Engineering Large Software Systems Notes

Created: 2024-09-04
Updated: 2024-09-14

References

- Engineering Large Software Systems course at the University of Toronto

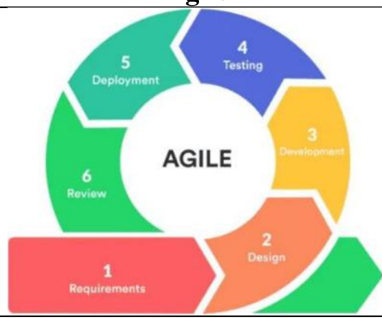
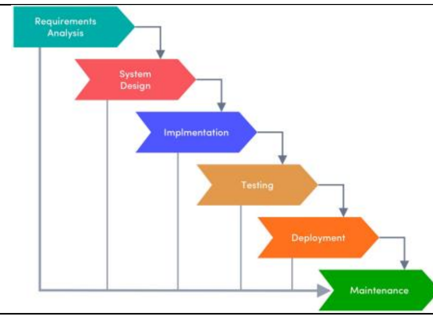
Prerequisites

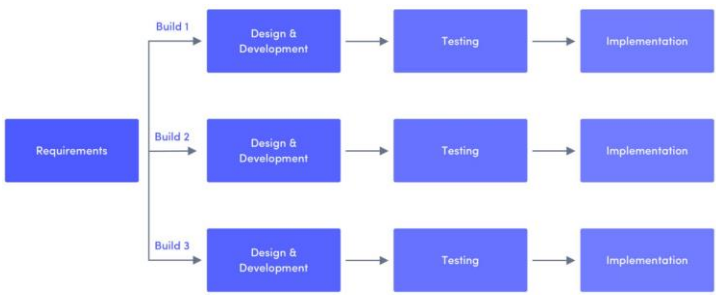
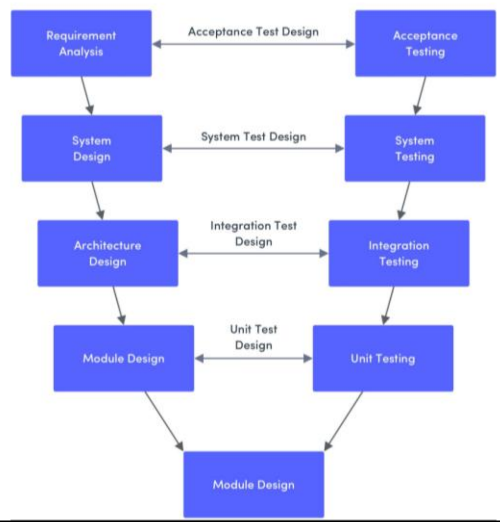
1. Design pattern theory (eg. factory, builder, observer, strategy, etc.)
   - Observer: whenever action occurs, observers will be notified, aka. listeners.
   - Factory: a class that can generate more classes.
   - Strategy: similar to factory but dealing with functions.
2. Testing code
   - Unit testing
   - Integration testing
3. Code smells
   - Anti patterns when writing code
4. Code design principles (eg. SOLID)
   - S: single responsibility principle, every module should focus on one task.
   - O: open-close principle, open for extension closed for modification.
5. Git usage
   - Git merge vs rebase

1. Large Software Systems

Large: Numerous contributors, impacts many stakeholders.
Software Engineering: six step process of creating software through SDLC, e.g., agile, waterfall. 1. requirements engineering. 2. system design. 3. implementation. 4. testing. 5. deployment. 6. maintenance.

1.0. SDLC Models

Agile	Waterfall
	
Iterative development process.	Defined requirements at the beginning.
Client can change requirements.	Scope does not change.

Iterative & Incremental Model	V Model
	

1.1. Requirements Engineering

Requirements Engineering: Discovering and documenting requirements necessary for project success through talking with client, interviews, surveys.
Known Requirements: What users told us.
Overlooked Requirements: What users didn't tell us yet.
Emergent Requirements: What will surface while building product.
Functional Requirements: What a system should do; system features.
Non-Functional Requirements: Requirements that enable a system to operate, maintain, and extend in quality.

- ***Operational NFRs***: performance of a system.
- ***Structural NFRs***: code quality of the system.

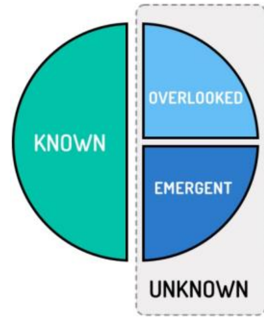


Figure: Relationship between types of system requirements.

TODO: chaos report 1995 standish group
https://www.csus.edu/indiv/r/rengstorffj/obe152-spring02/articles/standishchaos.pdf

1.2. System Design

System Design: Defining software architecture of a system; solving structural and not code problems.

- Creating software architecture documents
- Architecture risks
- How to calculate cost for infrastructure
- Increase in **NFRs** aims to increase quality and performance of system at cost of capital and time.
- ***Vertical Scaling***: improving existing infrastructure by switching to better hardware.
- ***Horizontal Scaling***: adding/expanding more infrastructure e.g., more servers. Requires additional component to manage/integrate new additions e.g., load balancer server, Kubernetes.
- ***Scalability***: ability for application to respond well to heavy load.
- ***Elasticity***: ability for application to scale up with sudden demand.

Deciding on Tradeoffs

- ***Consistency***: every read returns most recent write or error.
- ***Availability***: every request to non-failing node must result in response even in server failure and update/maintenance (security updates, infrastructure version updates).
  - Metric: time-based availability. **Availability = uptime / (uptime + downtime)**.
    - Periodic request to **health check endpoint** to confirm server responsive to requests, API and DB connections/latency, cache warmed.
    - **Service-Level Agreement** (SLA), e.g., 99.9% availability allows only 43 min downtime/month. Reducing downtime involves automated recovery and alerting.
  - Metric: aggregated availability. **Availability = successful requests / total requests**.
- ***Partition tolerance***: system continues to operate even if some nodes fail. E.g., a system depending on a single database is not partition tolerant.

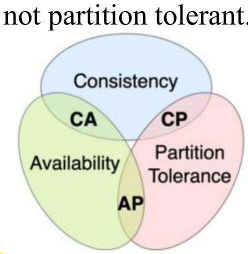


Figure: ***CAP Theorem***: can only satisfy 2/3 of these characteristics.

- Low ***latency***: response time to request.
- High **performance**: improve performance by improving data retrieval (e.g., caching) and compute time.
    - ***Caching***: method to increase data retrieval performance. Retrieve from RAM instead of disk. Perform computation in advance instead of on request. E.g., memcached, redis.
    - ***Read-through caching***: data loaded into cache on demand.
    - ***Write-through caching***: write operation writes to DB and cache.

Cache	Pro	Con
Read-through	Fast for frequently accessed data and reduces load on DB.	Slow initial read if not cached.
Write-through	Fast for accessing recently written data.	Slower write performance.
Read-through and write-through	Fast access for most recent data.	Performance overhead. Complexity in implementation and maintenance.

    - Increase in performance with caching leads to a:
        - decrease in maintainability, code readability, freshness of data.
        - increase in memory usage, costs, operations overhead.
- Size of input / output.
    - Decreasing size of output:
        - Reduces transport time.
        - Increases time to compress and decompress.
- Maintainability
- Cost

TODO:
[CRITICAL] https://sre.google/sre-book/handling-overload/
[CRITICAL] https://sre.google/sre-book/addressing-cascading-failures/
https://sre.google/sre-book/table-of-contents/
o'reilly site reliability engineering

1.3. Implementation

Implementation: Writing the code based on identified requirements and adherence to system design.

Costs of Implementing Software

1. Labor: developers, architects, management
2. Infrastructure: production and test environments
3. Maintenance: documentation, change management, tech debt

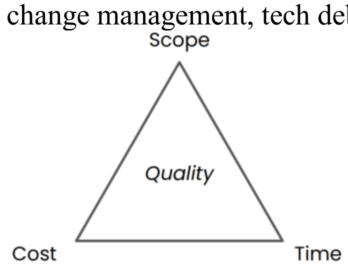


Figure: interdependence of scope, cost, and time on software quality.

Evaluating the Success of a Project

1. delivering on time
2. on scope
3. at cost.

1.4. Testing

1.5. Deployment

Deployment: Making software available to users.

1.6. Maintenance

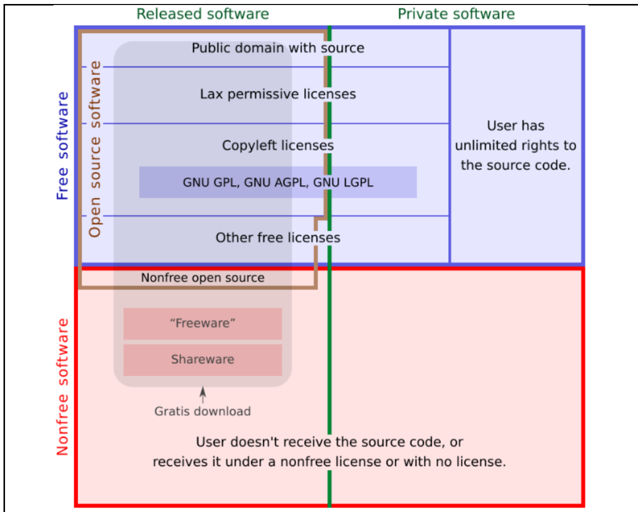
Maintenance: Ensuring software continuously satisfy users.

1.7. Contributing to Open Source

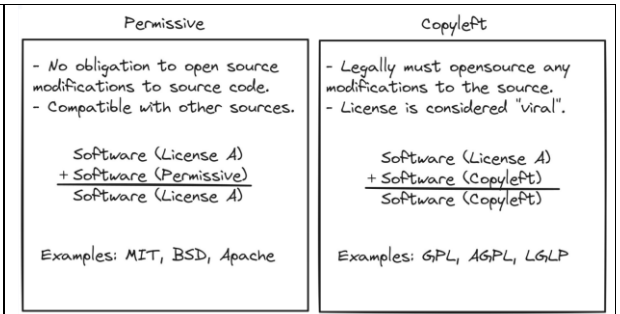
Open/Closed source software: whether source code of a software program is public.

- Advantage of closed source: security by obscurity.
- Open source doesn't mean free. Depends on licence.
- Free and open source software (FOSS) is both free and open source.
- Value of open source software: makes a developer's life easier, e.g., git, TensorFlow, React.
- Why contribute? Get hired faster, access to industry talent, work on your craft.

Software Licences



https://www.gnu.org/philosophy/categories.en.html



Contribute to Which Project?

- GitHub stars,
- "used by" count
- Low barrier to contribute
  - Large number of contributors
  - Large rate of contributions over time (commits over time)
  - Good documentation (e.g., readme)
  - Simple development setup (Time to hello world)
  - Streamlined (easy to understand) design
  - Healthy project

How to Contribute?

- Look for contributor documentation
- Fork repo. Why fork? So your changes can't affect changes in parent repository. Then PR.

Issue Hunting

- Discover gaps in project by being a user

- GitHub issues: filter by tags such as “help wanted”, “good first issue”.
- Messaging forums: discord, reddit, GitHub discussions