

## Unit 2

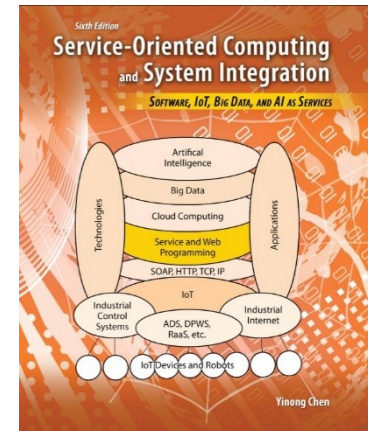
### Software Development by Composition and Integration

## Lecture 2-1

# Enterprise Architecture and Business Process

Dr. Y. Chen

<https://myasucourses.asu.edu/>



- 2-1 { ■ **Enterprise Architecture and Business Process**
- 2-2 { ■ Workflow Foundation 1: Concepts
- 2-3 { ■ Workflow Foundation 2: Case Study
- 2-4 { ■ BPEL (Business Process Execution Language)
  - WSDL in BPEL
  - BPEL constructs and BPEL Process Definition
- 2-5 { ■ A Case Study of BPEL Application
- 2-6 { ■ Stateful Services
- 2-6 { ■ Development Frameworks Supporting BPEL
  - Oracle SOA Suite, BPMN, and BizTalk
- 2-7 { ■ Message-Based Integration
- 2-8 { ■ Web Caching and Recommendation

Unit Test 2

Mid-Term Exam

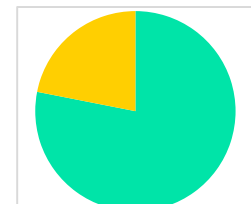
# Why do you want to be a Software Architect?

## Software Engineers and CS Occupations (There are many more) in U.S. DoL Occupational Outlook Handbook

<http://www.bls.gov/ooh/>

Occupational title	Employment in 2008	Employment in 2018	Change in number	Change in percentage
Software engineers / Software Architect	909,600	1,204,800	295,200	32
Computer systems analysts	532,200	640,300	108,100	20
Computer network, systems, and database administrators	961,200	1,247,800	286,600	30
Computer programmers	426,700	414,400	-12,300	-3
Computer support specialists	565,700	643,700	78,000	14
Computer and information systems managers	293,000	342,500	49,500	17

IT Jobs: 4,875,600.00 (78%)  
All other eng. jobs: 1,368,200.00 (22%)



Y. Chen

Why do you  
want to be a  
Software  
Architect?

In top 50:

17 IT Program Manager  
32 Software Quality Assurance Manager  
38 IT Security Consultant

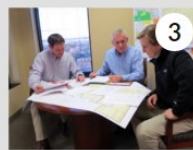
How do you  
become a Software  
Architect?

In top 50:

13 Information Tech Director  
14 Webmaster  
22 IT Operations Manager  
33 Video game designer  
35 IT Training Specialist  
38 IT Business Analyst  
50 IT Security Director

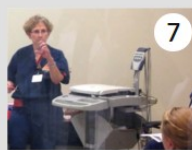
**2015**
**Top Ten Jobs**
[See the full list](#)

**Software Architect**

**Video Game Designer**

**Landman**

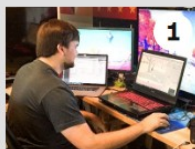
**Patent Agent**

**Hospital Administrator**

**Continuous Improvement Mgr.**

**Clinical Nurse Specialist**

**Database Developer**

**Info Assurance Analyst**

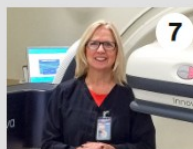
**Pilates/Yoga Instructor**
**2017**
**Top Ten Jobs**
[See the full list](#)

**Mobile App Developer**

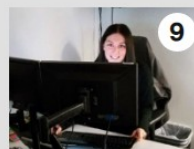
**Risk Management Director**

**Landman**

**Product Analyst**

**Info Assurance Analyst**

**QA Coordinator**

**Clinical Applications Specialist**

**Hospital Administrator**

**Database Analyst**

**Director, Finance & Administration**
**2019**

**Software Developer**
**#1 in 100 Best Jobs**

**1. Data Scientist**

Number of Job Openings: 6,510

Median Base Salary: \$108,000

*Y. Chen*

### How do you become a Software Architect?

#### Enterprise Architecture and Business Process

- Business and Technology Interaction
- Enterprise Architecture Integration (EAI)
- Enterprise Architecture Framework (EAF)
- Business Process Management (BPM)
- Development Life Cycle
- Dynamic Application Architecture for Dynamic Business

# eBusiness and Technology Interaction

e-business

Computerized establishment of e-business with basic information exchange with clients

Maintain a multi page Web site; Use Web-form and Web-email for data exchange with clients

Core business on Web with database and Web-enabled execution of business process and transaction.

Enterprise level collaboration & integration, Dynamic business composition, **EAI, BPM**

User-provided contents, Dynamic discovery, Social networking, Social integration

*On Demand e-business with AI-based real-time reconfiguration, resilient, & automated evolution*

Early stage of Internet: Email FTP

Static Web 1.0 with HTML forms and email support

Web-based computing model and Web database integration

Web 2.0, Web 3.0, SOA, SOC, SOD, **ESB, Dynamic application architecture**

Web 4.0, HTML5, REST services, Cloud computing, Big Data, Social computing and networking platforms

*Web 5.0 with proactive artificial intelligent services and applications*

Technology

80s

90s

00-04

05-09

10-14

15-20

# Enterprise Architecture Integration (EAI)

- **Architecture:** The fundamental organization of a system, its components, and the relationships among the components;
- **Enterprise Architecture:** An architecture of a system involves one or more enterprises, including their business processes, data and information, as well as the technologies;
- **Enterprise Architecture Integration (EAI):** Seamless integration of architectures, business processes, data and information, as well as the infrastructure / technologies within an enterprise and across enterprises.

Enterprise  
level  
collaboration  
& integration,  
Dynamic  
business  
composition,  
**EAI, BPM**



- **Architecture Integration**: Defining architecture framework for managing the development and maintenance of architecture descriptions.
- **Data (information) Integrity**: Ensuring that information in multiple systems is kept **consistent**.
- **Application Integration**: Different applications can communicate with each other, and are **ready** for integration.
- **Vendor Independence**: If a business application is replaced with a different vendor's application, the business rules do not have to be re-implemented.
- **Common Facade**: An EAI system could be a cluster of different applications. It can provide a single consistent access interface to these applications and shielding users from having to learn to interact with different software packages.





# Enterprise Architecture Integration (EAI)

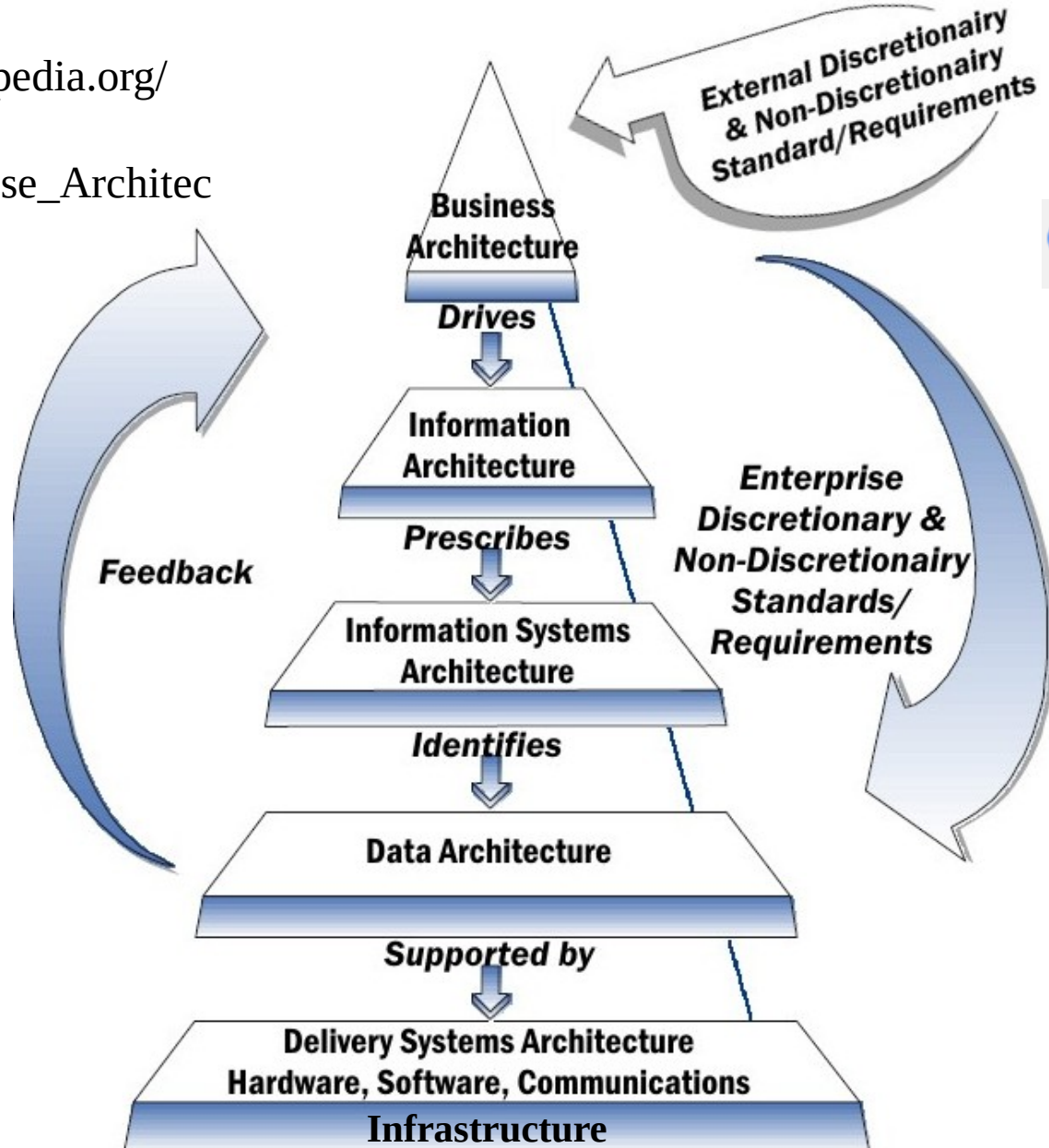
- EAI is composed of a collection of technologies and services.
- A **middleware** to enable integration of systems and applications within and across the enterprises.
- Examples
  - ASU Website;
  - Supply chain management applications (for managing inventory; shipping, and interaction with other enterprises);
  - Customer relationship management applications (for managing current and potential customers);
  - Business **intelligence** applications (for finding patterns from existing data generated from operations). Big data is a major tool for today's business intelligence applications.

- EAF is a standard developed by the U.S. NIST, dealing with architecture integration.
- EAF is an organizing mechanism for managing the development and maintenance of architecture descriptions.
- EAF provides a structure for organizing resources and describing related activities.
- EAF follows Enterprise Architecture Model (EAM)
- The other layers of integration in EAM (data, application, and infrastructure) will be discussed in the following lectures.

# Enterprise Architecture Model (EAM)

11

[https://en.wikipedia.org/wiki/NIST\\_Enterprise\\_Architecture\\_Model](https://en.wikipedia.org/wiki/NIST_Enterprise_Architecture_Model)



Google

EAM jobs

# Federal Enterprise Architecture Framework (FEAF)

[https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/egov\\_docs/fea\\_v2.pdf](https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/egov_docs/fea_v2.pdf) 2013

- Developed by The Chief Information Officers Council
- Follow the NIST Enterprise Architecture Model
- Purposes of developing this framework:
  - Organize Federal information and promote Federal interoperability;
  - Promote information sharing among Federal organizations;
  - Help Federal organizations developing their architectures;
  - Help Federal organizations quickly developing their IT investment processes;
  - Serve customer needs better, faster, and more cost effectively;
  - Provide potential for Federal and Agency to reduce costs.

# Federal Enterprise Architecture Framework (FEAF)

## Development in Five Steps

### Organize and Plan

### Implement and Measure

1.  
Identify  
and Validate

2.  
Research  
and Leverage

3.  
Define  
and Plan

4.  
Invest  
and Execute

5.  
Perform  
and Measure

1.1  
Engage Sponsor and  
Assess Stakeholder  
Needs

2.1  
Identify Organizations  
and Service Providers to  
Engage

3.1  
Formalize Collaborative  
Planning Team and  
Launch Planning

4.1  
Define Funding Strategy  
and Make Decision

5.1  
Operate with the New  
Capabilities

1.2  
Analyze and Validate  
Needs

2.2  
Analyze Opportunities  
to Leverage

3.2  
Refine the Vision for  
Performance and  
Outcomes

4.2  
Obtain Resources and  
Validate Plan

5.2  
Measure Performance  
Against Metrics

1.3  
Formulate Case to  
Address the Needs

2.3  
Determine Whether to  
Leverage

3.3  
Analyze the Current  
State, Determine  
Adjustments, and Plan  
the Target State

4.3  
Execute the Plan

5.3  
Analyze and Provide  
Feedback

1.4  
Identify and Engage  
Governance

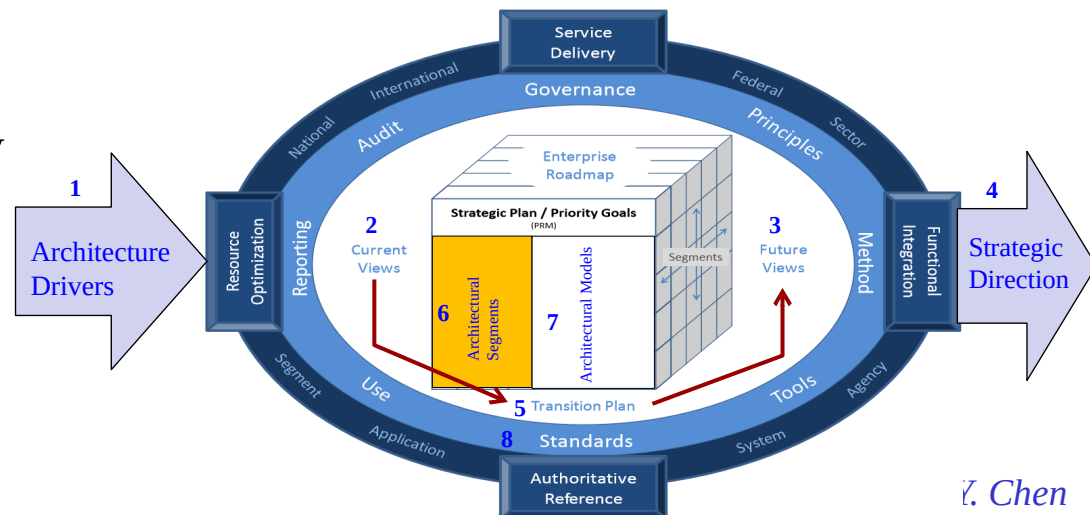
3.4  
Formulate the  
Integrated Plan and  
Roadmap

3.5  
Initiate Execution  
Governance



# Eight Key Components of the FEAF

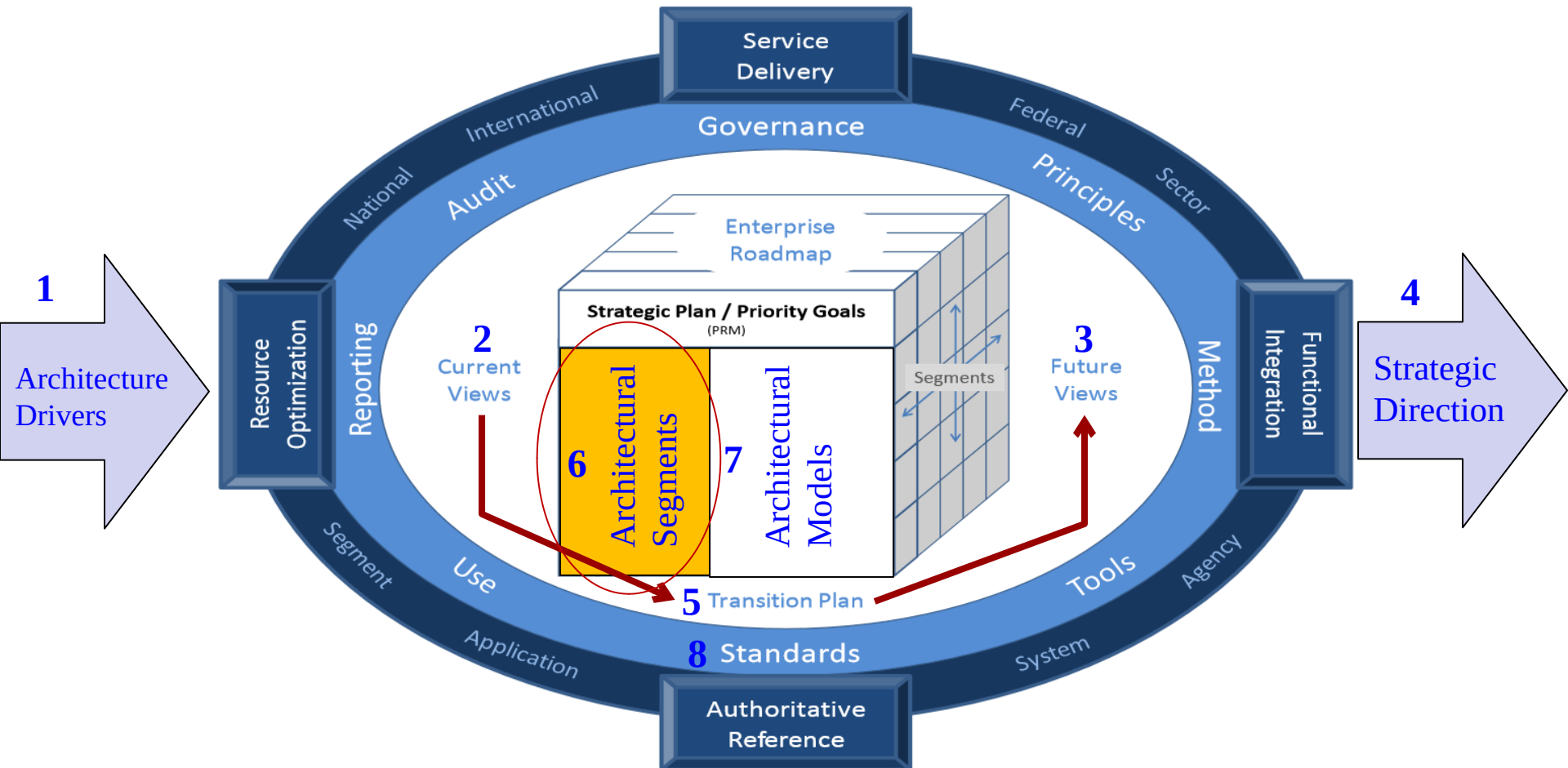
1. **Architecture Drivers**: business and design stimuli
2. **Current Architecture (View)**: the "as is" enterprise architecture
3. **Future Architecture (View)**: the "to-be-built" enterprise architecture
4. **Strategic Direction** – Overall guidelines to the development from current architecture to the target architecture
5. **Transition Plan** – Concrete support to the migration from the current to the target architecture
6. **Architectural Segments** - Enterprises within the total Federal Enterprise.
7. **Architectural Models** - business and design models that describe the segments of the enterprise
8. **Standards** - All standards and references (some of which may be mandatory), and best practices





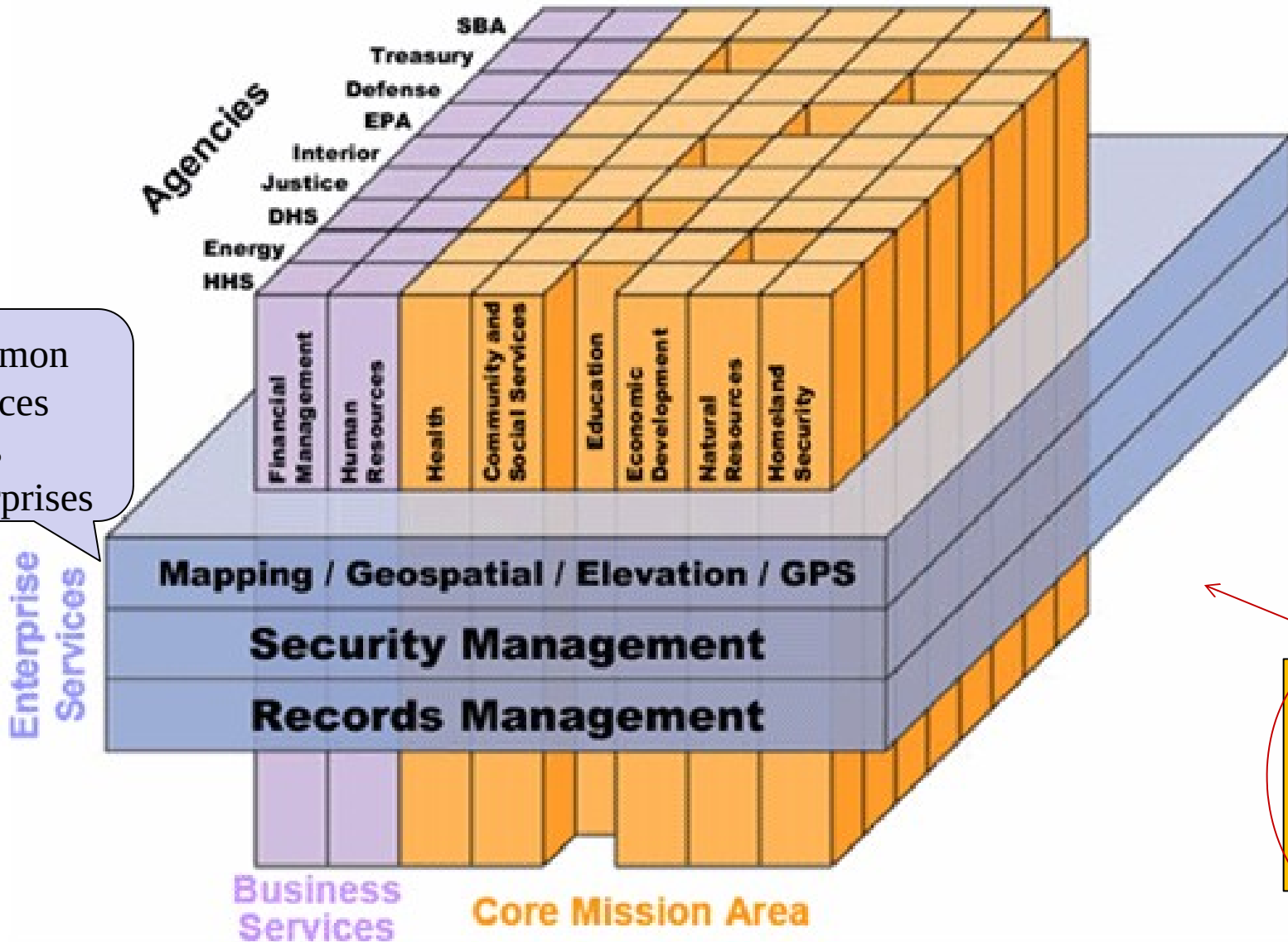
# FEAF Level I View (from 20,000 feet)

- The eight components needed for developing and maintaining the Federal Enterprise Architecture



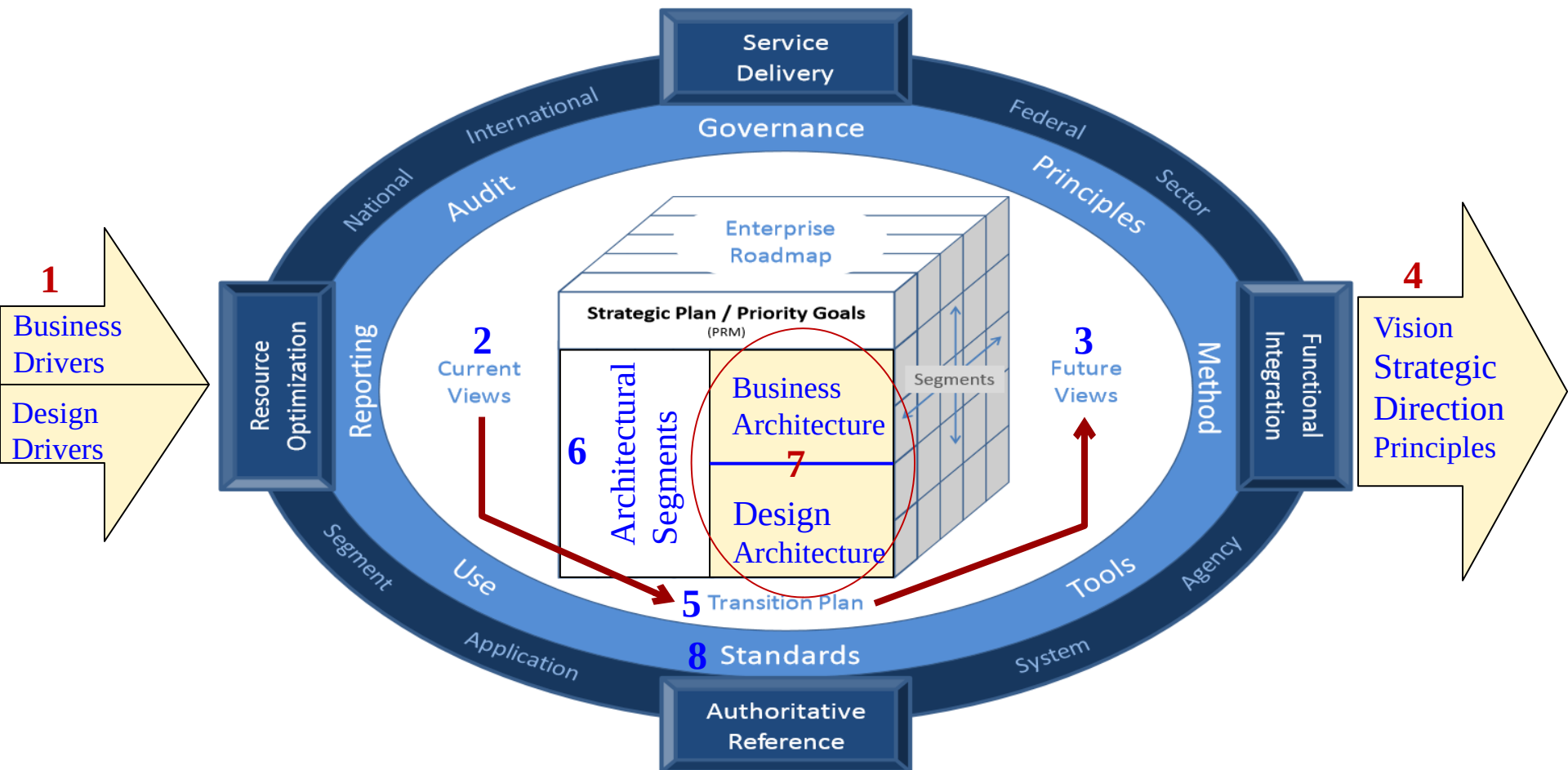
# Architectural Segments in FEAF

Each architectural segment is an enterprises within the total Federal Enterprise.



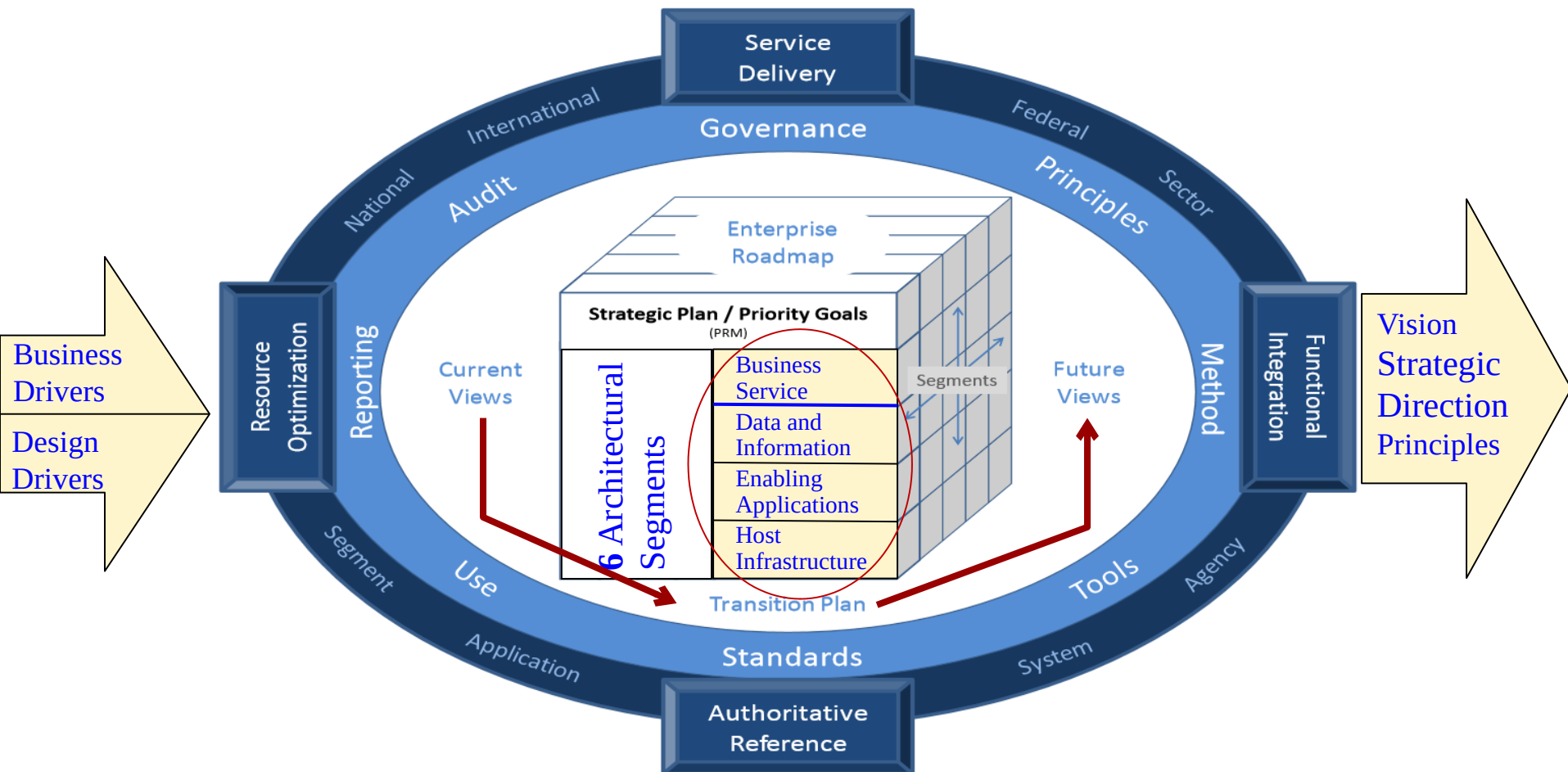
# FEAF Level II View (from 10,000 feet)

- The business and design pieces of the Federal Enterprise Architecture and how they are related

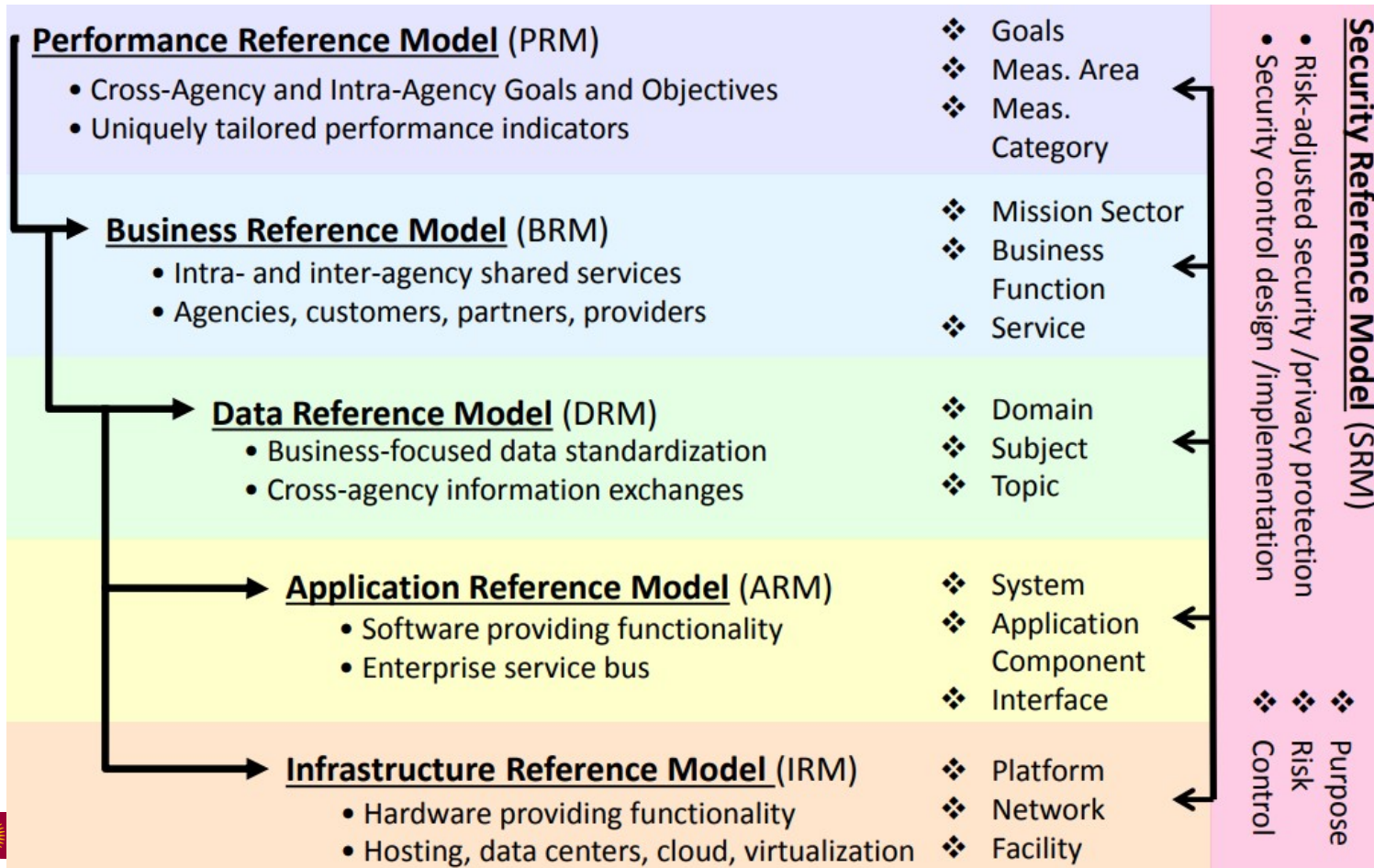
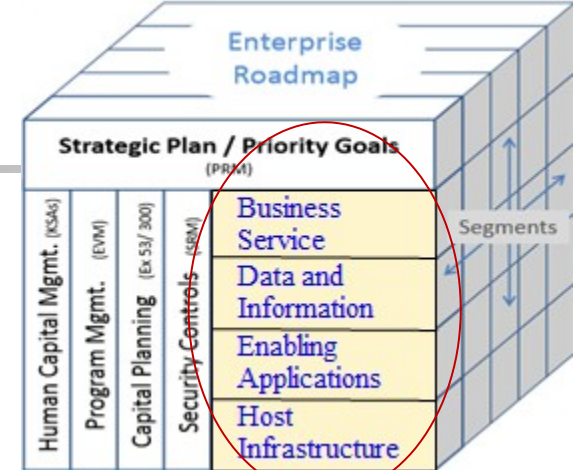


# FEAF Level III View (from 5,000 feet)

Expand design pieces of the framework to show the three design architectures: data, applications, & infrastructure



# Architecture Standards and Reference Models

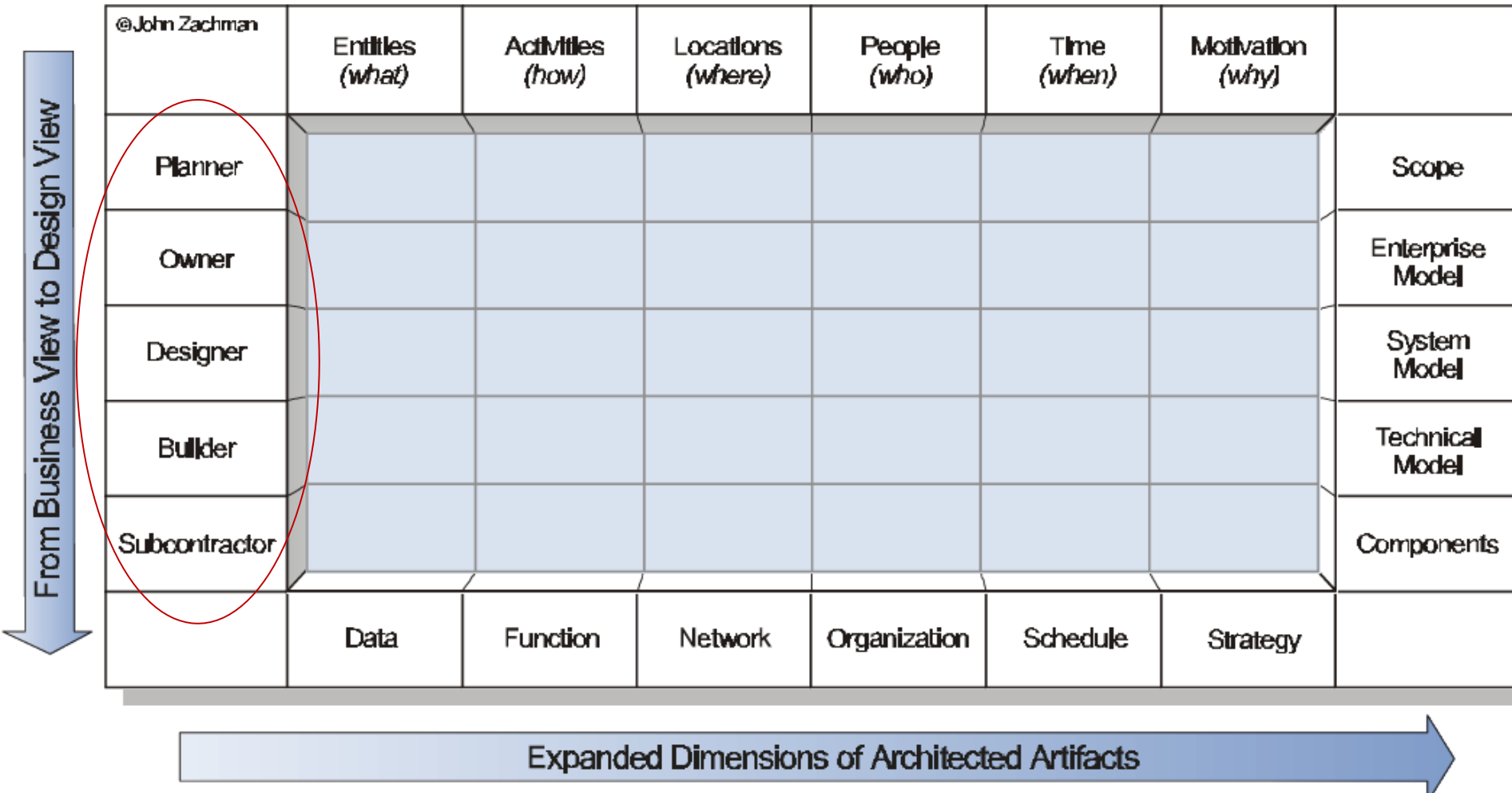


## FEAF Level IV View (from 500 feet)

- How is the **business architecture** supported by the three design architectures based on architecture **reference models**?
- Zachman Model: *IBM Systems Journal* 1987 article: "A Framework for Information Systems Architecture":
  - It is a model for bridging the business architecture to the design models.
  - The cost involved and the success of the business depend increasingly on its information systems, and a disciplined approach to the management of those systems is required.
  - Architecture framework is simply a logical structure for **classifying and organizing** the **descriptive representations** of an enterprise that are significant to the management of the enterprise, as well as to the development of the enterprise's systems.

# FEAF Level IV View Based on Zachman Model

The Framework enables communication among the various **participants** involved in developing or changing the structure

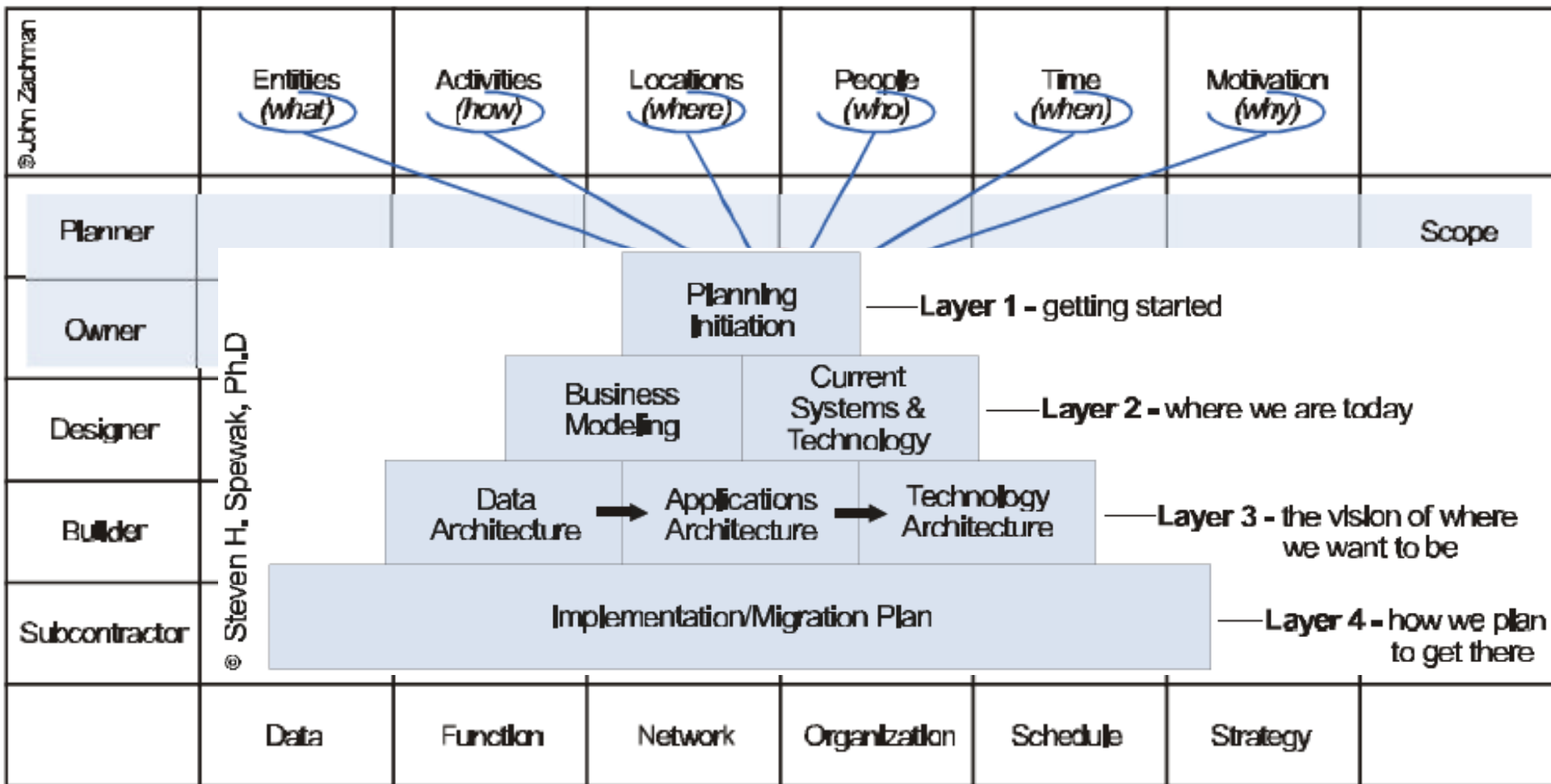




## From Zachman Model to EAP

- The **Zachman Model** tells what need to be done, how, where, when, why, and by whom.
- It categorizes and organizes the artifacts: data, function, network, organization, schedule, and strategy.
- **Enterprise Architecture Planning (EAP)**, proposed by Dr. Steven Spewak,
  - defines the **process** of completing Zachman model;
  - focuses on defining what data, applications, and technology architectures are appropriate for supporting the overall enterprise.

# Enterprise Architecture Planning (EAP)



# Open Group Architecture Framework (TOGAF)

- TOGAF describes another architectural **process**;
- It elaborates Zachman model. Zachman tells you how to categorize your artifacts. TOGAF gives you a process for creating them;

## Phase: Prelim.

Framework  
and  
Principles



## Phase: A

Architecture  
Vision



## Phase: B

Business  
Architecture



## Phase: C

Information  
Systems  
Architectures



## Phase: D

Technology  
Architecture



## Phase: E

Opportunities  
and  
Solutions



## Phase: F

Migration  
Planning



## Phase: G

Implementation  
Governance



## Phase: H

Architecture  
Change  
Management



# BPM: Business Process Management

[http://en.wikipedia.org/wiki/Business\\_process\\_management](http://en.wikipedia.org/wiki/Business_process_management)

- is an EAI technology at the **design/process level**;
- is a management approach focusing on aligning all aspects of an organization with the wants and needs of clients;
- allows organizations to **abstract** business process from technology infrastructure;
- goes beyond automating business processes or solving business problems using software;
- enables business to **respond to changing** consumer, market, and regulatory demands faster than competitors - creating a competitive advantage.

# BPM Lifecycle (Before Service Orientation)

- **Process Design:** encompasses both the identification of existing processes and the design of "to-be" processes.
- **Modeling:** takes the theoretical design and introduces combinations (relationships) of variables or parameters;
- **Execution:** develops an application that executes the required steps of the process;
- **Monitoring:** tracks processes and statistics on the performance of one or more processes;
- **Optimization:** retrieves information from modeling or monitoring phase; identifying the potential or actual bottlenecks and the potential opportunities for cost savings or other improvements; and then, applying those enhancements in the design of the process.

# BPM Suite (BPMS) Development Framework

BPM Suite contains four critical components

- **Process Engine** – a robust platform for modeling & executing process-based applications and business rules;
- **Business Analytics** — enables managers to identify; business issues, trends, and opportunities with reports and dashboards and react accordingly;
- **Content Management** — provides a system for storing & securing documents, images, and other files;
- **Collaboration Tools** — removes intra- and interdepartmental communication barriers through discussion forums, dynamic workspaces, and message boards.

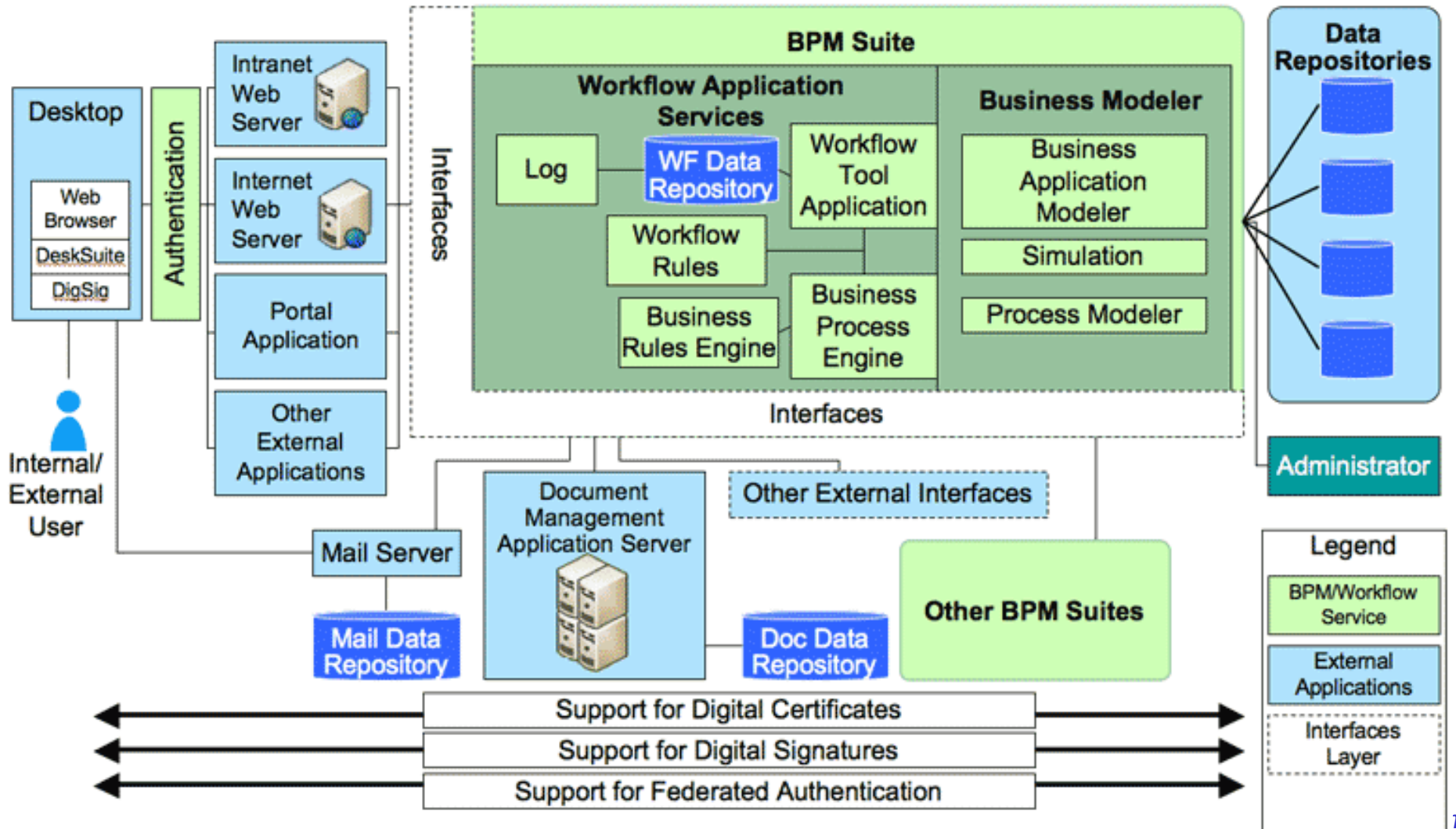
# BPM Suite and Its Implementing a Business Process

[http://en.wikipedia.org/wiki/Business\\_process\\_management](http://en.wikipedia.org/wiki/Business_process_management)

Presentation Tier

Business Process Tier

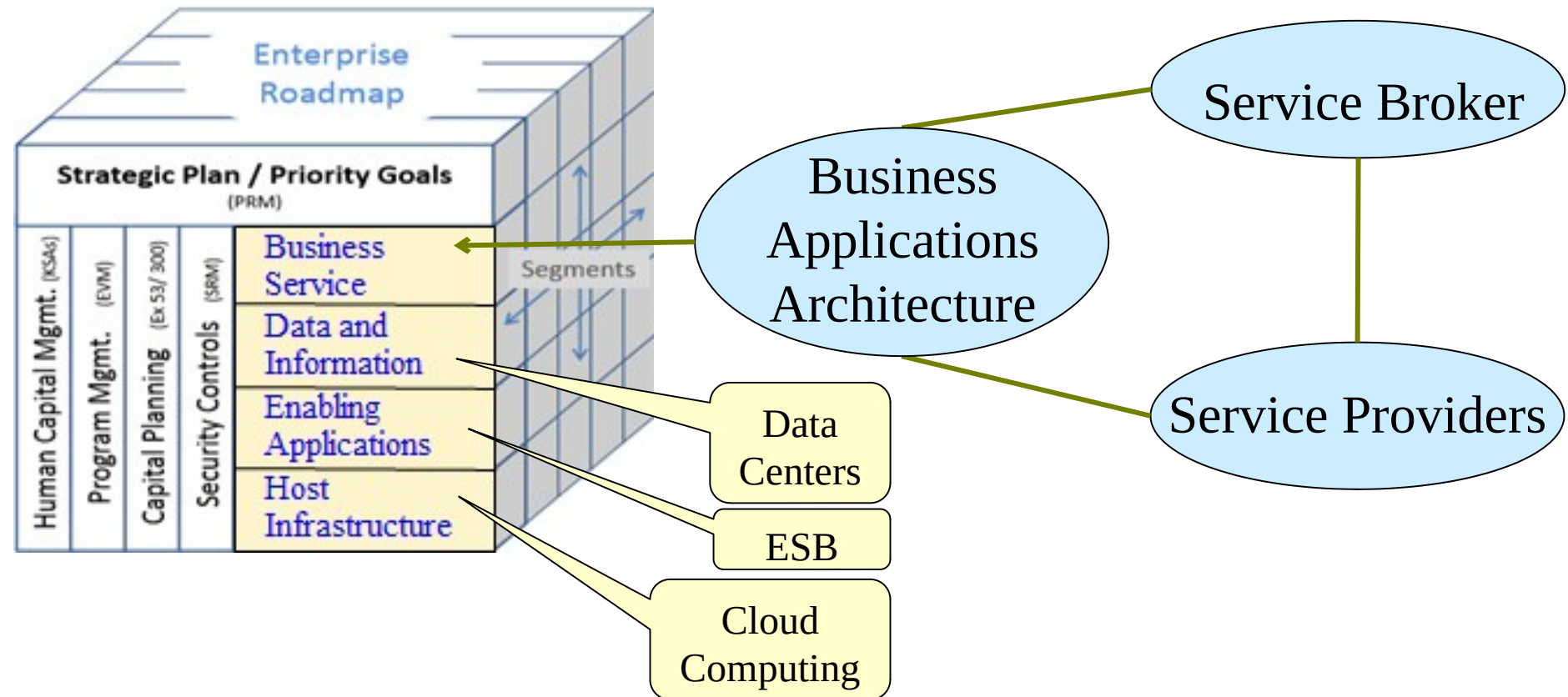
Data Mgmt Tier





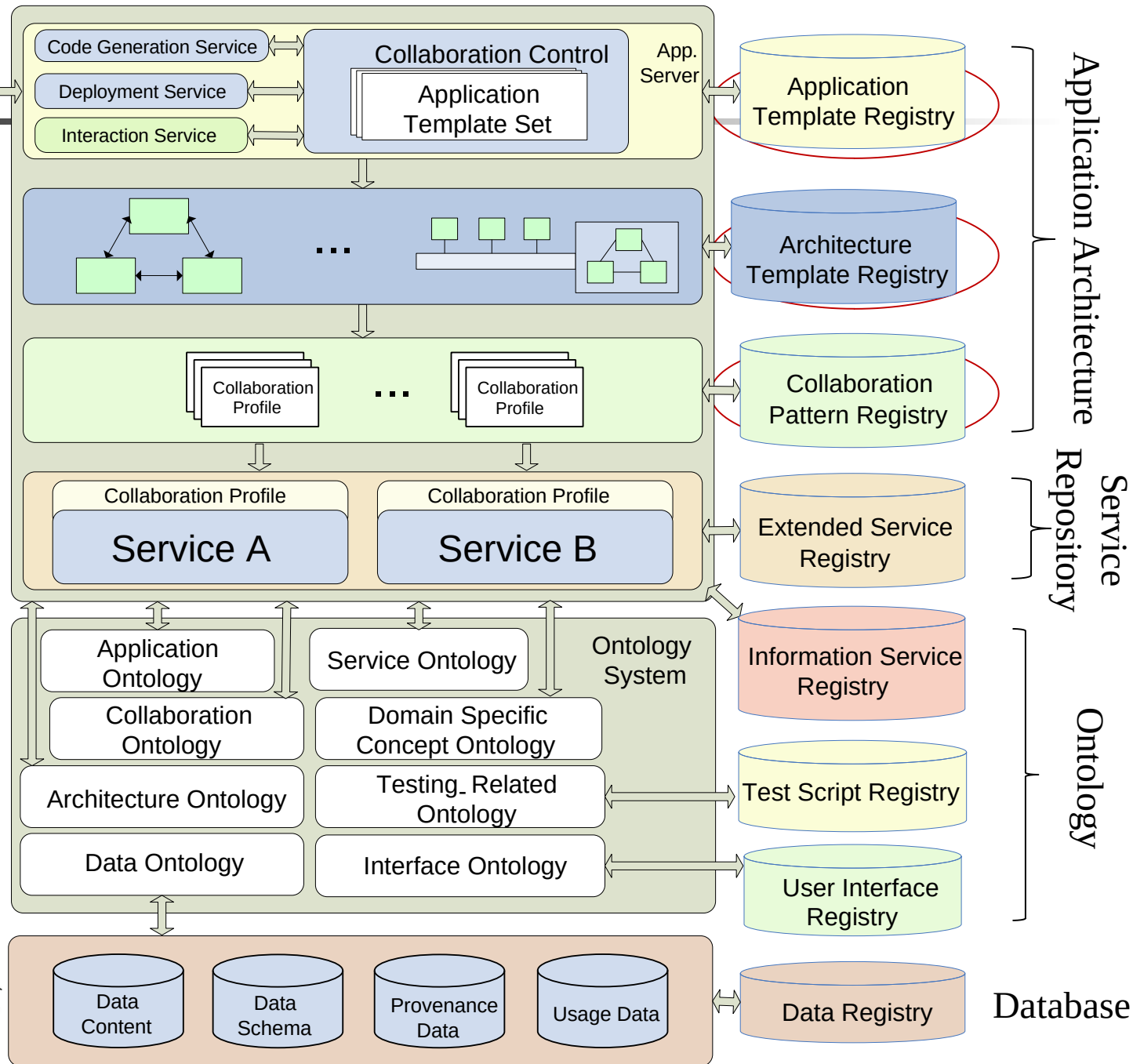
# Service-Oriented Applications Architecture (SOAA) at the Process Level

30



# Extended Service Broker with Applications Templates and Other items

Application Builder



Extended Service Broker

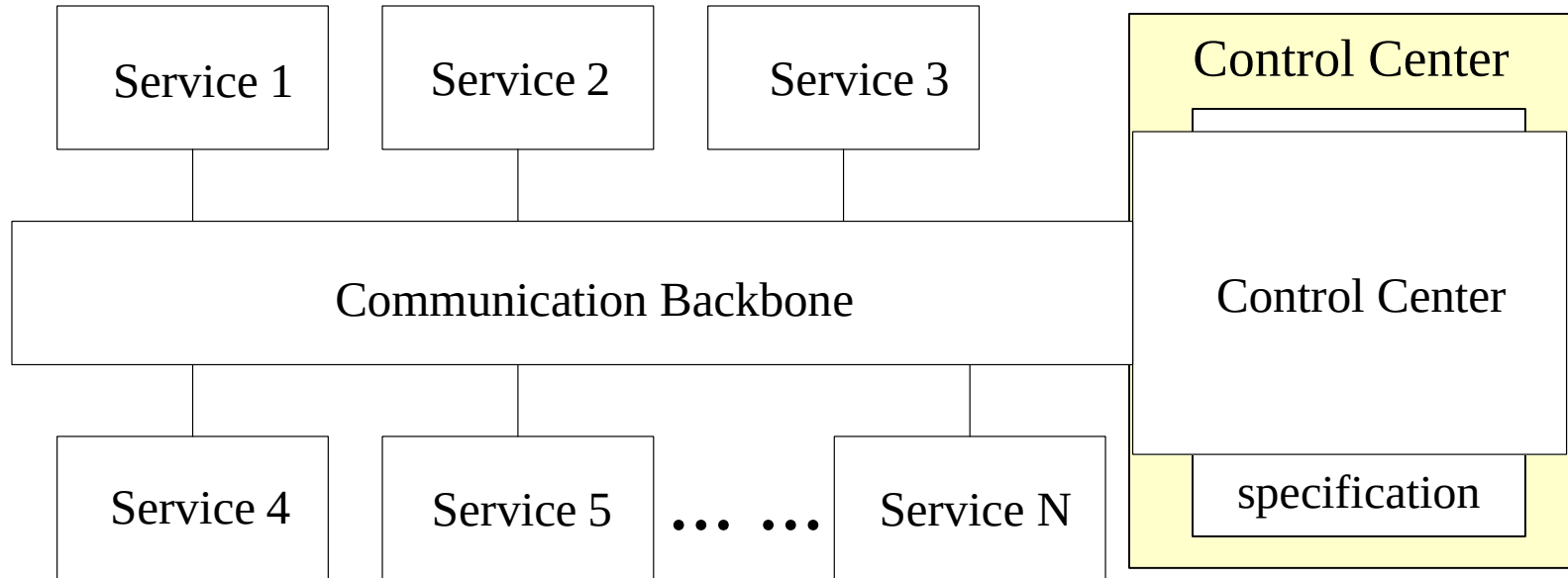
- Publish architecture templates;
  - Publish application template/workflow;
  - Publish collaboration templates;
- } Help in application architecture design
- Publish SOAP services with collaboration templates;
  - Publish data and information services (RESTful services)
  - Publish test scripts
  - Publish user interfaces
  - Publish Data: a typical example is Data-Centric SOA (DCSOA) and data center in cloud computing

# Service-Oriented Application Architecture and Case Studies

- Dynamic Reconfigurable Application Architecture  
Organizing services in application;
- Different architectures:
  - SAP Netweaver
  - Oracle SOA Suite
  - IBM ESB

Web 2.0, Web  
3.0, SOA,  
SOC, SOD,  
**ESB,**  
**Dynamic**  
**application**  
**architecture**

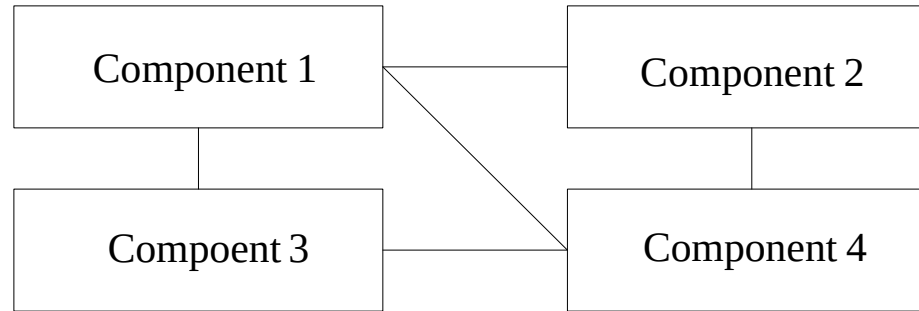
# General Service-Oriented Application Architecture



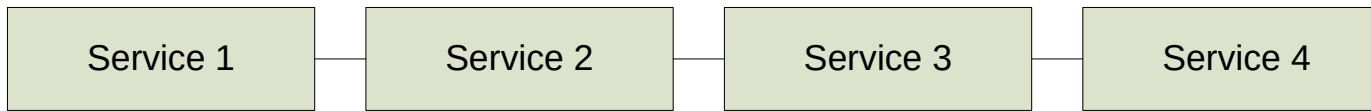
- ❑ Composition manager specifies and controls the application composition configuration via a workflow specification.
- ❑ The application composition configuration/workflow specification defines how the services shall be connected together to deliver the desired application and how the messages are transferred among the services

# Static vs. Dynamic Architecture

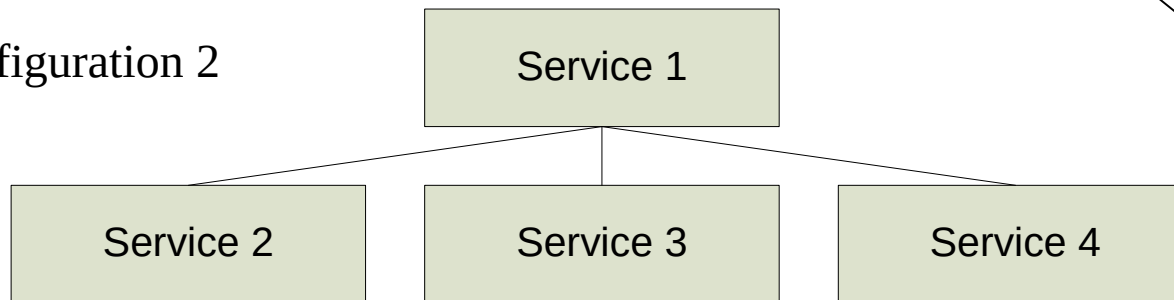
Static architecture  
with integrated  
components



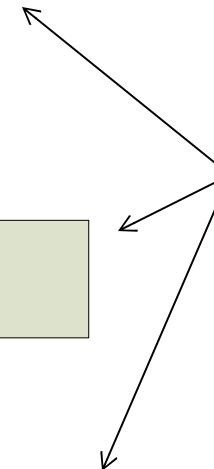
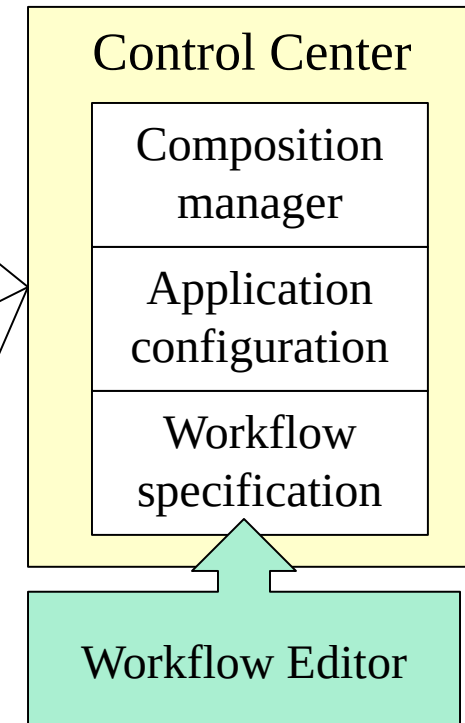
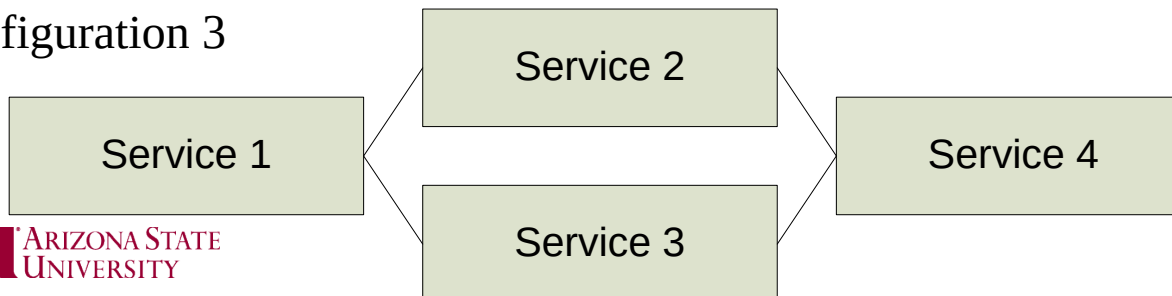
Configuration 1



Configuration 2

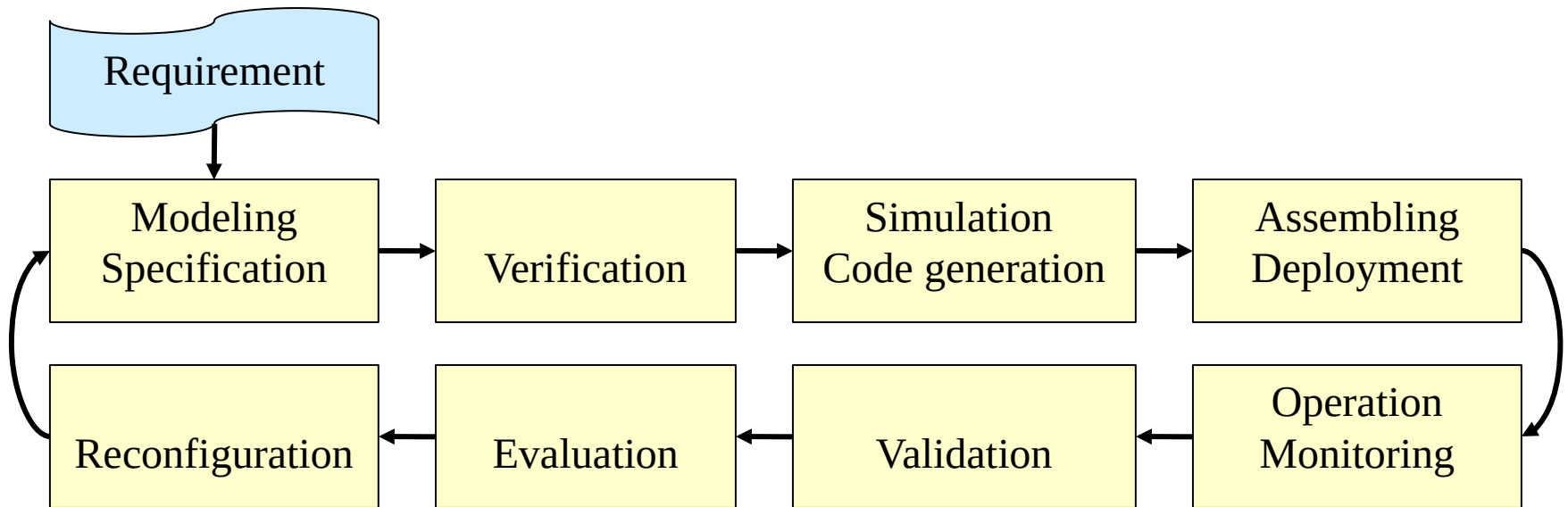


Configuration 3



# Lifecycle Reference Model of SOAA

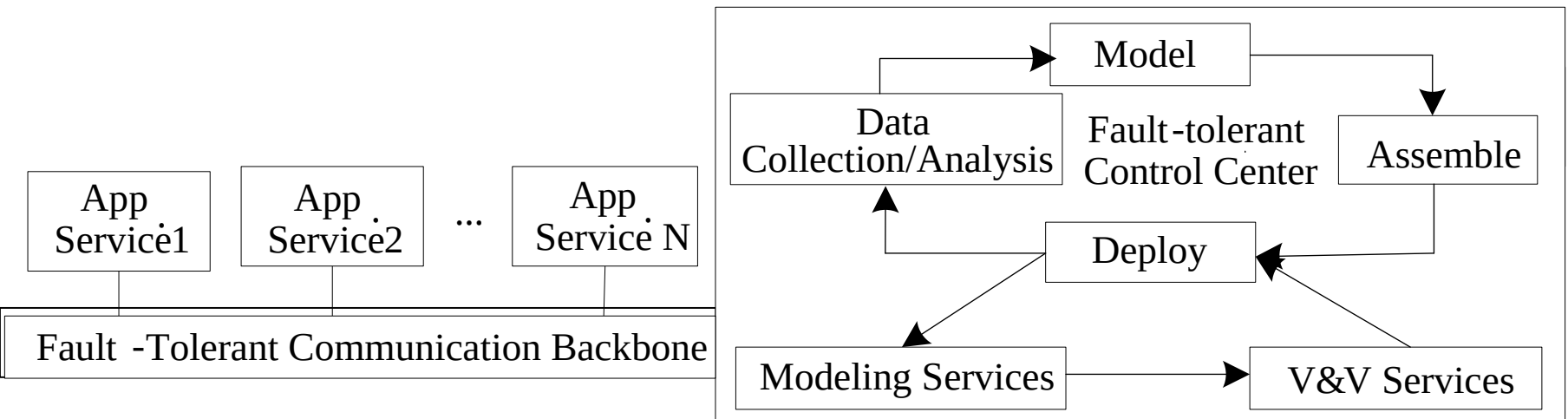
Based on BPM and with additional implementation detail





# Lifecycle Reference Model

## with Dynamic Application Architecture





# Dynamic Architecture Case Studies

---

- SAP Netweaver
- Oracle SOA Suite
- IBM ESB

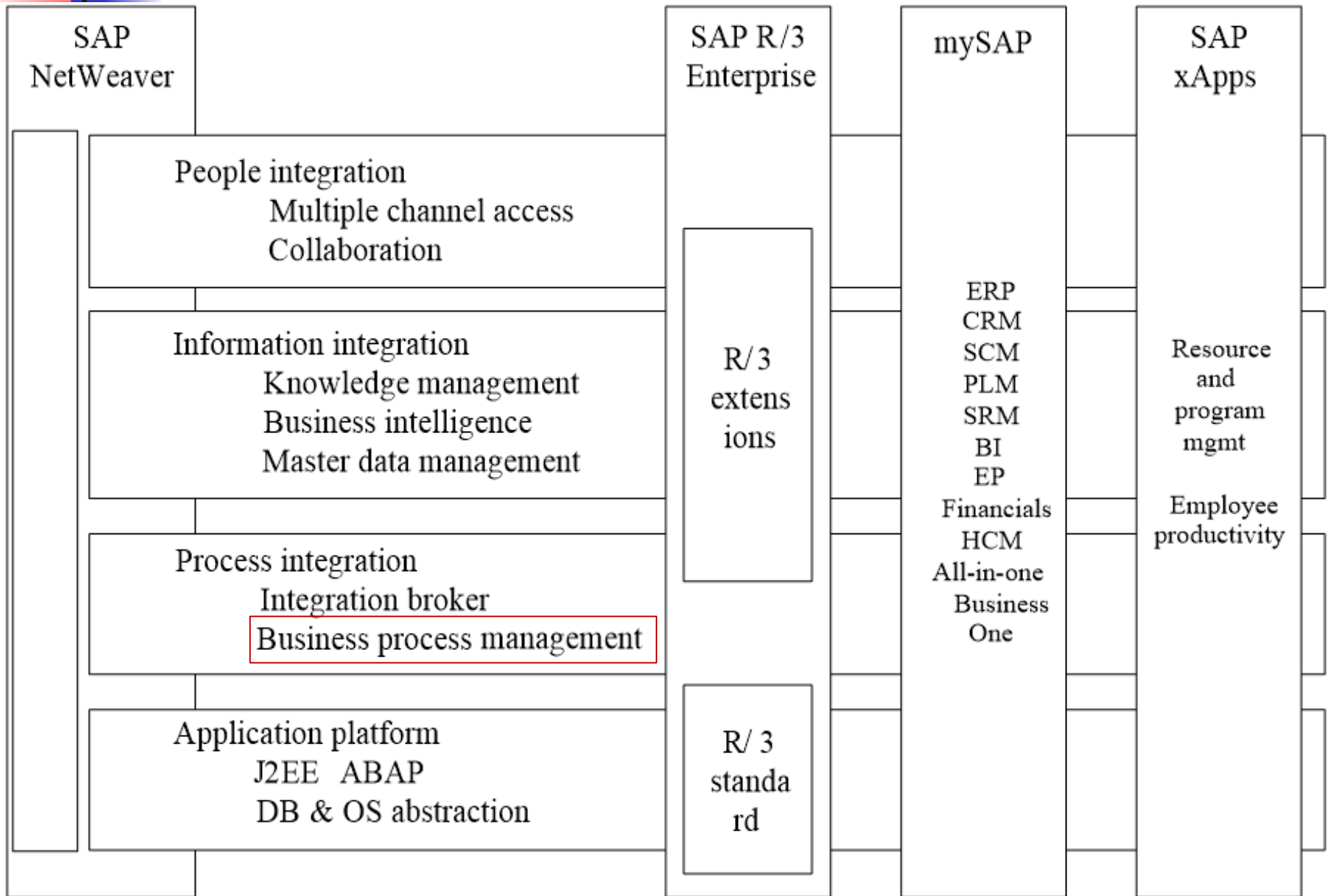
# Application Architecture Development Tools

39

Project Name	Architecture Style	Characteristics
SAP NetWeaver	Layered architecture	Providing integration with the traditional applications, with the SOA applications on Microsoft .Net and IBM WebSphere platforms
Oracle Dynamic Business Process	Visual architecture in workflow	Separate architecture from business process; allowing dynamically revising architecture and process on the fly.
IBM WebSphere Reference Architecture	Layered Architecture	Merging the SOA application development and the SOA application operation into one single infrastructure based on ESB
Microsoft Workflow Foundation	Visual architecture in workflow	Aiming at providing an integrated platform for specifying architecture, modeling, code generation, and execution of SOA applications

- Proposes a concept "**Enterprise Services Architecture**" (ESA), which provides an architecture framework for process modeling and service applications;
- Provides integration with the traditional applications, such as SAP R/3 and mySAP, with the SOA applications on J2EE, Microsoft .Net, and IBM WebSphere platforms;
- Provides interoperability and integration with other applications by following standards established by W3C.

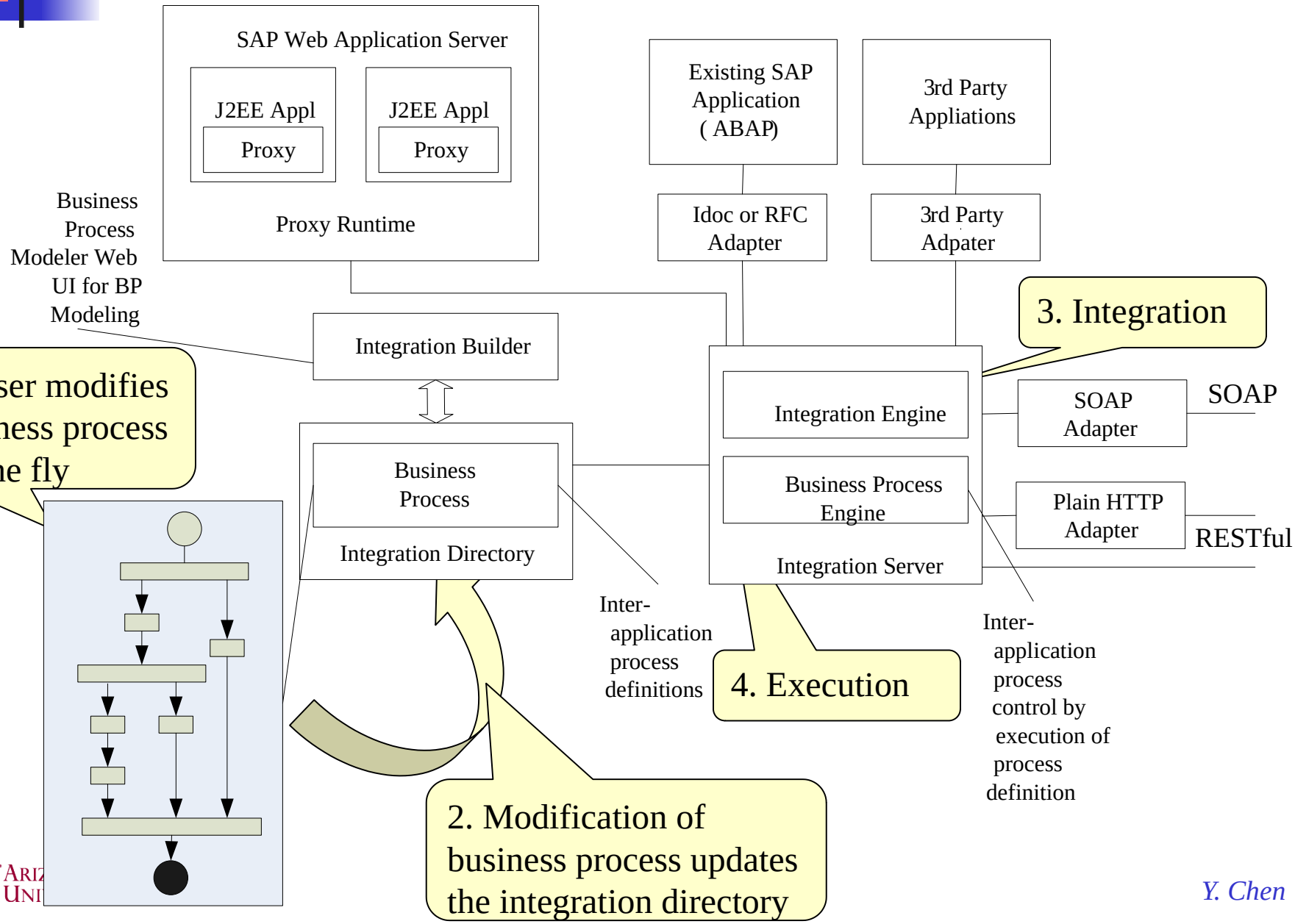
# SAP NetWeaver Architecture



- One of the key modules in SAP Netweaver is the BPM, consisting of the following components:
  - Integration Builder: supports BPEL process
  - Integration Repository,
  - Integration Directory,
  - Business Process Engine

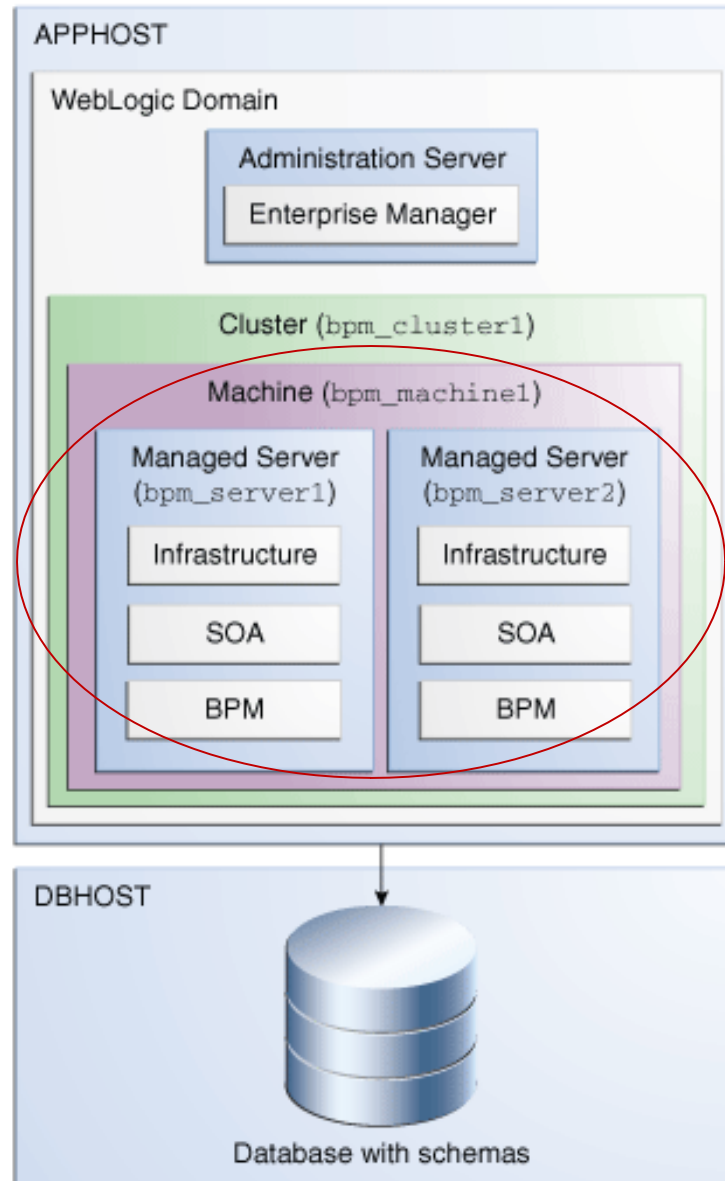
# SAP BPM Supporting Dynamic Application Architecture

43



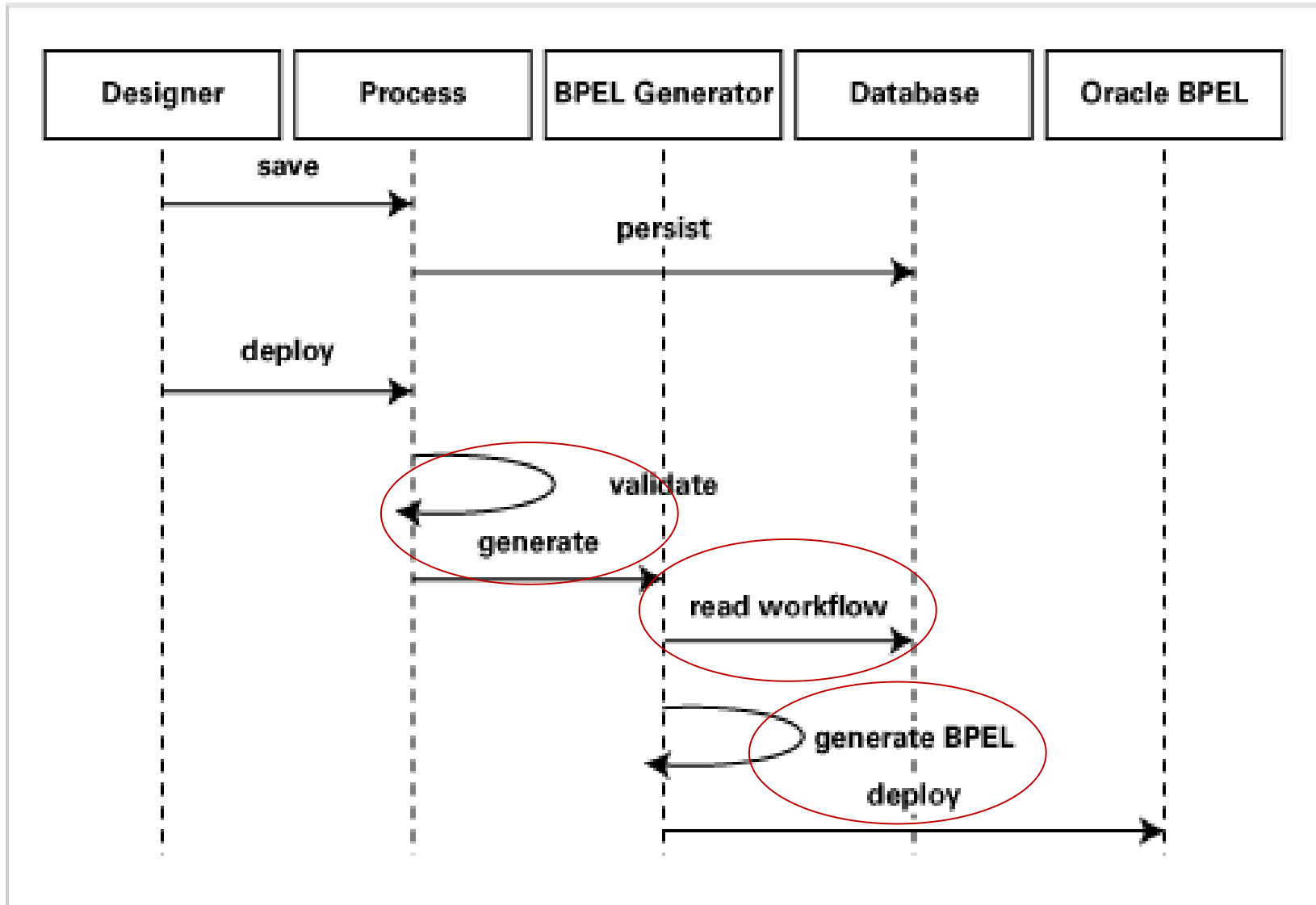
# Oracle SOA Suite for BPEL

<https://docs.oracle.com/middleware/1213/core/INSOA/planning.htm#INSOA352>





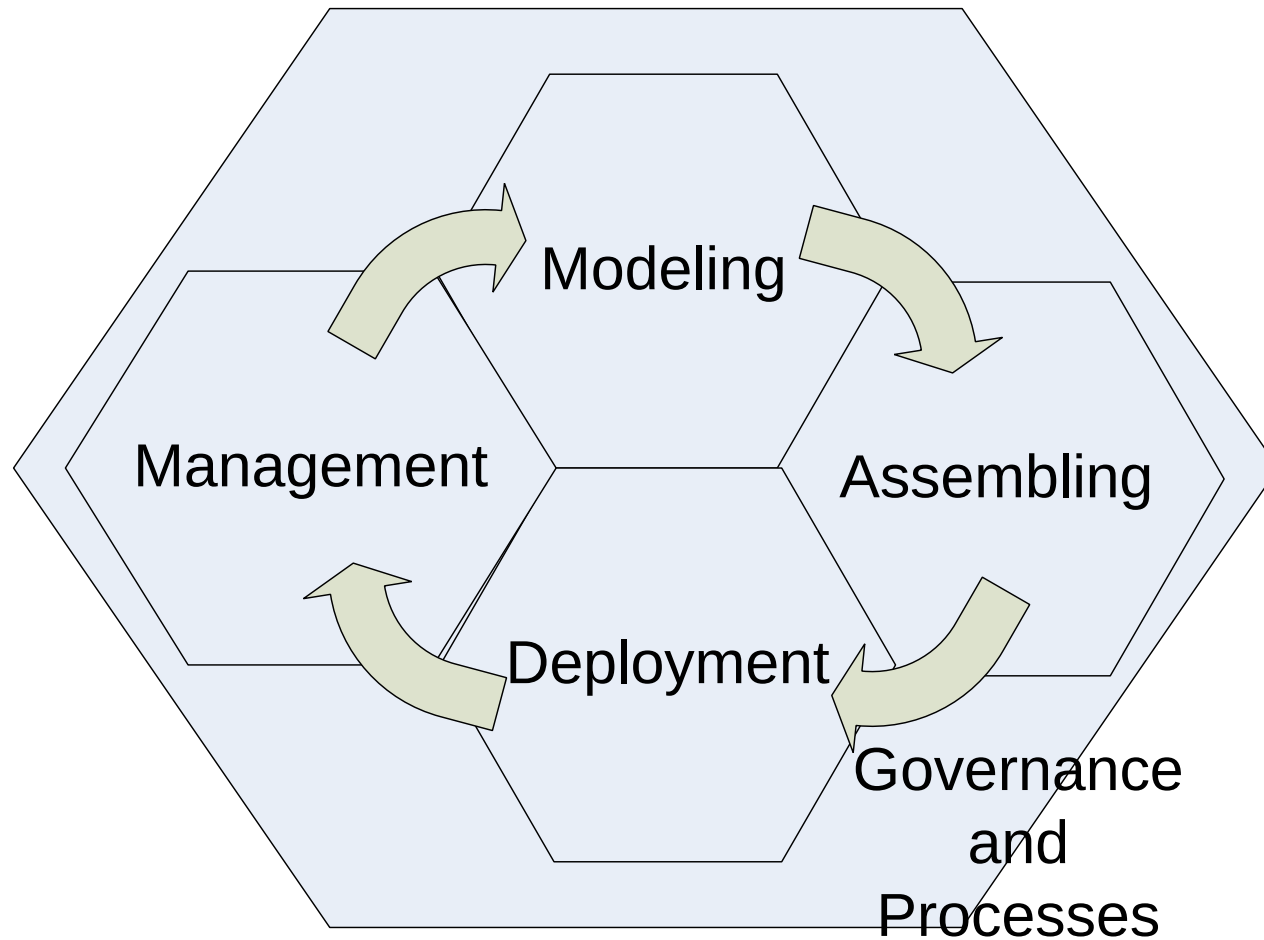
# Oracle SOA Suite for Dynamic Architecture



# Oracle SOA Suite for Dynamic Architecture

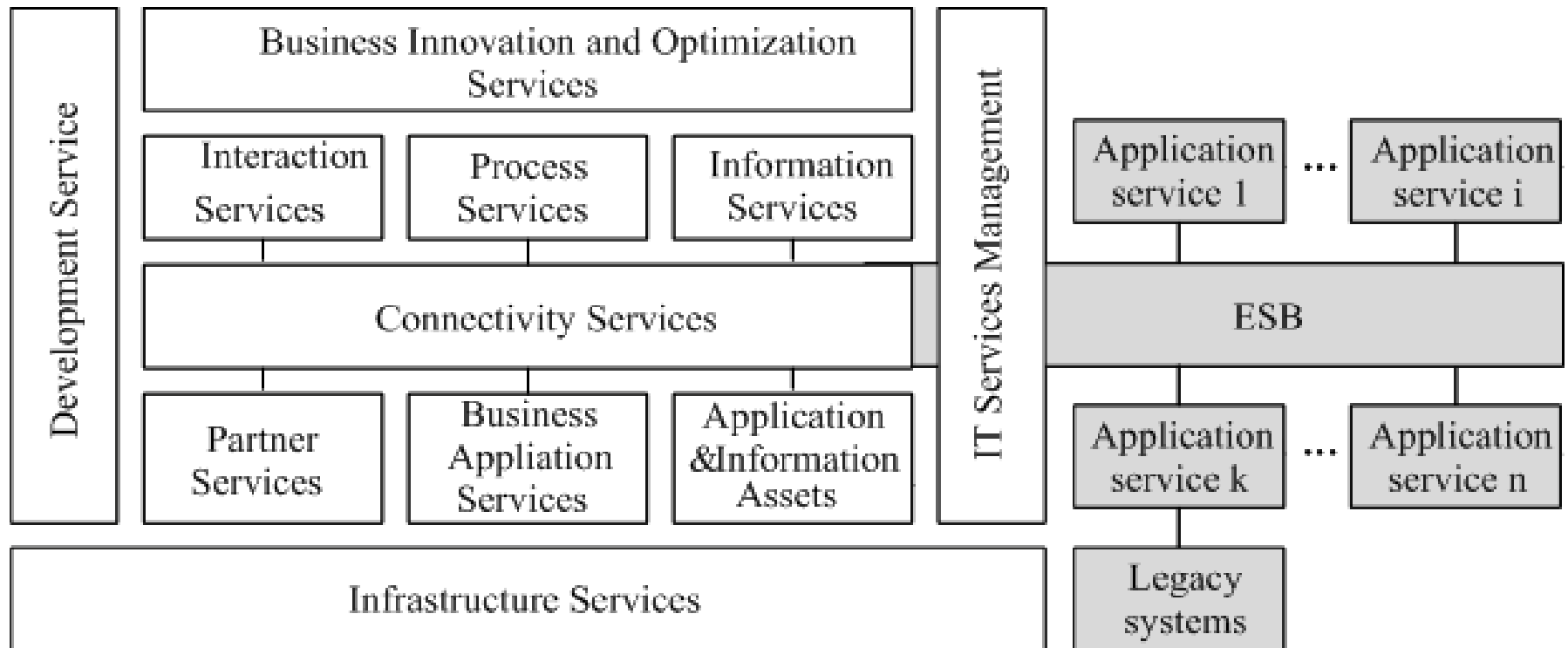
- An analyst uses a custom designer to **graphically** model the **business process**.
- The **business process** definition is stored in a database.
- The BPEL Generator reads and validates the process definition, and then generates the BPEL XML file from the database representation as well as associated files used for deployment.
- The BPEL process is **dynamically** deployed on the Oracle BPEL Process Manager Server.
- Just-In-Time compilation can be used to convert BPEL process to executable.

# IBM SOA Foundation Lifecycle Model (Based on Service Oriented Computing)

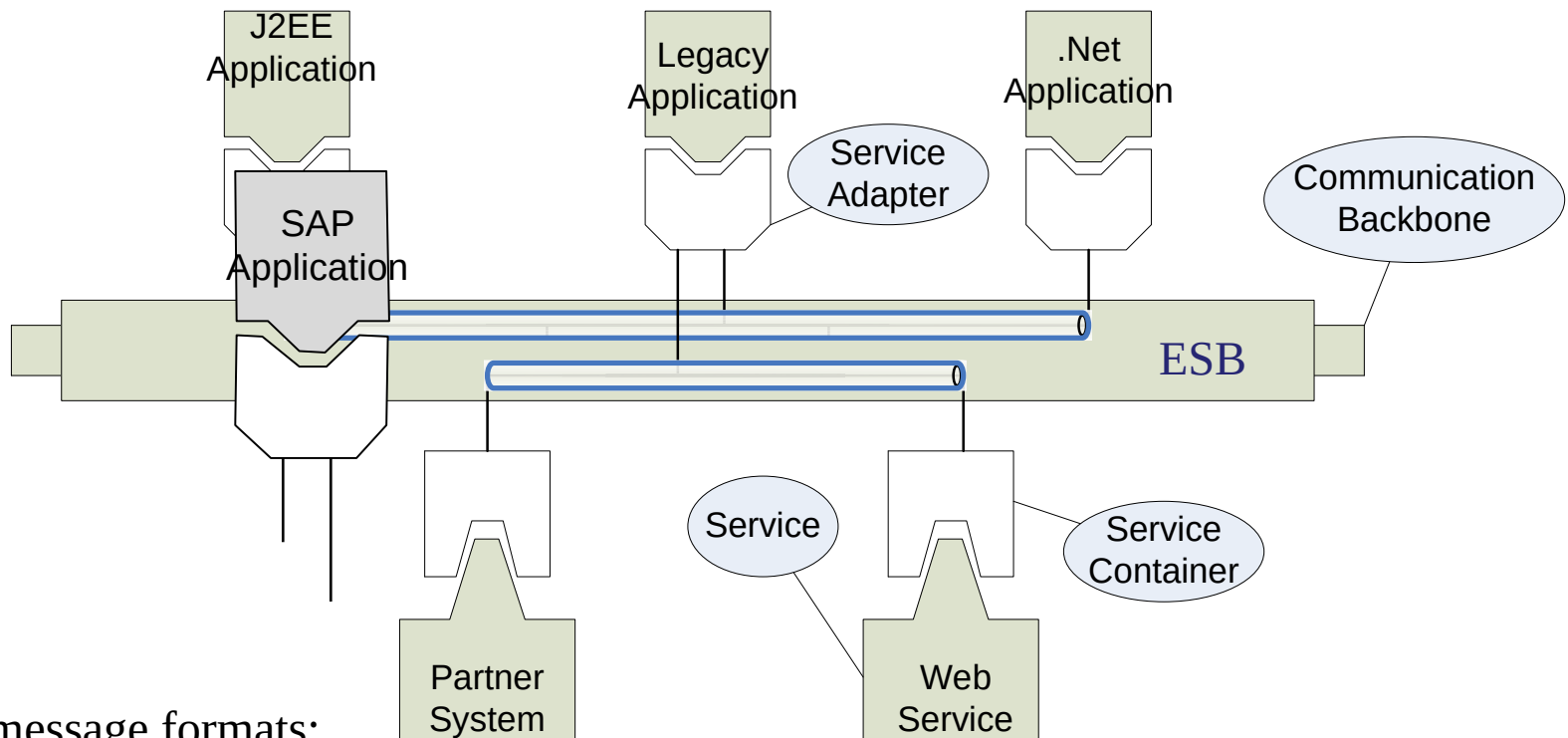


# IBM SOA Foundation Lifecycle Model

## with its Application Architecture and ESB



# IBM Enterprise Service Bus (ESB)



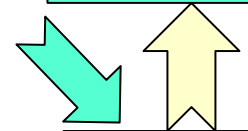
- Translate message formats;
- Adapt different interaction patterns;
- Convert transport protocols;
- Analyze and share the service interface;
- Propagate the security content;
- Provide WS-\* support, including WS-RM, WS-Security, and WS-Transaction;
- Track and monitor service activities

## What Next?

### From Dynamic to On Demand Business

- Dynamic Business Composition
  - Changing environment and changing partners
  - Reconfiguring business without stopping operations
  - Manual reconfiguration
- On Demand Business with Artificial Intelligence
  - Proactive discovery
  - Responsive reconfiguration in real-time
  - Resilient around the world and around the clock
  - Automated reconfiguration

*On Demand  
eBusiness  
with AI-  
based real-  
time  
reconfig-  
uration,  
resilient &  
automated  
evolution*



*Web 5.0  
with  
proactive  
artificial  
intelligent  
services and  
applications*

2015-2020