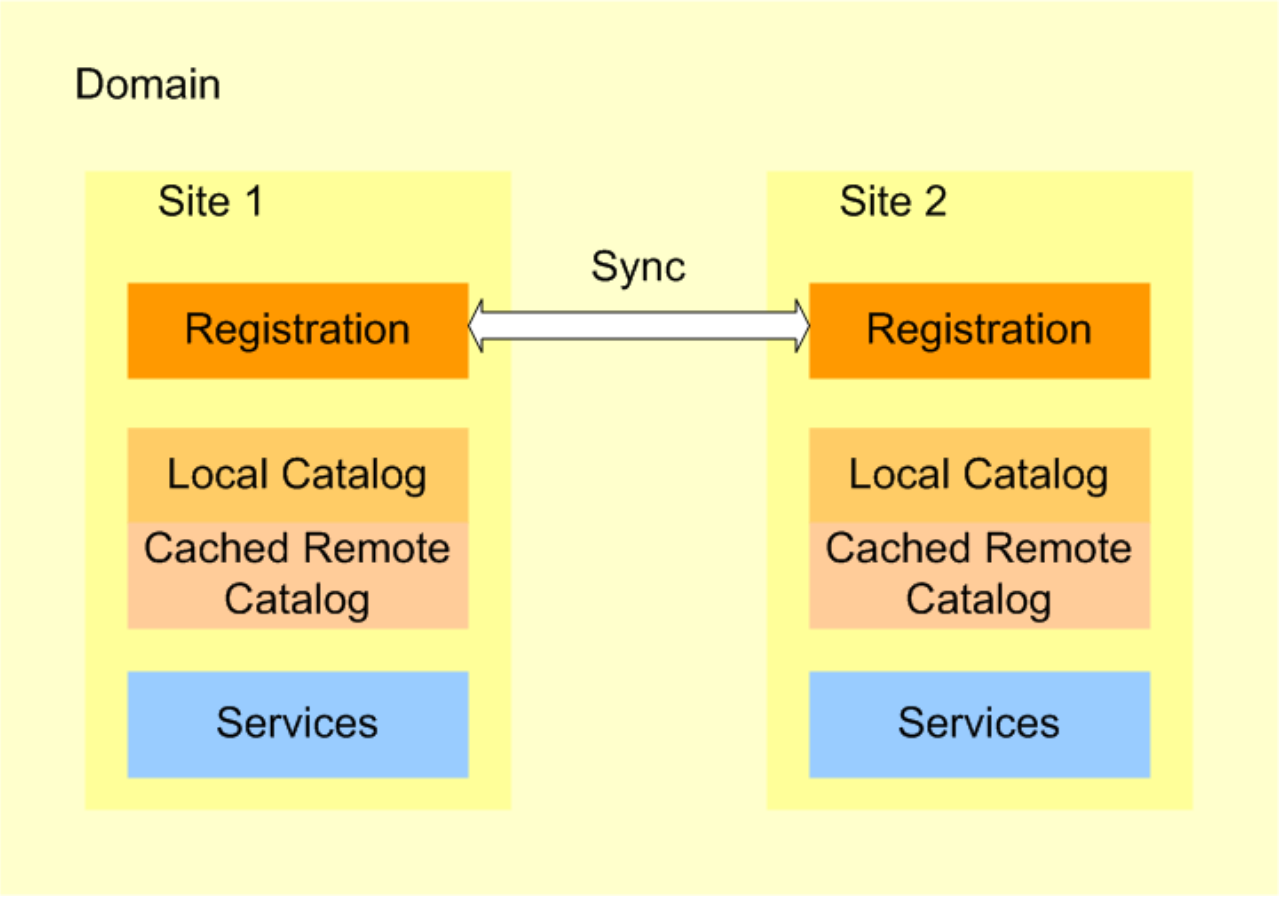
Role of ESB

- Message passing highway
  - SOAP
- Middleware layer (glu)
- For client application, hiding unnecessary service details and keep state between services

Distributed Catalog

- Inter-system catalog protocol that helps to locate remote resources (services)
- Services are associated with
  - Registration: service name, service type, catalog location
  - Catalog: service description
  - Services: functions could be remotely executed

Framework Overview



Distributed Catalog Roles

- Discover services
- Keep services semantics in catalog profiles
- By caching catalog, as well as machine learning technology, catalog helps to automated workflow (service selection and combination)

Two Application Scenarios

- Background
  - Facilities
  - Boeing 747 fun facts
- Example 1: Crane Service
  - ESB, SysML, RFID, Distributed Catalog, Workflow
- Example 2: Part Search Service
  - Product lifecycle, Workflow, Local Index

Boeing Corporation Facilities Background

- Partners and internal suppliers
  - Partners and external suppliers
  - Internal suppliers: interiors, electrical system, …
- Product lines: Boeing 737, 747, 767, 777, and 787
- 25,000 people on 3-shift work
- Parts and subassemblies come to plant by truck, air, rail, and ship from 50 states and globe
  - Rail terminal building (33,000 ft^2)
  - Interior supply building (500,000 ft^2)

Boeing Corporation Facilities Background (cont'd)

- Proud of loading and unloading system
  - Overhead bridge crane (90 feet)
  - 31 miles crane rail network
  - Order, track, and distributes assembling parts by plans to correct points
- Production rate
  - Depends on market activities
  - Typical off line rate: 5 ~ 7 airlines per month (not including wings)

737-900 Photo* (* Provided by boeing.com)

747-400 Photo* (* Provided by boeing.com)

Some Boeing 747-400 Facts

- Parts
  - six million parts, half of which are fasteners
  - 171 miles (274 km) of wiring and 5 miles (8 km) of tubing.
- Improvement
  - aerodynamic improvement
    - 6-foot longer wing with a 6-foot-high winglet angled upward and slightly outward (*1)
  - state-of-the-art assembly processes (*2)
  - advanced materials allows considerable structural weight reductions (*3)

Example 1: Crane Service

- Purpose
  - Crane operators need to know deliver what, how many parts to assembly point with corresponding devices and tools(*1)
  - More complicated: allocate crane rails to deliver (not our focus)
    - Several cranes share the several miles of rails

Example 1: Crane Service

- Information needed and providers
  - Progress plan (how much needs to accomplished in a shift): HR Plan and Scheduling
  - Assembly plan (what parts and subassemblies are used for assembling): Design
  - Assembly point capacity (What materials do assembly point have): On-site Assembly Point
  - Part and device current locations (where to get the parts): Part Supplier

On-Site Parts Tracking

- Assume that Parts with RFID Tags and on-site assembly point set up RFID reader
- The RFID reader tracks the flow from parts stack region to assembly region
- Assembly point service
  - For given time, return current on-site parts and capacity

RFID Tags and Readers

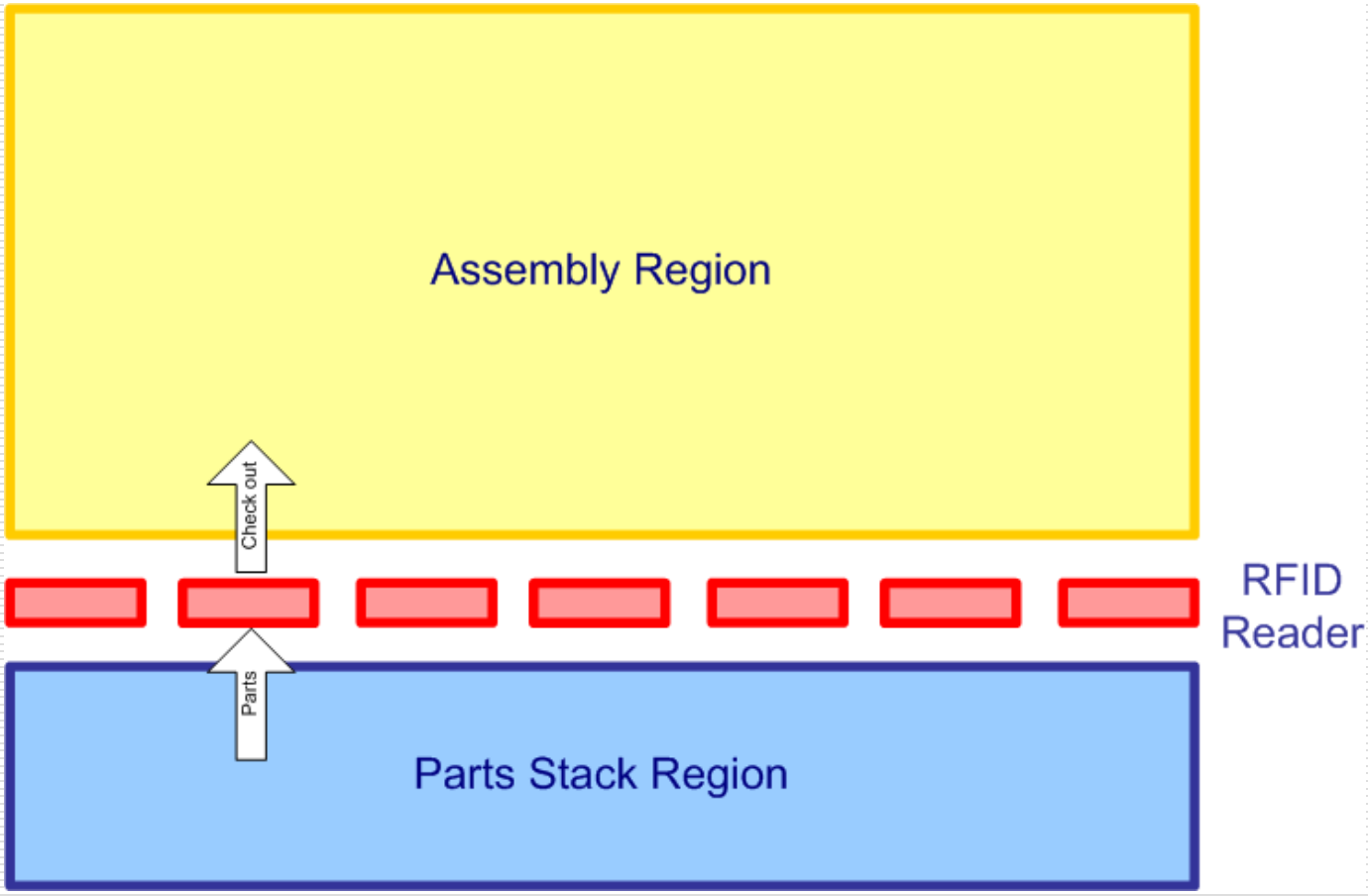
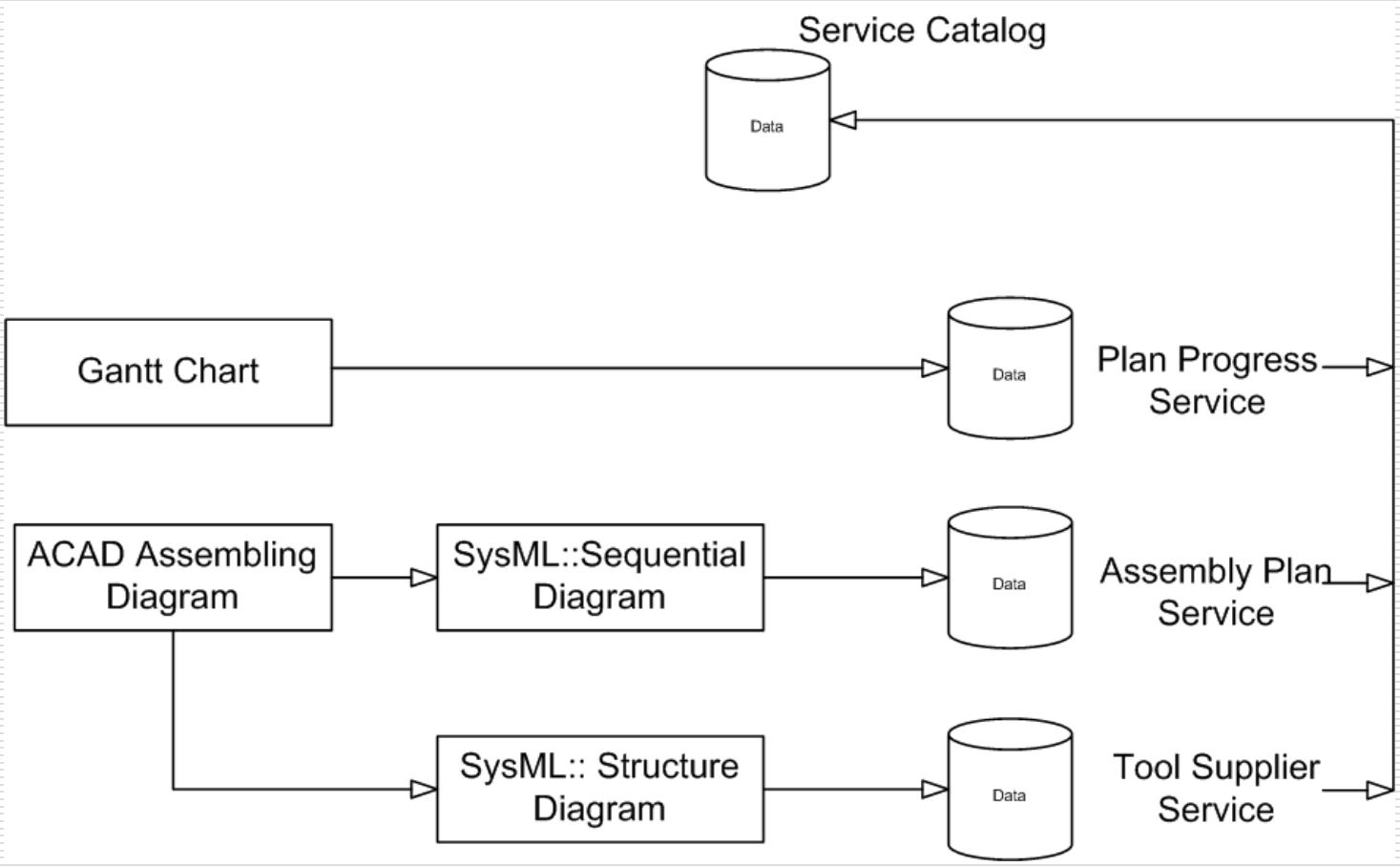
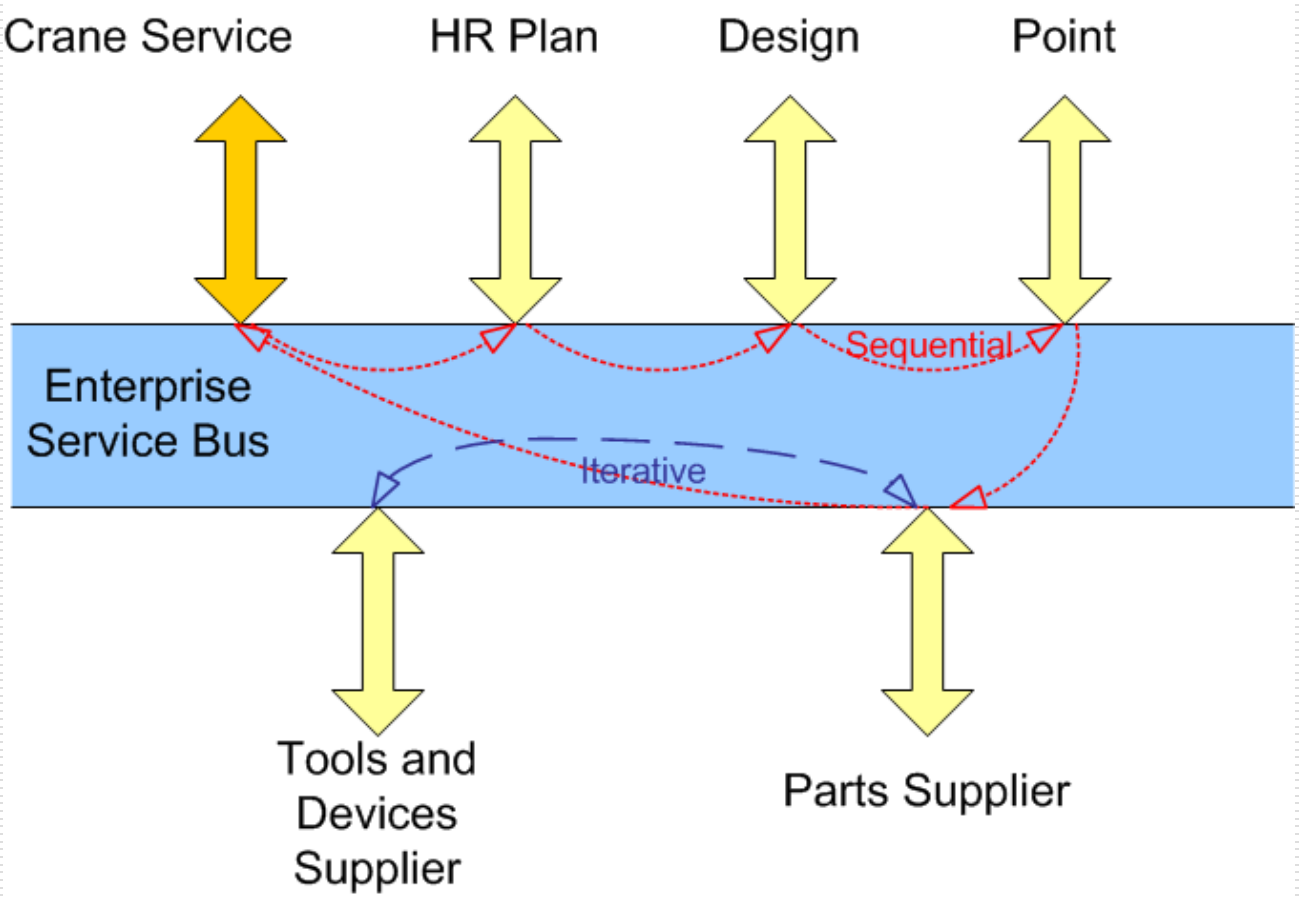


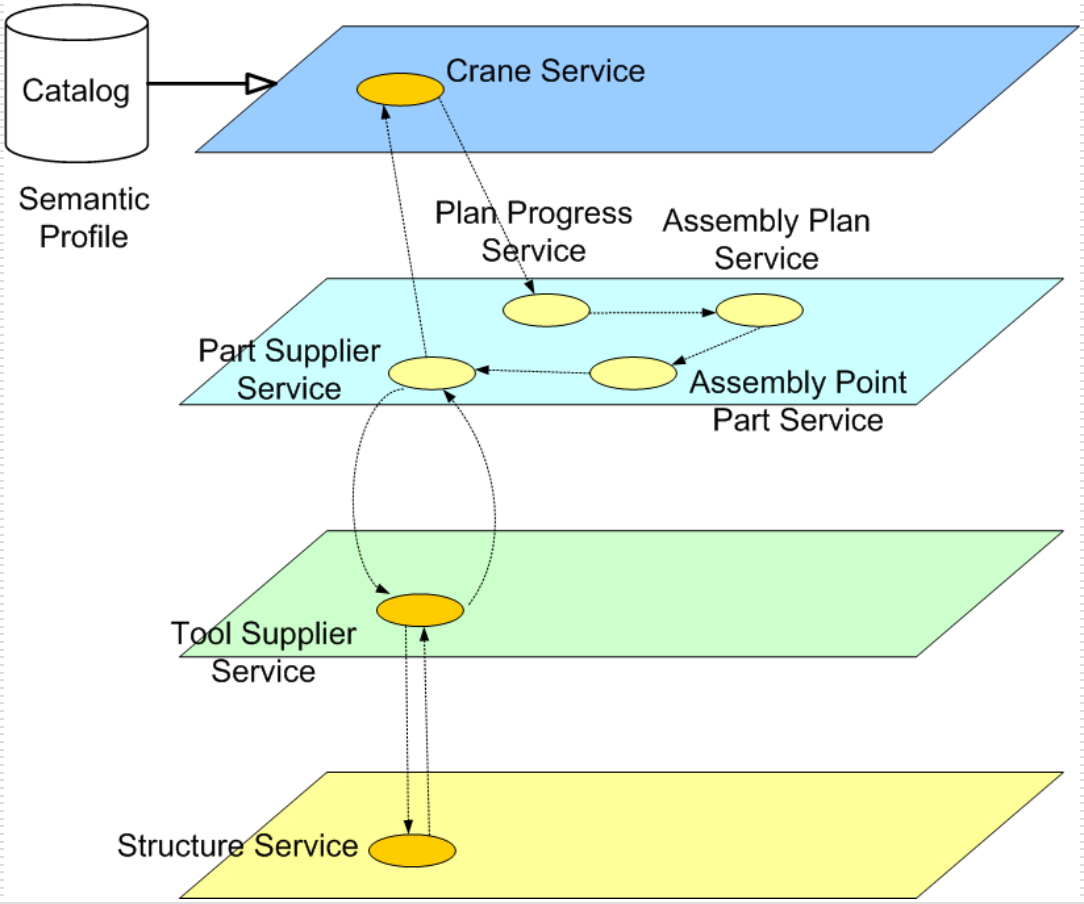
Diagram to Services



Using ESB


Crane Service
HR Plan
Design
Point
Enterprise
Service Bus
Sequential
Iterative
Tools and
Devices
Supplier
Parts Supplier

Abstract Service and Workflow



New service is coming…

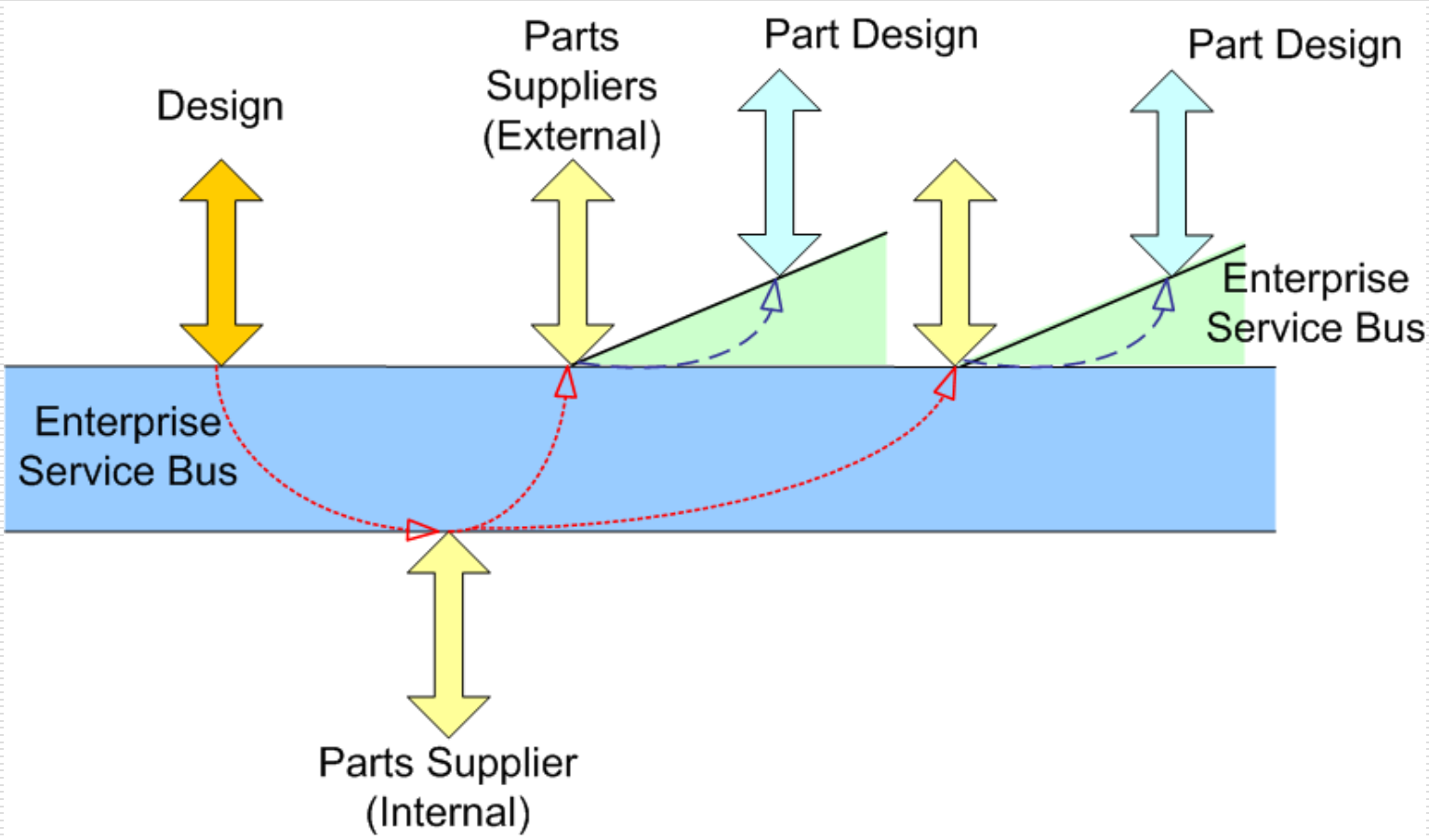
- When a new service is published, the local catalog and registration are updated
- Based on its semantic profile, it can be linked into workflow
- Business Office provide market activities service to indication which order should be slowed down or kept in full production rate
  - Profile: it is useful for progress plan

Example 2: Search Parts Service

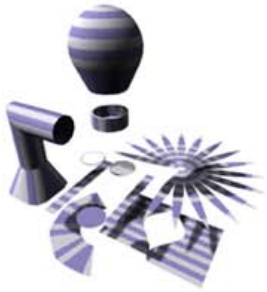
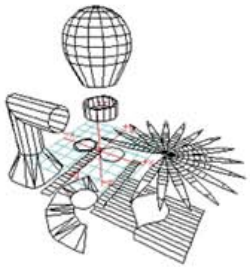
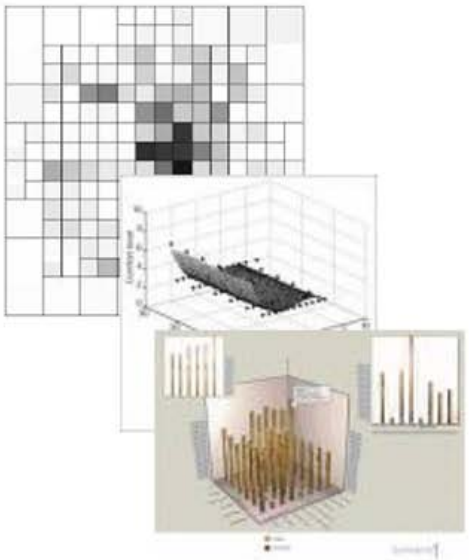
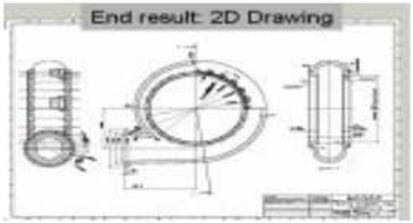
- Purpose
  - Design department needs to find a part fit for some special dimension requirement.
- Assumption

  At the beginning, design department knows the part supplier search service only.
  - Part supplier knows to ask the services of external supplier.
  - External suppliers have their domain (view of services)
    - In different domains, they have different registrations.

Workflow


Design
Parts Suppliers (External)
Part Design
Part Design
Enterprise Service Bus
Enterprise Service Bus
Parts Supplier (Internal)

Search 3D Objects

Object in 3D	Feature Extraction	Feature for Index of SP-GiST
		
		

Summary

- Data Management for PLM, including data collection, sharing, and providing services, are challenging research topics.
- New technologies, such as RFID, SysML, ESB, and distributed catalog, are helpful to overcome some difficulties.
- Introduced crane service and search service based on Boeing Company by exploiting the new technologies.

Acknowledgement

- Center for Advanced Manufacturing, Discovery Park, Purdue University
- IBM

Thank You

- Questions?