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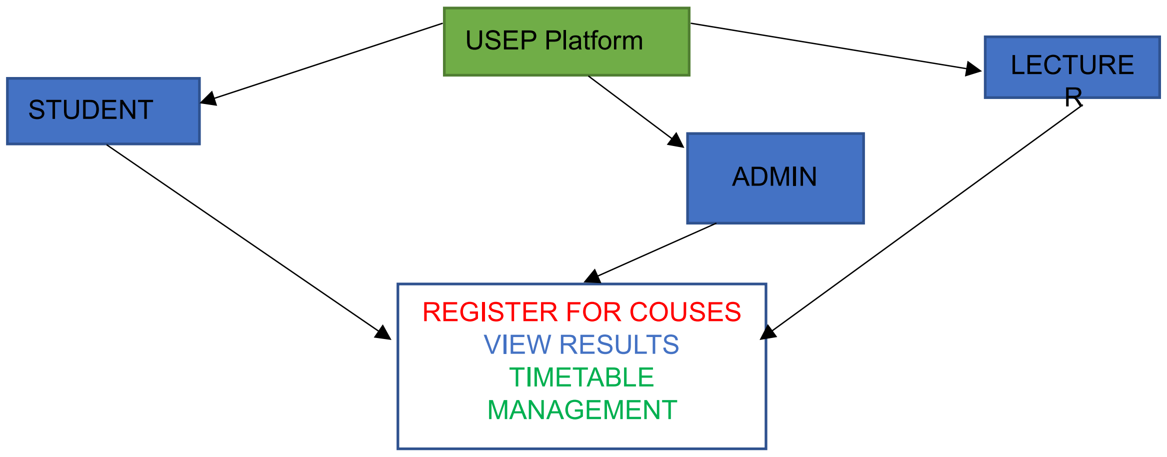
Design process and artifact

Software design as a process refers to the structured activities involved in transforming requirements into a workable solution. It includes requirement analysis, modelling, architectural decisions, prototyping, and validation. As an artifact, software design represents the tangible outputs of this process, such as diagrams, architecture documentation, and design records.
For USEP, two relevant artifacts include:

- UML Use Case Diagram — showing main actors (students, lecturers, admin) and their interactions with USEP.
- System Overview Diagram — high-level modules such as Academic Services, Support Services, and Community Services.



<u>**Trends**</u>
Modern design trends relevant to USEP include:

- Microservices — USEP can be split into independent modules (e.g., Academic, Financial Aid, Community), improving scalability and maintainability.
- AI Integration — AI-powered academic advising can provide personalized guidance and support to students.

Sustainable Architecture — designing for scalability on cloud infrastructure ensures lower energy usage and long-term sustainability. Modern Design Trends

Modern software design has evolved to meet the demands of agility, scalability, and user-centric experiences. Some of the key trends in modern software design include:

a. **Microservices Architecture:**

Instead of monolithic applications, microservices advocate for decomposing applications into small, independent services that communicate over well-defined APIs. Each service can be developed, deployed, and scaled independently, promoting flexibility and fault tolerance.

- **Benefits:** Scalability, fault isolation, flexibility, technology diversity, easier deployment.
- **Challenges:** Complexity in service communication, data consistency, managing many services, and monitoring.

b. Event-Driven Architecture:

This design approach is based on asynchronous communication via events. Systems are designed to respond to events (changes in state, messages, etc.) and can be loosely coupled, which makes them highly scalable and responsive.

- **Benefits:** Improved scalability, decoupling of components, real-time processing.
- **Challenges:** Eventual consistency, managing complex workflows.

c. Cloud-Native Design:

Cloud-native design emphasizes building software optimized for deployment in cloud environments. This involves using technologies such as containers (e.g., Docker), orchestration tools (e.g., Kubernetes), and serverless computing.

- **Benefits:** Scalability, flexibility, cost-effectiveness, easy deployment, high availability.
- **Challenges:** Managing cloud costs, vendor lock-in, distributed tracing.

3. Principles-First vs. Application-First Perspectives

The “principles-first” and “application-first” perspectives are two broad approaches to software design. They differ in how they prioritize certain aspects of the design process.

a. Principles-First Design:

In a principles-first approach, the focus is on establishing broad design principles before delving into specific technologies, architectures, or features. It’s about creating a strong conceptual foundation based on software engineering best practices.

b. Application-First Design:

In contrast, an application-first perspective focuses on addressing the specific needs of the application itself from the outset. It prioritizes practical, immediate concerns over high-level principles. The design focuses on features and user needs, and principles evolve around the application's requirements.

1. The Business Case

The **business case** is a formal document or justification that outlines the rationale for a particular software project. It's often created to secure funding or approval from stakeholders (e.g., executives, investors, or clients) and ensure that the project aligns with the business goals, objectives, and strategic priorities. The business case focuses on demonstrating how the software project will add value to the organization or customers.

• Problem: University services are fragmented across multiple platforms, creating inefficiency and poor student experience.
• Solution: Develop USEP as a unified platform that integrates academic, support, and community services.
• Value: Improved student retention, operational efficiency, reduced administrative costs, and enhanced international student satisfaction.

Key Components of a Business Case:

1. **Problem Statement:**
   - Define the business problem or opportunity the software solution will address.
2. **Objectives and Goals:**
   - Clarify the specific objectives the software aims to achieve, often tied to business KPIs (Key Performance Indicators).
3. **Solution Overview:**
   - Provide a high-level description of the software solution.
4. **Benefits and Value Proposition:**
   - Highlight the tangible and intangible benefits, such as cost savings, efficiency improvements, revenue generation, or customer satisfaction.

The business case is often used by decision-makers to evaluate the feasibility of the project and decide whether it’s worth pursuing. A strong business case is data-driven and clearly connects technical decisions with business goals.

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1. 2. Outsourcing

Outsourcing is a common strategy where businesses delegate certain tasks or the entire software development process to external vendors, often in different geographic locations. Outsourcing decisions require thorough analysis to ensure that the benefits outweigh the potential risks.

Outsourcing options include:

- Onshore — within Zambia, higher cost but easier communication.
- Nearshore — nearby countries (e.g., South Africa), lower cost than onshore with fewer cultural differences.
- Offshore — distant regions (e.g., India), cheapest option but greater time-zone and cultural barriers.

Recommendation: Nearshore outsourcing (South Africa) balances cost with cultural and time-zone compatibility, making it ideal under budget constraints.

Key Aspects of Outsourcing Analysis:

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1. **Cost Considerations:**
    - Outsourcing is often motivated by cost savings. A comparison of in-house versus outsourced development costs should consider:
        - Development team salaries
        - Infrastructure costs
        - Licensing or software subscription costs
        - Overhead costs (management, communication, etc.)
2. **Quality Assurance:**
    - Outsourcing can sometimes lead to lower quality if the external vendor doesn't meet the required standards. This analysis should evaluate:
        - The vendor's track record and reputation
        - The quality of previous projects delivered
        - The vendor's adherence to industry standards and best practices (e.g., ISO certifications)
        - Quality control mechanisms (e.g., code reviews, unit testing)
3. **Time Zone and Communication:**
    - Consider the impact of different time zones on project management and communication. Outsourcing can create challenges in coordination, real-time communication, and project tracking.
    - Evaluate whether the vendor has a dedicated project manager or communication protocols in place to mitigate delays or misunderstandings.

Outsourcing Decision:

Based on the analysis of these factors, the decision-maker would decide whether outsourcing is a viable option, which vendor to choose, and what kind of contractual arrangements should be made to ensure the project's success.

4. **Defending the Value Proposition**

Once the software project is proposed, especially if it's a complex or large initiative, it's critical to defend the value proposition effectively.

Key Elements of Defending the Value Proposition:

1. **Clarify the Business Impact:**
    - Ensure stakeholders understand the business outcomes the software will drive. This can include operational efficiencies, market differentiation, or revenue generation.
2. **Quantitative Evidence:**
    - Use data and metrics to demonstrate the expected financial benefits and ROI. This could include savings in operational costs, increased productivity, or new revenue streams.
3. **Address Risks and Mitigation:**
    - Acknowledge potential risks and present clear strategies for mitigating them. This shows that the project team has thoroughly thought through the risks and is prepared to handle challenges.

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Defending the Value Proposition with Stakeholders:

When defending the value proposition, use storytelling, data visualization (e.g., graphs, ROI calculations), and strong, evidence-based arguments. It's important to speak in terms that stakeholders can relate to, typically focusing on business outcomes rather than just technical details.

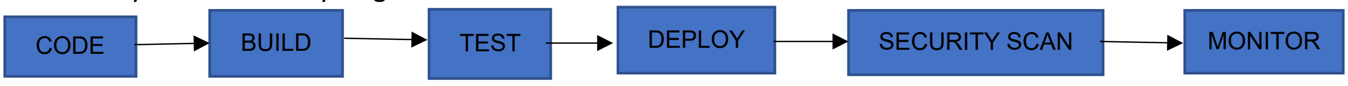
2. Cultural Intelligence

Design inclusivity is vital for international and diverse student populations. Key requirements include:

- Multilingual user interface — support for English, French, Swahili, and Chinese.
- Accessibility features — compatibility with screen readers, high-contrast design, and subtitles for multimedia.

3. DevOps & Dev SecOps

A CI/CD pipeline helps automate delivery and ensures sustainability. Dev SecOps integrates security checks at every stage.



2.1 Cultural Intelligence Examples

Cultural Intelligence (CQ) refers to the ability to understand, respect, and adapt to cultural differences in a professional or social environment. In software design and development, CQ is especially important in global teams, outsourcing, or user base diversity.

Examples of Cultural Intelligence in Software Development:

- **Global Team Collaboration:**
  - A project manager leading a distributed team across the U.S., India, and Germany adjusts meeting times to accommodate different time zones and work habits.
  - The team recognizes that direct communication is preferred in Germany but that Indian colleagues may use more indirect or polite language. So, feedback is phrased respectfully to ensure clarity without offending.
- **Localization of Software:**
  - When designing a user interface for a multilingual app, the team adapts date formats, currency, and reading direction (e.g., right-to-left for Arabic).
  - The team also avoids idioms or culture-specific humor that might confuse users from other countries.
- **Conflict Resolution:**

- A Scrum master notices a misunderstanding during sprint planning due to cultural differences in expressing disagreement. Instead of confrontation, they facilitate anonymous feedback tools and encourage open, inclusive dialogue.

2. DevOps / DevSecOps Pipeline Design

DevOps is a set of practices that combines software development (Dev) and IT operations (Ops) to shorten the development lifecycle and deliver high-quality software continuously. **DevSecOps** integrates security (Sec) into this process, embedding security practices throughout the pipeline.

Typical DevOps Pipeline Stages:

1. **Source Code Management (SCM):**
   - Code is stored in repositories like Git (GitHub, GitLab, Bitbucket).
   - Branching strategies (e.g., GitFlow) ensure organized development.
2. **Continuous Integration (CI):**
   - Code changes trigger automated builds and unit tests.
   - Tools: Jenkins, GitLab CI, CircleCI.
   - Ensures new code integrates smoothly without breaking the build.
3. **Automated Testing:**
   - Includes unit tests, integration tests, UI tests.
   - In DevSecOps, security testing (static code analysis, vulnerability scanning) is added here.
   - Tools: SonarQube, OWASP Dependency-Check.
4. **Continuous Delivery/Deployment (CD):**
   - Automated deployment of builds to staging or production environments.
   - Canary releases or blue-green deployments reduce risk.
   - Tools: Kubernetes, Helm, Spinnaker.
5. **Monitoring and Logging:**
   - Real-time monitoring of application health and performance.
   - Security monitoring for suspicious activities.
   - Tools: Prometheus, Grafana, ELK stack (Elasticsearch, Logstash, Kibana), Splunk.

3. AI Ethics Discussion

As AI systems become more pervasive, ethical considerations become critical. AI ethics deals with the responsible development, deployment, and use of AI technologies to avoid harm and ensure fairness, transparency, and accountability.

Key AI Ethics Topics:

- **Bias and Fairness:**
  - AI systems trained on biased data can perpetuate or amplify societal inequalities.
  - Example: Facial recognition systems with lower accuracy for certain ethnic groups.

    - Mitigation: Use diverse training data, fairness-aware algorithms, and regular audits.
- **Transparency and Explainability:**
    - Many AI models, especially deep learning, are “black boxes” — it’s hard to understand how they make decisions.
    - Ethical AI requires explainability so users and regulators can trust AI decisions.
    - Techniques: Explainable AI (XAI), model interpretability tools.
- **Privacy:**
    - AI often relies on large datasets, raising concerns about personal data usage and consent.
    - Regulations like GDPR enforce data protection.
    - Approaches: Data anonymization, federated learning (data stays local).
- **Accountability:**
    - Who is responsible if an AI system causes harm (e.g., autonomous vehicle accident)?
    - Clear roles and legal frameworks are necessary.
    - Documentation and audit trails in AI development processes.

4. AI Awareness

- Opportunity: An AI chatbot for academic advising can help answer FAQs and guide students through course selections.
- Ethical Concern: AI career recommendations may inherit bias from training data, risking unfair guidance for certain groups.