Software Engineering

Session 5 – Main Theme
High-Level Analysis and Design

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Agenda

1. Introduction
2. High-Level Analysis and Design
3. Architecture Blueprinting
4. Sample Architecture Blueprints
5. Architectural Mapping Process Illustrated
6. Reference Architecture Cataloguing Framework
7. Summary and Conclusion
What is the class about?

- **Course description and syllabus:**
  - [http://www.nyu.edu/classes/jcf/g22.2440-001/](http://www.nyu.edu/classes/jcf/g22.2440-001/)
  - [http://www.cs.nyu.edu/courses/spring14/G22.2440-001/](http://www.cs.nyu.edu/courses/spring14/G22.2440-001/)

- **Textbooks:**
  - *Software Engineering: A Practitioner’s Approach*
    - Roger S. Pressman
    - McGraw-Hill Higher International
High-Level Analysis and Design in Brief

- High-Level Analysis and Design Processes
- Architecture Blueprinting
- Sample Architecture Blueprints
- Architectural Mapping Processes
- Reference Architecture Cataloguing Framework
- Summary and Conclusion
  - Readings
  - Individual Assignment #1 (due)
  - Individual Assignment #2 (assigned)
  - Team Assignment #1 (ongoing)
  - Course Project (ongoing)
Icons / Metaphors

- Information
- Common Realization
- Knowledge/Competency Pattern
- Governance
- Alignment
- Solution Approach
The goal of high-level analysis and design is to quickly produce a **high-level model** that reflects the current understanding of the future state architecture.

This high-level model is helpful in putting together high-level program/project estimate and providing a **view** of the future state that can be used as a starting point.

Various architecture models may be used to represent this view and they are typically based on **blueprinting notations/process** and **blueprints** that have been standardized within the Enterprise working on the high-level analysis and design.

There are currently no industry standard blueprinting notation/process and/or blueprints; the blueprinting process typically goes top down to document the various facets of the future state architecture starting from the **Enterprise** level and going through the **business**, and **technology architectures**.

Technology architecture blueprinting can be conducted in parallel at the application, data, and technical levels.
An Architecture provides the organizing logic for mapping business onto IT capabilities.

Creating models to describe an Architecture is a complex exercise as various levels of abstractions may need to be considered to effectively cover all requirements in increasing levels of detail.

Architecture Models are typically based on an integration of existing reference architecture styles:

- e.g., OMA and SOA, SOA and BPM, etc.
A Reference Architecture consists of foundational principles, an organizing framework, a comprehensive and consistent method, and a set of governing processes and structures.

- **Principles** provide the foundation upon which the Reference Architecture is based. It includes a set of architectural terms as well as numerous principles, policies, and guidelines for governing the architecture.

- **Framework** is the organizing basis for the Reference Architecture and defines the architectural domains and disciplines that enable separation of concerns and IT to business alignment.

- **Method** is the comprehensive set of defined repeatable processes that are followed for a consistent and controlled realization of the Reference Architecture.

- **Governance** is the set processes and organizational structures that ensure conformity to the Reference Architecture.
Sample Application Server Reference Architecture

JBoss Enterprise Portal Platform
Content aggregation, presentation and personalization

JBoss Enterprise Application Platform
JBoss Enterprise Web Platform
JBoss Enterprise Web Server
Application and service containers, data persistence, messaging and transactions

JBoss Enterprise SOA Platform
JBoss Enterprise BRMS
Service integration/orchestration, business process automation, rules definition and event management

JBoss Enterprise Data Services Platform
Data integration, data service federation, data abstraction and management

JBoss Developer Studio
Eclipse IDE
Integrated tooling (plugins)
Embedded runtime platform
Fully integrated dev environment

JBoss Operations Network
Administration, management, and monitoring
A “reference” architecture model is an accepted representation of the architecture that drives the mapping of business capabilities onto IT capabilities.

A reference architecture model may not represent any specific organization needs.

A reference architecture model is rarely developed using a top-down or bottom-up approach, it is typically put together by integrating requirements from various architectural domains according to accepted heuristics (e.g., reuse via unification or best practices / standardization) and using accepted frameworks.
Enterprise Architecture Modeling Heuristics

**Coordination**
- Shared customers / products / product data / suppliers
- Operationally autonomous and unique business units
- Transactions impact other business units

**Unification**
- Customers and suppliers may be local or global
- Business units with similar or overlapping operations
- Globally integrated business processes supported by Enterprise systems

**Diversification**
- Few, if any, shared customers or suppliers
- Operationally autonomous and unique business units
- Independent transactions

**Replication**
- Few, if any, shared customers
- Operationally similar business units
- Independent transactions aggregated at a higher level
- Autonomous business units with limited discretion over processes

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**Key customers**
- Linked and standard (core) processes
- Shared data
- Linking and automating technologies

**Business process standardization**

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Required

Optional
Architects working at the Enterprise, Portfolio, and System levels use different models to represent their own views of a given architecture.

<table>
<thead>
<tr>
<th>Architecture Scope</th>
<th>Business Architecture</th>
<th>Data Architecture</th>
<th>Application Architecture</th>
<th>Technical Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise</td>
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<tr>
<td>Portfolio / Domain</td>
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<tr>
<td>System (Project)</td>
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</table>

An Architecture Asset Catalog enables the representation of stakeholder views in matrix form to help catalog such models.
What is the Level of Abstraction?

- The level of abstraction refers to how far a blueprint is removed from “practical” considerations such as application servers, programming languages, DBMS technology, etc.

- Although the levels of abstraction vary by architecture domain, four different types levels are recognized:

  > **Presentation** - a stylized model intended to greatly simplify an architecture so that key messages can be effectively communicated, typically to business leadership.
  
  >  Presentation level diagrams are generally created by summarizing lower level architecture diagrams.

  > **Conceptual** - a highly generalized yet more formal depiction of an architecture that suppresses much of the actual detail -- either because the details are not important to the model and/or they had not been decided at the time the diagram was created.

  > **Logical** - a detailed representation of an architecture that is generally independent of the underlying technology that is used (or will be) used to implement an architecture.

  > **Physical** - A representation that is typically dependent on the underlying technology that will be (or is) used to implement an architecture.
In this context, relevant views are those that match the phases of an solution development life cycle

<table>
<thead>
<tr>
<th>Architecture and Solution Engineering Views</th>
<th>Enterprise Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Business</td>
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<tr>
<td>Deployment</td>
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<tr>
<td>Product</td>
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<tr>
<td>Analysis/Design</td>
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<tr>
<td>Implementation</td>
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</tbody>
</table>

Sample Architecture and Solution Engineering Asset Catalog
# Conceptual Business Architecture Framework

## Value Chain

<table>
<thead>
<tr>
<th>Value Chain</th>
<th>Sales and Marketing</th>
<th>Product Development</th>
<th>Underwriting</th>
<th>Finance and Accounting</th>
<th>Servicing</th>
<th>Claim Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Capabilities</td>
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</tr>
</tbody>
</table>

## Business Users

- Bond Business Users
- Agents
- Customers
- Public

## Business Events

- Transactional
- Analytical
- Operational

## Business Channels

- Direct
- Indirect

## BPM Processes

- Design
- Execute
- Monitor

## Process Metrics

- Key Performance Indicators
- Service Level Agreements

## BRM Rules

- Business Rules
- Contractual Rules

## Business Services

- Product Development
- Underwriting
- Finance and Accounting
- Servicing
- Claim Processing

## Business Entities

- Surety
- Management Liability
- Enterprise
- Claims
- Business Unit
What is Blueprinting?

- Blueprinting is fundamentally concerned with the high-level representation of intangible assets (e.g., applications, databases, interfaces, networks, servers, etc.) so that:
  - The interrelationship between the various assets can be understood
  - The assets may be changed more reliably
  - Architectural level design decisions become observable
What is a Blueprint?

- A blueprint is an architectural drawing
  - Created using a consistent representation to represent a high-level model of the as-it, to-be, or in-transition IT environment

- Unlike UML models, which are software engineering level diagrams, blueprints are at an architectural-level of detail and provide the context needed to visualize the “big picture”
  - As such, blueprints are analogous to the “city-planning” level in the building construction industry
  - They enable architects to communicate the overall design of the city as opposed to the design of the individual buildings that make up the city
What Does a Blueprint Look Like and How is it Used?

- The appearance of a blueprint varies considerably depending upon a number of factors including:
  - The architectural domain being modeled (e.g., application architecture versus technical architecture)
  - The scope of the blueprint (e.g., Enterprise, Portfolio, Project)
  - The level of abstraction (e.g., Presentation, Conceptual, Logical, Physical)
  - The communication objectives of the model

- Blueprints are also used to document and define three different states of technology evolution
  - A current state called the As-Is or POD
  - A future state called the To-Be or POA (typically 12 - 24 months out)
  - One or more transition states, each one called a Transition or planned landing point between the as-is and to-be state
    - Once implemented, a Transition represents a new As-Is state
Why is there a Need for a Common Way to Document Architectures?

- In the absence of standardized blueprinting techniques, architectural models would be highly individualized and would range from artifacts that may be fairly structured to models that would be very general and stylistic.

- As a result, the readers interpreting the models would be required to ask (and assume an answer to) a number of critical questions including:
  - What concepts is the model attempting to explain?
  - Are the concepts highly abstract or is the model depicting a precise design?
  - What do the symbols on the diagram represent?
  - What architecture domain is being modeled?
  - Does the design apply to the Enterprise as a whole, a LOB, a portfolio, or a project?
  - Does the model represent the As-Is, To-Be, or Transition architecture?
  - If the model represents a Transition architecture, what changes to the IT environment are being planned?
  - etc.
Blueprinting and UML at a Glance

- Blueprinting and UML are intended to be used together on the same project.
- Blueprint artifacts are used to document the end-to-end high-level designs for projects.
  - Blueprints are analogous to the “city-planning” level in the building construction industry.
  - They enable architects to communicate the overall design of a city (project) as opposed to the design of the individual buildings (applications) that make up the city.
- UML artifacts are used for software engineering tasks (e.g., architecting the buildings).

<table>
<thead>
<tr>
<th>UML</th>
<th>Blueprinting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Focus</strong></td>
<td>Software development</td>
</tr>
<tr>
<td><strong>Use</strong></td>
<td>Analyze and design software systems and modules, typically using an OO approach</td>
</tr>
<tr>
<td><strong>Level of detail</strong></td>
<td>High to low-level</td>
</tr>
<tr>
<td><strong>Central Element of Granularity</strong></td>
<td>A system and its subsystems</td>
</tr>
<tr>
<td><strong>Learning Curve</strong></td>
<td>Significant</td>
</tr>
</tbody>
</table>
According to Research Analysts and reports…

» Modeling at the Enterprise and Portfolio levels tends to be fairly generalized
  • The goal at these levels is to communicate the “big picture“ (as opposed to “application-level” designs)

» UML is an OO modeling system with schematics and notations for application development (e.g., "building-level" designs)
  • It is not well suited for modeling portfolio and Enterprise level architectures (e.g., the "city-level" or “big picture” designs)

» There may never be industry standards at the Enterprise and Portfolio levels
The Legend Box is a text box that must appear on all blueprints. It is used to denote important information that is needed by the reader to correctly interpret a blueprint. The following information is included in the Legend Box:

- **Architecture Domain** - Used to specify what aspect of the environment is the subject of architecture artifact - One of the following domains must be specified:
  - *Business Architecture* — specify this when the model depicts the company’s business capabilities, business processes, organizational structure, major locations, or relationships with partners and customers
  - *Application Architecture* — specify this when the model depicts the application assets that support business capabilities and processes
  - *Data Architecture* — specify this when the model depicts the company’s business rules, business data and/or information types, along with their interrelationships
  - *Technical Architecture* — specify this when the model depicts hardware and facilities, system software, data storage resources, networks, and other underlying technologies
    - Technical architecture provide the platform that supports the activities and interfaces of the other domains
Legend Box (continued)

- **Scope** - Defines the breath (or scope of authority) for a blueprint. Several different scopes are recognized:
  - **Enterprise** - A model that generally depicts a company's environment as a whole
  - **Portfolio** - A model that depicts the architecture of a portfolio (e.g., Field Management)
  - **Program/Project** – A model that depicts the architecture of a program or project
  - **Asset** - A diagram that depicts the architecture of an asset

- **Abstraction** - Refers to how far the model is removed from “practical” considerations such as application servers, programming languages, etc
  - Four different levels are recognized: Presentation, Conceptual, Logical and Physical

- **State** – Used to answer the question: *Does this model represent the current state or some proposed future state?* Three different states are typically recognized:
  - **As-is** - the current state.
  - **To-be** - the desired future state that is to be achieved in a specified time period (typically 12 – 24 months). In reality, the to-be state is a moving target that generally represents an aspiration, as opposed to a fixed target that will be achieved
  - **Transition** - a planned landing point between the current state and the to-be state
    - A Transition diagram shows progress towards the future state
    - Once implemented, a transition architecture represents the new As-Is and the previous current As-Is becomes the As-Was
Importance of the Scope of a Blueprint

- Specifying the scope of a diagram is critical because there is a direct correlation between the scope and the amount of detail that can be depicted on a blueprint. The reason is that the amount of generalization (e.g., simplification, feature selection, grouping, etc.) must increase with the scope of the blueprint. The following examples illustrate this key point:

**Blueprints**

- **Scope = Enterprise**
  - As-Is Application Architecture for App Port "C"
  - Daily Extract
  - Com
  - Scope = Portfolio

- **Scope = System/Project**
  - As-is Application Architecture for "App D"
  - Pgm 1
  - Daily Extract
  - Scope = Subsystem/program

- **Scope = Subsystem/program**
  - As-is Application Architecture for "Pgm 1"

**Map Analogy**

- **Scope = United States**
  - City of Minneapolis

- **Scope = State of Minnesota**
  - Downtown Minneapolis

- **Scope = City of Minneapolis**
  - As-Is Application Architecture for "App D"
Sample Enterprise Architecture Blueprint for Unification Operating Model

Delta Air Lines’ Enterprise Architecture

Operational Pipeline
- Allocate Resources
- Prepare for Flight Departure
- Load Aircraft
- Flight Departure and Closeout
- Monitor Flight
- Flight Arrival and Closeout
- Unload Aircraft
- Clean/Service Aircraft

Delta Air Lines’ Enterprise Architecture

Electronic Events
- Location
- Flight
- Schedule
- Maint.
- Employee
- Aircraft
- Customer
- Ticket

Business Reflexes
- Pagers
- Voice
- Video
- Cell Phones
- Desktops

Delta Nervous System

Nine core databases

Profile
- Skylinks
- Skymiles
- Reservations
- Travel Agent
- SkyCap
- Ticket Counter
- Crown Room
- Boarding
- InFlight
- Baggage

Personalization
- Digital Relationships
- Loyalty Programs

Customer Experience

Source: Adapted from Delta Air Lines documents – used with permission.
Sample Enterprise Architecture Blueprint for Diversification Oper. Model

Enterprise Architecture for Carlson’s Diversification Operating Model

Customer Requirements

Business Initiatives
- Travel Management
- Loyalty
- Hotel Distribution
- CRM

Enterprise Portal
- Presentation

Application

Data Trust

Middleware

Data Object

Platform

Network

Source: Carlson Company

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Sample Enterprise Architecture Blueprint for Replication Operating Model

Enterprise Architecture for ING DIRECT’s Replication Model

External Services
- Prospect Fulfillment
- Statement Fulfillment
- Payments
- Checks
- Reports Local/HQ/Tax

Customer Relationship Services
- CIF
- CRM
- Contact History
- Product Info

Core Banking Services
- Mutual Funds
- Brokerage
- Banking Engine
- Credit Score

Common Business Services
- Transactions
- Customers
- Products
- Services

Channel Services
- IVR/CTI server
- Imaging server
- E-mail server
- Web server
- Gateway server

Customer Contact: Call Center, IVR, E-mail, Direct mail

Self-Service: Internet, MinTel, ATM, WAP, (WebTV)

Source: Robertson, D. “ING DIRECT: The IT Challenge (B),” 2003, IMD-3-1345. Used with permission.

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Sample Detailed Level Business Architecture Blueprint
Sample High-Level Business Architecture Blueprint

- **Client Focus** (Client and Channel Mgmt)
  - **Product**
  - **Sales**
  - **Service**
- **Business Management and Support** (Information Technology, etc.)
- **Risk and Financial Mgmt**
Sample Application Architecture Blueprint

Participants
- Prospect
- Contract Holder
- Financial Professional
- Employee
- Firm
- Clearinghouse
- Vendor / Partner Systems

Interaction
- Media
  - Forms
  - Browser
  - Email
  - Phone PDA
  - Text Message

- Views
  - Contract Holder
  - Financial Professional
  - Service
  - Sales
  - Other Views

Electronic Business Gateway

Processes
- New Business – Form based
  - Death
  - Spousal Continuance
  - Remittance
  - Programmed Reallocation
  - Valuation

Services
- Business Services
  - Process Services
    - Get Contract
    - Get FP Detail
    - Get Last Touch
    - Contract Setup
    - Check Appoint.
    - Other Services
  - Atomic Services
  - Composite Services

Components
- Business Services
  - Process Services
    - Get Contract
    - Get FP Detail
    - Get Last Touch
    - Contract Setup
    - Check Appoint.
    - Other Services
  - Atomic Services
  - Composite Services
  - Other Components

Data
- Party
- Product
- Contract
- Activities
- Commissions
- Other Stores

Integration (Application Bus)

Technical Services
- Security Services
- Session Management
- Event Management
- Connection Management

Rules
- Navigation
- Process
- Product
- Security
Sample Infrastructure Architecture Blueprint
Agenda

1. Introduction
2. High-Level Analysis and Design
3. Architecture Blueprinting
4. Sample Architecture Blueprints
5. Architectural Mapping Process Illustrated
6. Reference Architecture Cataloguing Framework
7. Summary and Conclusion
Mapping Dimensions to Consider

- Levels of abstraction
- Breadth (i.e., architectural domain)
- Depth (i.e., services/facilities needed)
- Specialization (i.e., styles and related pattern)
- Integration of various patterns results in integration variants/hybrids
- Mapping relies on the selection of standards and products that implement that standard
  » e.g., JEE – IBM WebSphere Application Server
Separation of concerns through layering enables high cohesion and low coupling across the application components.
Sample Reference Application Architecture Implementation Blueprint (OMA/SOA Hybrid)
Sample Product Mapping:
- JEE Standard
- IBM WebSphere Product Family
- Various Third Party Products (as indicated)
Challenges of an Architecture Continuum Catalog

Scope and Detail of Architectures

- Any Enterprise is likely to have many Solutions and Architectures
- Different Segments of the Enterprise, Product lines or Divisions
- Different Levels of Detail suitable for different purpose and audience
- Time horizon of an Architecture

Specialization Hierarchy of Architectures

- Generic Architectures common to all industries
- Industry Specific Architectures
- Reference Architecture of a particular Organization
- ...

Domains and Views of an Architecture

- Business Domain, Information Domain, Application Domain, Infrastructure Domain
- A Master Architecture can cover all these domains at a high level
- Each Domain can have a single comprehensive view of an Architecture
- Each Domain can have multiple views to cover an Architecture
- Specialized views for specific purposes within each domain
Specialization Hierarchy for Architectures (TOGAF-Centric)
Objectives:

A catalog with a scope comprehensive enough to hold all reference architectures blueprints in a meaningful and well-understood structure (i.e. be able to accommodate different types of reference architectures blueprints)

A set of processes to access and maintain the catalog as well as the reference architectures in the catalog, so the reference architecture blueprints could be easily preserved and reused, providing the following functions:

- Retrieve a specific reference architecture at any time, given the dimension specifications
- Searchable given any dimension specifications
- Allow adding variants to any existing reference architecture
- Extendable in terms of new options (attributes) in each dimension
Although we show only 3 basic dimensions here, one could extend this to n dimensions
- An architecture in this catalog will have coordinates \((x_1, x_2, x_3, \ldots, x_n)\)
<table>
<thead>
<tr>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
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<tr>
<td>Level of Architecture</td>
<td>Area of Specificity</td>
<td>Area of applicability</td>
<td>Breath of Applicability</td>
</tr>
<tr>
<td>High</td>
<td>Foundation</td>
<td>common services</td>
<td>Finance</td>
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<tr>
<td>Low</td>
<td>Generic</td>
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<th>D9</th>
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<tr>
<td>Domain</td>
<td>Depth of Scope</td>
<td>Specialization</td>
<td>Product Mapping</td>
<td>Level of Abstraction</td>
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<td>Business Application services facilities</td>
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<td>.NET SOA</td>
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Reference Architecture Catalogue Processes
Dimensions Selection

Diagram #1
Dimension Selection

Reference Architecture Blueprint (RFB)
Catalog Framework Activity Diagram
Reference Architecture Cataloguing Framework at Work
Sample from Joint NYU-CTS ITP Project (Fall 2009)
Agenda

1. Introduction
2. High-Level Analysis and Design
3. Architecture Blueprinting
4. Sample Architecture Blueprints
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6. Summary and Conclusion
Summary – Key High-Level Analysis and Design Objectives

- Enable Rapid Development of Business and Technical Solutions
- Quickly produce a high-level model that reflects the current understanding of the future state architecture
- Put together a high-level program/project estimate and provide a view of the future state that can be used as a starting point
- Leverage blueprinting notations/process and blueprints that have been standardized within the Enterprise working on the high-level analysis and design
- Follow a top-down process to document the various facets of the future state architecture starting from the Enterprise level and going through the business and technology architectures
- Conduct technology architecture blueprinting in parallel at the application, data, and technical levels
Course Assignments

- **Individual Assignments**
  - Reports based on case studies / class presentations

- **Project-Related Assignments**
  - All assignments (other than the individual assessments) will correspond to milestones in the team project.
  - As the course progresses, students will be applying various methodologies to a project of their choice. The project and related software system should relate to a real-world scenario chosen by each team. The project will consist of inter-related deliverables which are due on a (bi-) weekly basis.
  - There will be only one submission per team per deliverable and all teams must demonstrate their projects to the course instructor.
  - A sample project description and additional details will be available under handouts on the course Web site
Team Project

- **Project Logistics**
  - Teams will pick their own projects, within certain constraints: for instance, all projects should involve multiple distributed subsystems (e.g., web-based electronic services projects including client, application server, and database tiers). Students will need to come up to speed on whatever programming languages and/or software technologies they choose for their projects - which will not necessarily be covered in class.
  - Students will be required to form themselves into "pairs" of exactly two (2) members each; if there is an odd number of students in the class, then one (1) team of three (3) members will be permitted. There may **not** be any "pairs" of only one member! The instructor and TA(s) will then assist the pairs in forming "teams", ideally each consisting of two (2) "pairs", possibly three (3) pairs if necessary due to enrollment, but students are encouraged to form their own 2-pair teams in advance. If some students drop the course, any remaining pair or team members may be arbitrarily reassigned to other pairs/teams at the discretion of the instructor (but are strongly encouraged to reform pairs/teams on their own). Students will develop and test their project code together with the other member of their programming pair.
Team Project Approach - Overall

- Document Transformation methodology driven approach
  - Strategy Alignment Elicitation
    - Equivalent to strategic planning
      - i.e., planning at the level of a project set
  - Strategy Alignment Execution
    - Equivalent to project planning + SDLC
      - i.e., planning at the level of individual projects + project implementation
- Build a methodology Wiki & partially implement the enablers
- Apply transformation methodology approach to a sample problem domain for which a business solution must be found
- Final product is a wiki/report that focuses on
  - Methodology / methodology implementation / sample business-driven problem solution
- Document sample problem domain and business-driven problem of interest
  - Problem description
  - High-level specification details
  - High-level implementation details
  - Proposed high-level timeline
Assignments & Readings

- Readings
  - Slides and Handouts posted on the course web site
  - Textbook: Part Two-Chapter 5

- Individual Assignment (due)
  - See Session 3 Handout: “Assignment #1”

- Individual Assignment (assigned)
  - Sess Session 5 Handout: “Assignment #2”

- Team Project #1 (ongoing)
  - Team Project proposal (format TBD in class)
  - See Session 2 Handout: “Team Project Specification” (Part 1)

- Team Exercise #1 (ongoing)
  - Presentation topic proposal (format TBD in class)

- Project Frameworks Setup (ongoing)
  - As per reference provided on the course Web site
Any Questions?
Next Session: Detailed-Level Analysis and Design