Welcome to CSE 4407: System Analysis and Design

- Why
  - Core for systems analysts, developers, and managers
  - Business Problems $\leftrightarrow$ Technical Solutions
  - Leads to clearer requirements, defined scope, fewer reworks
- Your Role: Systems “Architect”
  - Plan before you build: know users and environment
  - Define requirements precisely
  - Ensure solutions fit real-world needs
- Course Roadmap
  - Systems Analysis Fundamentals
  - Information Requirement Analysis
  - The Analysis Process
  - The Essentials of Design

Course Logistics

- Google Classroom Code
  - Theory: `caqarlqw`
  - Lab: `ad22vdpj`
- Communication
  - Discussion in Google Classroom
  - Email: cse.bakhtiarhasan@iut-dhaka.edu
- Book: Kendall and Kendall, Systems Analysis and Design, 10th Edition
- Grading Policy
  - Attendance (10%)
  - Quiz (15%)
  - Mid Semester (25%)
  - Semester Final (50%)
- Academic Integrity Policy: Do not submit others' work as yours

Systems, Roles, and Development Methodologies

CSE 4407

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Introduction

- Opening thought
  - Information is now a **key organizational resource**, just like people or materials.
  - It needs *management*
- The Information Explosion: Networked computers and the web have amplified the amount and complexity of information we handle
- Chapter Goals: We will explore
  - Fundamentals of Information Systems (IS)
  - Roles of Systems Analysts
  - Development Lifecycles (SDLC, Agile, O-O)
  - Open Source and CASE Tools

Why Bother with Systems Analysis and Design (SAD)?

- What: A systematic way to
  - Understand user **needs**
  - Analyze data **input/flow**
  - Analyze data **processing/transformation**
  - Analyze data **storage**
  - Analyze information **output**
  - *(All within an organizational context)*
- Primary Goal
  - Identify and solve the **RIGHT** problem
  - Analyze, design, and implement **improvements** to computerized information systems
- Analogy: Doctor diagnosing a patient

The Cost of Chaos vs. The Value of Structure

- Why SAD is CRITICAL
  - Avoid Disaster: Prevents user dissatisfaction and systems falling into disuse (*Shelfware*)
  - Manages Complexity and Cost: Provides structure to what can be a very expensive and complicated endeavor
  - Business Improvement: Aims to enhance the business using *computerized* information systems
  - Collaboration is Key: User involvement throughout the project is non-negotiable for success!
  - Global Teams: Emphasis on user interaction is even *more* critical with international development teams

Security and Privacy: Not Just an Add-On!

- The Reality
  - Security is **critical** but challenging
  - Multiple vulnerabilities exist in any system
  - “Perfect” security is unrealistic – it involves **trade-offs** (value of data vs. risk vs. cost)
- The SAD Approach: Security by Design
  - Build security and privacy controls in from the VERY BEGINNING
  - Much more effective and desirable than trying to patch security onto older systems (legacy systems)
  - Always assess and improve security when updating existing systems
  - User training on security is also crucial

The Systems Analyst: Bridging Worlds

- Who: Someone who **systematically assesses**
  - How users interact with technology
  - How businesses function
  - *(By examining data input, processing, output, and information flow)*
- Intent: To **improve** organizational processes, often using computerized IS
- Key Characteristics
  - Works with diverse **people**
  - Experienced with **computers** and technology
  - Often balances **multiple roles** simultaneously

The Analysts Wears Many Hats...

- Primary Role 1: The Consultant
  - Often an **external** hire
  - Pros: Brings a fresh, objective perspective
  - Cons: Lacks deep knowledge of internal organizational culture/politics
  - Relies on: Systematic methods (like those in this course!) and user input
- Primary Role 2: The Supporting Expert
  - Usually an **internal** employee (part of the organization)
  - Draws on **specific technical expertise** (HW, SW, databases, etc.)
  - Often involved in smaller modifications, decisions, or specific parts of a larger project
  - Acts as a **resource** for project managers, not *the* manager

...Agent of Change and Essential Qualities

- Primary Role 3: The Agent of Change
  - The most **comprehensive** and responsible role
  - Can be internal or external
  - Involved throughout the **Systems Development Life Cycle (SDLC)** (often long-term: weeks to years)
  - Their mere **presence** and activities **change** the business
  - Must work closely with users/management from Day 1
- What Makes a GREAT Systems Analyst?
  - Problem Solver: Enjoys challenges, finds workable solutions (The Core!)
  - Communicator: Relates meaningfully to diverse people over time. Understands human needs with tech (HCI). Bridges gap to developers
  - Self-Disciplined and Motivated: Manages self, coordinates people, handles resources
  - Ethical: Acts with integrity, especially with sensitive info and client relationships
  - Technically Adept and Business Savvy: Understands both sides

The Traditional Blueprint: Systems Development Life Cycle (SDLC)

- What: A **phased** approach to systems analysis and design
- Assumption: Systems are best developed using a specific cycle of analyst and user activities
- Common Analogy: The "Waterfall" Method
  - Phases flow sequentially downwards, like water over falls
  - (PMI calls this a "Predictive" life cycle) [1]

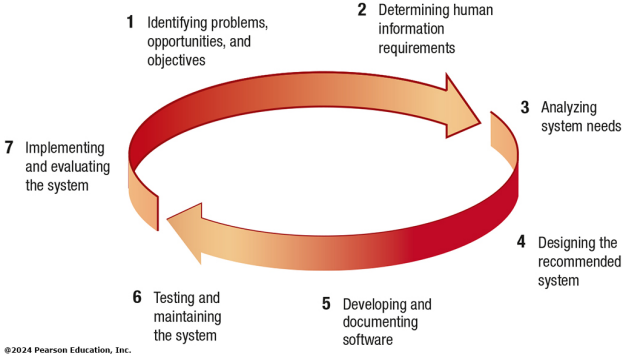


Figure. The 7 Phases (Kendall and Kendall Model)

SDLC Phase 1: Where Do We Start?

- Main Goal: Correctly identify the core **Problems**, **Opportunities**, and **Objectives**
- Why: Getting this wrong means wasting significant time and resources solving the *wrong issue*!
- Activities
  - Honestly assess the current business situation
  - Pinpoint specific **problems** (often the reason the analyst was called in)
  - Identify **opportunities** (situations where IT can provide improvement or competitive advantage)
  - Discover and define clear business **objectives**
- Who's Involved: Users (especially management), Analysts, Systems Managers
- Key Output: Feasibility Report (Defines problem, summarizes objectives, initial scope estimate, recommends Go/No-Go)

SDLC Phase 2: Understanding Users and Their Needs

- Main Goal: Determine **human needs** regarding the information system. How do users *need* to interact?
- Methods for Gathering Info
  - Interactive: Interviews, Questionnaires, Sampling data
  - Unobtrusive: Observing users work, analyzing existing documents (“hard data”)
  - All-encompassing: Prototyping (building preliminary versions)
- Focus: Human-Computer Interaction (HCI)
  - Physical aspects? (Legible, audible, safe?)
  - Cognitive aspects? (Easy to learn, use, remember?)
  - Affective aspects? (Pleasing, engaging, fun?)
  - Productivity? (Support tasks, enable new capabilities?)
- Key Framework: Understand the **Who**, **What**, **Where**, **When**, **How** of current processes, and Critically: **WHY?**
- Who’s Involved: Analysts, Users (Operational level often)

SDLC Phase 3: Analyzing System Needs

- Main Goal: Analyze the information gathered in Phase 2 to determine system requirements
- Key Tools and Technologies
  - Process Modeling: *How data moves and transforms*
    - Data Flow Diagrams
    - Activity Diagrams/Sequence Diagrams
  - Data Modeling: *What data is needed?*
    - Data Dictionary
  - Logic/Decision Modeling: *How are decisions made?*
    - Structured English
    - Decision Tables
    - Decision Trees
- Key Output: Systems Proposal (Summarized findings from Phase 1 and 2, includes Cost-Benefit Analysis, provides specific recommendations for the new system)
- Who's Involved: Analyst

SDLC Phase 4: Blueprinting the Solution - The Logical Design

- Main Goal: Use the requirements from Phase 3 to design the *logical* structure of the new system
- Key Design Activities
  - Input Design: Designing procedures, forms, screens for accurate and efficient data entry
  - Interface Design: Defining *how* the user interacts with the system (menu, GUI, navigation). Focus on usability, accessibility (audible, legible, safe), aesthetics. **User involvement** is crucial here.
  - Database Design: Designing the logical structure of the database to store data effectively and intuitively
  - Output Design: Designing reports, screen displays, etc. to deliver the needed information effectively
- Who's Involved: Analyst (leading design), often working closely with Users (especially for UI/Output)

SDLC Phases 5 and 6: Construction and Quality Checks

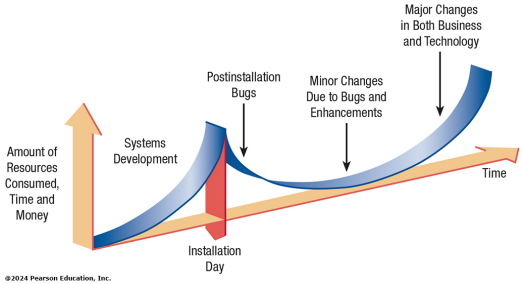
- **Phase 5:** Developing and Documenting Software
  - Analyst works with coders/developers
  - Activities
    - Develop/Code the actual software components
    - Create **Documentation** (User Manuals, Online Help, FAQs, Technical Docs) - *Should reflect user needs identified earlier!*
  - Quality: Code walkthroughs/reviews
- **Phase 6:** Testing and Maintaining the System
  - Goal: Find errors **BEFORE** the system goes live (much cheaper!)
  - Activities
    - Conduct various tests (unit, integration, system)
    - Use test data, then actual (anonymized) data
    - Follow pre-defined **Test Plans**
    - Begin **System Maintenance** activities and documentation updates
  - Who's Involved: Analysts, Coders/Developers, Testers, Users (for User Acceptance Testing - UAT)

SDLC Phase 7: Go Live and Look Back!

- Implementation Activities
  - User Training: Teaching users how to operate the new system (Analyst oversees)
  - System Conversion: Planning and executing the switch from the old system to the new one (e.g., parallel run, direct cutover, phased)
  - Data Conversion: Migrating data from old formats/systems
  - Installation: Setting up hardware, software
  - Go Live: The new system is officially launched!
- Evaluation
  - Occurs **throughout** the SDLC, not just a final step
  - Continues **after** implementation
  - Key Question: Is the system meeting objectives? Are users using it **effectively**?
- Reality Check: SDLC is often **Cyclical**. Discoveries might force revisiting earlier phases

After Launch: The Ongoing Cost and Effort of Maintenance

- The Reality: Maintenance consumes a **significant** portion of IT time and budget (Estimates range widely, but often $> 50\%$!)
- Why Maintain Systems?
  - Correct Errors: Fixing bugs missed during testing
  - Enhancements: Adapting the software due to:
    - New User Requests (after using the system)
    - Changes in the Business Environment
    - Changes in Technology (Hardware/Software updates)



- Implication: Eventually, the cost of maintaining an old system outweighs the cost of developing a new one

Boosting Analyst Productivity: CASE Tools

- What: **C**omputer-**A**ided **S**oftware **E**ngineering Tools
- Purpose: To improve and automate tasks performed by Systems Analysts, especially those using structured methods like SDLC
- Key Benefits
  - Increased Productivity: Automates repetitive tasks (drawing diagrams, checking consistency)
  - Improved Communication: Visual models are easier for users to understand than text. Facilitates feedback.
  - Integration: Links different phases and outputs of the SDLC together
- Core Concept: The **CASE Repository**
  - A central **encyclopedia** storing *all* project information (diagrams, data definitions, screen/report layouts, project management details, etc.)
  - Enables consistency checks and report generation
- Example: Visible Analyst (Full CASE) vs. Microsoft Visio/OmniGraffle (Primarily Diagramming Tools)

Beyond the Waterfall: The Agile Approach

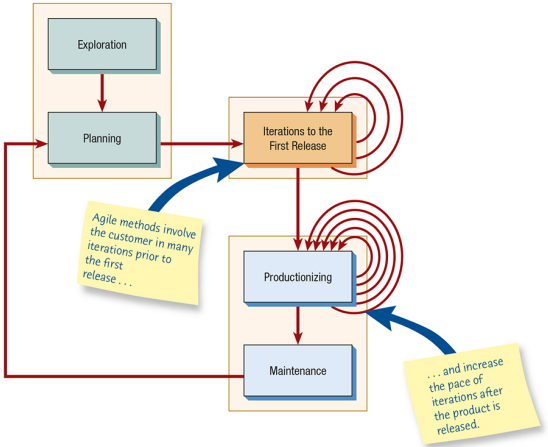
- What: A software development methodology based on:
  - Values: (Communication, Simplicity, Feedback, Courage) - *Good advice for ANY project!*
  - Principles
  - Core Practices
- Underlying Idea: An outgrowth of Object-Oriented Approaches
- Alternative/Supplement to SDLC: Used when flexibility is key, or traditional methods haven't fit
- PMI Terminology: An "Adaptive" Lifecycle (vs. SDLC's "Predictive") [1]
- Key Characteristics: Highly **Interactive** (constant communication) and **Incremental** (building in small pieces)

Agile in Practice: Flexibility and Teamwork

- Dynamic Resource Balancing: Agile methods often adjust **Time**, **Cost**, **Quality**, and **Scope** to meet goals
- Core Practices
  - Short Release Cycles
  - Sustainable Pace (e.g., 40-hour work week)
  - Onsite Customer (Direct, continuous user involvement)
  - Pair Programming
- Popular Agile Framework: Scrum
  - Named after a rugby formation (emphasizes teamwork)
  - Sprints: Short, fixed-duration work cycles (typically 2-4 weeks)
  - Goal per Sprint: Deliver a **potentially releasable** increment of the product
  - Team Empowerment: Teams often choose *how* to accomplish the work for a sprint

The Agile Journey: 5 Key Stages

- Overall Process: Characterized by frequent **iterations** and **feedback loops**
- Interesting Loops!
  - Iterations Loops and Maintenance to Planning Loops $\rightarrow$ Adaptive, incremental nature
  - Productionizing $\rightarrow$ Increased pace of iteration after the initial release



Getting Started with Agile: Exploration and Planning

- **Stage 1:** Exploration (Duration: Weeks to Months)
  - Goal: Understand the landscape; Confirm Agile is suitable
  - Activities: Assemble team and assess skills, Investigate potential technologies, Practice estimating task effort, **Customers** practice **writing** User Stories (informal feature descriptions)
  - Mindset: Be Playful, Curious!
- **Stage 2:** Planning (Duration: Typically Days!)
  - Goal: Agree on initial *scope* for the first major release and *target date* (e.g., 2-6 months out)
  - Focus: Tackle the **smallest** set of the **most** valuable features first
  - Uses “Planning Game” Metaphor (from Extreme Programming [2])
    - Goal: Maximize delivered Business Value
    - Strategy: Limit risk (simple design, early feedback, adapt quickly)
    - Pieces: User Story cards (features, notes, tracking)
    - Players: Development Team + Business Customer (sets priorities!)

The Cycle: Iterate, Produce, Maintain

- **Stage 3:** Iterations to First Releases (Cycles: ~3 weeks each)
  - Activities: Build selected features, Run customer tests *frequently*, Get feedback and adapt, Sketch out/refine system architecture incrementally
  - Important: **Celebrate** successful iterations (motivates!)
- **Stage 4:** Productionizing (Cycles: Faster, e.g., ~1 week)
  - Activities: **Release** the product! Implement faster feedback cycles (daily meeting?), Continue adding features based on feedback
  - Important: **Celebrate** the release (Development should be fun!)
- **Stage 5:** Maintenance
  - Activities: Keep the released system running smoothly, Continue adding new features (possibly riskier ones now), Adapt to changing needs, Rotate team members as needed
  - Mindset: Shifts to more **Conservative** (“Keeper of the flame”) while still evolving

Thinking in Objects: Object-Oriented Analysis and Design

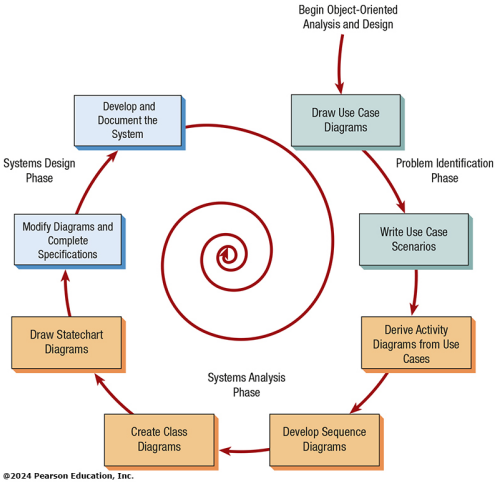
- What: An approach focused on **Objects** (representing real things/events like Customers, Orders, Products) grouped into **Classes** (defining shared attributes/behaviors)
  - Attributes: Characteristics
  - Methods: Things they do
- Contrast: Differs from traditional *procedural* programming (which focused on functions/procedures)
- Goal: Facilitate development and maintenance of systems needing **rapid change** and continuous adaptation, especially complex ones
- Key Benefit: Promotes **reuse** of components and improves system **maintainability**
- Standard Tool: Uses **Unified Modeling Language (UML)** for modeling O-O systems (e.g., Use Case Models)

O-O: Similar Phases, Different Rhythm

- Similarities to SDLC
  - Follows similar high-level phases (Problem Identification, Analysis, Design)
  - Uses rigorous, detailed modeling (UML)
- Pace: Because of the detailed modeling, the pace is often more deliberate than Agile (similar to SDLC in rigor)
- Key Difference: Iterative Nature within Phases
  - Often uses a **Spiral Model** approach:
    - Analyze $\rightarrow$ Design $\rightarrow$ Implement a *small part* of the system (e.g., a key feature)
    - Repeat (spiral outwards) for the next part
  - **Reworking** diagrams and components based on learning is **expected** and **normal**

The O-O Workflow with UML

- Understand user interactions
- Model the dynamic behavior
- Define the static structure
- Handle objects with complex lifecycle
- Refine and create detailed specifications
- Develop the system



O-O Steps 1 and 2: Understanding Interactions

- **Step 1:** Define Use Case Model (Problem ID/Analysis)
  - Identify **Actors** (Users or other systems interacting with our system)
  - Identify Major Events/**Use Cases** (What actors accomplish, e..g, “Place Order,” “Register User”)
  - Draw **Use Case Diagrams**: Visual map of actors and their use cases
  - Write **Use Case Scenarios**: Textual step-by-step description of a typical interaction
- **Step 2:** Draw Initial UML Diagrams (Analysis)
  - Draw **Activity Diagrams**: Show workflow/steps within a single use case
  - Draw **Sequence Diagrams**: Show how different objects interact over time to fulfill a use case
- Iterative Nature: Creating Activity/Sequence diagrams often reveals need to refine/clarify Use Cases

O-O Steps 3 and 4: Classes and States

- **Step 3:** Develop Class Diagrams (Analysis)
  - Identify potential **Classes** (Tip: Look for important *nouns* in Use Cases and requirements
  - Define **Attributes** (data held by objects of the class) and **Methods** (actions objects can perform)
  - Show **Relationships** between classes (e.g., A Customer *has* Orders)
  - *This defines the static structure (blueprint) of the system*
- **Step 4:** Draw Statechart Diagrams (Analysis)
  - Model objects with complex lifecycles or **states**
  - Show possible **states** an object can be in (e.g., Order: Pending, Paid, Shipped)
  - Show **transitions** between states and the events triggering them
  - Helps refine understanding of object behavior and Class diagrams
- Iterative nature: Discoveries here can lead to refinement of other diagrams

O-O Steps 5 and 6: Refining Design and Building

- **Step 5:** Modify Diagrams and Complete Specifications (Design)
  - Refine UML diagrams (Class, Sequence, etc.) based on specific design decisions (technology choices, patterns, optimizations)
  - Write detailed **Class Specifications**: Precise descriptions of attributes, methods
  - Write detailed **Method Specifications**: Define input/output, internal processing logic for each method
- **Step 6:** Develop and Document the System (Development)
  - Translate the detailed models and specifications into working code
  - Documentation is CRITICAL: UML diagrams + Specifications are vital guides for the development team
  - *Good models and docs lead to faster development and more robust system*

Common Ground: More Similar Than Different?

- Shared Foundations (ALL Approaches Require)
  - Understanding the Organization: Business context, goals, problems → Chapter 2
  - Project Planning: Budgeting time and resources, Project Proposal → Chapter 3
  - Detailed Data Gathering: Interviews, Questionnaires, Observation, Sampling → Chapter 4 and 5
- Overlapping Characteristics
  - SDLC and O-O: Emphasis on detailed planning and diagramming
  - Agile and O-O: Facilitate building systems incrementally or subsystem-by-subsystem
  - Agile and SDLC: Consider the logical flow of data
- Key Takeaway: Strong foundational analysis skills (understanding needs, gathering data, planning) are **essential** regardless of the methodology used!

Making the Choice (1/3): When to Use SDLC?

- Consider the SDLC (Waterfall/Predictive) when
  - The organization has a history of using SDLC; existing systems used it (consistency)
  - Rigorous, step-by-step **documentation** is a high priority or requirement (e.g., compliance, regulation)
  - Upper management strongly **prefers** or feels more comfortable with a detailed, upfront **plan** and predictable phases
  - Sufficient **time** and **resources** are confidently available to complete the full cycle thoroughly
  - Formal **documentation** is the primary means required for communicating how the new system operates to stakeholders

Making the Choice (2/3): When to Use Agile?

- Consider Agile Methodologies (Adaptive/Iterative) when
  - An influential **project champion** who understands and advocates for Agile exists within the organization
  - The business environment is **dynamic** and requirements are likely to change or evolve rapidly. Need for **speed**
  - It's a **project rescue** situation – need to deliver value quickly, less focus on analyzing past failures in detail
  - The customer/users understand and value receiving working software in **small** and **incremental** improvements
  - Executives, analysts, and the development team are aligned with and support **Agile principles** (collaboration, adaptation, etc.)

Making the Choice (3/3): When to Use O-O?

- Consider Object-Oriented Analysis and Design when
  - The problem domain naturally lends itself to modeling with **Classes** and **Objects** (e.g., complex entities, simulations)
  - The organization supports the team in learning and effectively using **UML** modeling tools and techniques
  - The system can be realistically developed **incrementally**, perhaps one subsystem or major feature set at a time
  - There is a strong possibility or goal of achieving significant **code**/**component** reuse
  - It's acceptable (or desirable, e.g., for risk mitigation) to tackle the **most difficult** or **complex** parts first (aligns with spiral thinking)

Beyond Proprietary: Open Source Software (OSS)

- What: Software where the source code is publicly available for anyone to **study**, **share**, and **modify**
- Contrast: Opposite to **proprietary** software (where source code is hidden/secret)
- Core Principles: Collaboration, Shared contribution and benefits, Modifications typically shared back, Adherence to specific **open source licenses**
- Philosophy: Often viewed as a **communal** process and product, sometimes aimed at broader societal benefit
- Examples: Linux, Android, Apache Web Server, Mozilla Firefox Browser
- Growing Importance In: Cloud Computing, Big Data Analytics, AI/Machine Learning, Internet of Things (IoT), Cybersecurity, Blockchain

The OSS Ecosystem: Communities and Platforms

- Diverse Communities: OSS isn't one entity; communities vary (e.g., based on goals, structure: ad hoc, standardized, organized, commercial)
- Supporting Foundations: Provide crucial infrastructure, governance, legal support, event organization
  - Example: The Apache Software Foundation, The Linux Foundation (hosts 1000s of projects)
- Key Development Platform: GitHub (Owned by Microsoft)
  - Provides: Code hosting (using **Git**), Collaboration tools, Issue tracking, Developer profiles and networking
- Underlying Technology: Git
  - The most widely used open source **version control system**. Essential for tracking changes to code files over time, especially in collaborative projects

Bridging Worlds: Corporations and OSS

- Historical Divide
  - Corporations → **Proprietary** code (Guarded for competitive advantage)
  - OSS Communities → **Shared** code and community values
- The Modern Reality: Collaboration
  - Companies increasingly participate in and contribute to OSS
- "The Third Design Space" [3]
  - A **metaphorical space** where corporate developers and community developers collaborate
  - Creates: New shared design environments, resources, associations
  - Results In: Innovative shared software, new development processes (blending corporate needs and community practices), developers skilled in both worlds
  - Enables: Innovations potentially not achievable in purely commercial or purely community settings alone

Corporate Motivations: Why Participate in OSS?

- Research identified multiple drivers [4]

- Rational Reasons (Business Logic)
  - Save Money/Reduce Development Cost (Leverage existing code)
  - Less Maintenance Burden (Shared effort)
  - Contribute Within Limits (Influence project direction strategically)
  - Reduce Long-Term Costs
  - Marketing Benefits (Enhanced reputation, attract talent)
  - make the First Move (Gain strategic advantage)

- Emotional Reasons (Cultural/Intrinsic)
  - Accept Responsibility/Give Back to community
  - Improve Shared Software (Make tools they rely on better)
  - Gain Community Influence/Respect
  - Relinquish Traditional Gatekeeper Role (Embrace openness)
  - Improve Developer's Skills and Morale (Exposure, learning)
  - Extend Life/Relevance of Internal Projects

The Rules of the Road: OSS Licensing and Compliance

- Licenses are CRITICAL: They define permissions, obligations, and restrictions for using, modifying, and distributing OSS code
- Community Consensus: Licenses arise from and are chosen by specific OSS communities
- Popular Examples: Apache Licence 2.0, GNU General Public License (GPL - v2, v3, LGPL), MIT License, BSD Licenses, Mozilla Public License 2.0
- Your Responsibility: When *using* OSS components, you **must** identify their licenses and **ensure compliance**. Failure can have legal consequences!
- Compliance Tools and Standards
  - Software Package Data Exchange (SPDX): A standard format for communicating license information clearly (Linux Foundation WG)
  - FOSSology: An open-source tool/toolkit (Linux Foundation Project) to scan codebases, identify licenses and copyrights, and help manage compliance workflows

OSS on Your Resume: Skills and Opportunities

- Highly Valued: Experience contributing to or effectively using OSS is a **marketable** skill
- Talent Shortage: Over 90% of hiring managers report difficulty finding sufficient open-source talent [5]
- Employer Interest
  - Many actively seek *certified* OSS professionals
  - Many are willing to *pay for employees* to get relevant OSS certifications
- How to Get Involved
  - Create a **GitHub** profile; contribute (even documentation!) to projects you use
  - Explore projects hosted by **The Linux Foundation** or others
  - Inquire about **employer's** open source programs or contribution policies
- Benefits: Demonstrates technical ability, collaboration skills, continuous learning, and engagement with modern development

The Analyst and Open Source

- Why Might You Be Involved?
  - Your employer may **request participation** in relevant OSS communities ($>$ 90% org reliance on OSS creates need for awareness/engagement)
  - Curiosity/"Bandwagon Effect": To understand what competitors are doing or explore potential OSS benefits
- Strategic Involvement: "Responsive Design"
  - Analyst acts as a bridge between OSS community and employer
  - Activities
    - Participate in relevant OSS projects
    - Understand community designs, practices, directions
    - Identify opportunities to **incorporate** or **adapt** valuable OSS ideas, components, or practices into the company's *proprietary* systems or products
  - Goal: Blend external innovation with internal strategic objectives
- Example: NASA hosts open source projects, demonstrating OSS use even in highly specialized domains [6]

References I

[1] Project Management Institute, *A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Seventh Edition and The Standard for Project Management*, 7th. Newtown Square, PA, USA: Project Management Institute, 2021 (cit. on pp. 11, 20).

[2] K. Beck and C. Andres, *Extreme Programming Explained: Embrace Change*, 2nd. Boston, MA: Addison-Wesley Professional, 2004 (cit. on p. 23).

[3] K. E. Kendall, J. E. Kendall, M. Germonprez, and L. Mathiassen, "The Third Design Space: A postcolonial perspective on corporate engagement with open source software communities," *Information Systems Journal*, vol. 30, no. 2, pp. 369–402, 2020. DOI: 10.1111/isj.12270. [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1111/isj.12270 (cit. on p. 37).

[4] J. E. Kendall, K. E. Kendall, and M. Germonprez, "Game theory and open source contribution: Rationale behind corporate participation in open source software development," *Journal of Organizational Computing and Electronic Commerce*, vol. 26, no. 4, pp. 323–343, 2016. DOI: 10.1080/10919392.2016.1228360. [Online]. Available: https://www.tandfonline.com/doi/full/10.1080/10919392.2016.1228360 (cit. on p. 38).

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[5] The Linux Foundation Research Team, "The 10th Annual Open Source Jobs Report," The Linux Foundation Research Team, Tech. Rep. 10, 2022. DOI: 10.70828/RZRE1873. [Online]. Available: https://www.linuxfoundation.org/research/the-10th-annual-open-source-jobs-report (cit. on p. 40).

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