COMP2511

Tutorial 9

Notices

- Assignment-ii (both parts) is due **next Wednesday 3pm**.
  - Remember that Part 2 is to be submitted on **Moodle**!
- A sample exam environment will be running on the lab computers next week.
  - The aim is to get you comfortable with the **structure** and **layout** of the exam.
  - The difficulty of the sample exam is not indicative of the actual exam.

Software Architecture

- Suppose you’ve built an online banking app that looks great and has a bunch of features that all work correctly. However, it crashes if more than 100 users log on at the same time. Is this a successful system?
    - Not necessarily; the system is missing **scalability**, the ability to handle growth in workload or user traffic without compromising performance.
    - Even if all the features work perfectly, the application isn’t going to be very useful if we can’t serve many users concurrently.
    - For software to be considered ‘good’, it has to satisfy both functional *and* non-functional requirements.

Architectural Characteristics

- **Architectural characteristics** (*non-functional requirements*) define fundamental qualities that software architecture must support.
  - For example, we may consider the **maintainability** of a system: how easy is it to fix, update or extend the system?
- Unlike functional requirements, they are often not explicitly defined.
  - This adds another layer of complexity to designing software; these are considerations that we have to be aware of and account for accordingly, and are typically ‘implicitly there’.

Architectural Characteristics

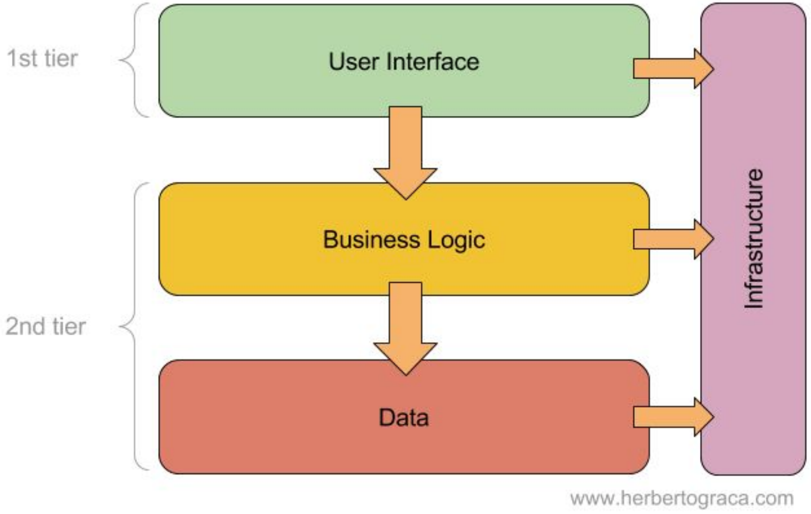
- More examples of some architectural characteristics, **not** exhaustive:
  - **Performance**: How fast does the system run?
  - **Availability**: How often is the system operational?
  - **Fault Tolerance**: How robust is the system against particular things not working?
  - **Reliability**: How error-prone is the system?
  - **Security**: How protected is the system against threats? Are there any vulnerabilities?
  - **Testability**: How easy is it to test the system?
  - **Data Consistency**: Do each of the components ‘agree’ on what data is in the system?
- Characteristics such as these influence how we decide to design software. Some characteristics will be more important than others, depending on the context and specific requirements.
  - At the end of the day, there are always **trade-offs** across characteristics. For example, more security → lower performance (more robust checking) and vice versa.

Architectural Styles

- **Architectural styles** are predefined patterns and philosophies guiding how software systems are structured.
- Common architectural styles include:
  - **Layered** architectures (usually **monolithic** - deployed as a single unit)
  - **Modular monolithic** architectures (also monolithic)
  - **Microservice** architectures (**distributed** - deployed as many smaller services that are independent and communicate with each other)
  - **Event-driven** architectures (usually also distributed)
- Each style comes with trade-offs for specific architectural characteristics. In practice, a *hybrid* of architectural styles may be used.
- The style of a system will influence how it behaves and evolves. It is **very** difficult to convert a system from one style to another!

Layered Architecture

- A layered architecture is a monolith where distinct responsibilities are separated into different technical layers, defining a clear separation of concerns.

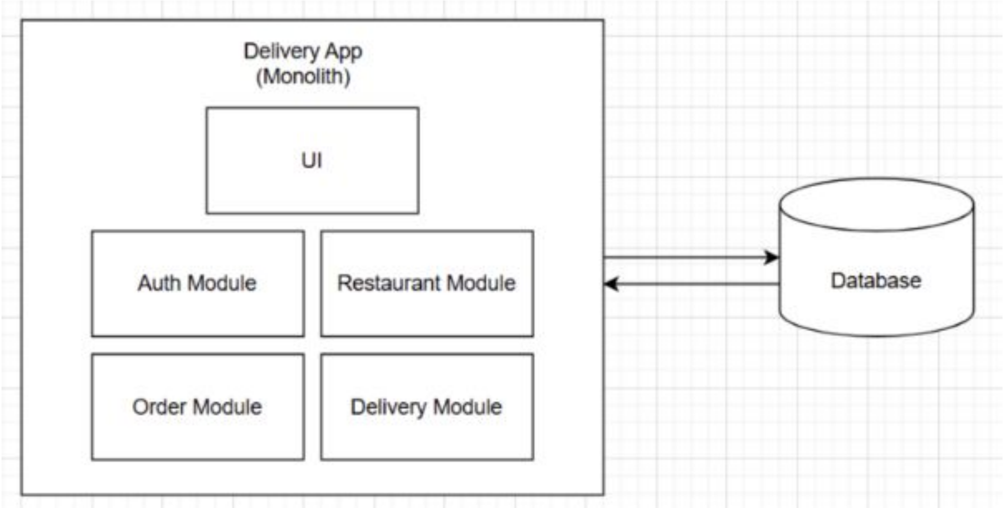


Layered Architecture

- Strengths of layered architectures:
  - **Simplicity**: in general, monoliths are typically the ‘most immediate solution’ and are the easiest to ‘get up and running’, as there is only one component to worry about
  - **Maintainability**: one technical layer can be modified without affecting other layers
  - **Data Consistency**: all layers share a single database, so data is consistent throughout
  - **Performance**: in-process calls are faster than API/network calls, (*but* may struggle with processing a large number of requests)
- Weaknesses of layered architectures:
  - **Scalability**: individual layers are hard to scale without changing other layers as well
  - **Fault Tolerance**: if one part of a monolith breaks, then the rest of the monolith is likely to also break; also another consideration for security

Modular Monolithic Architecture

- Modular monoliths are monoliths that are divided according to different business domains, rather than technical layers.
- Each module is responsible for a specific functional requirement.

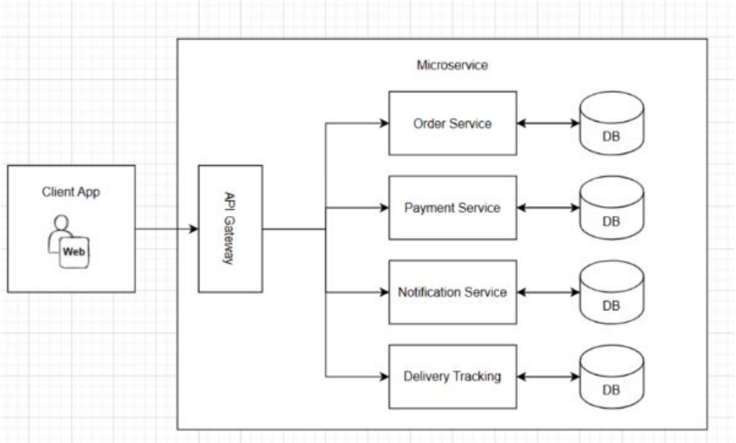


Modular Monolithic Architecture

- Strengths of modular monoliths:
    - **Maintainability**: code localised to a specific function/domain doesn't need to interact with other modules
    - **Data Consistency**: same as layered architecture (single shared database)
    - **Security**: can separate security handling into its own module, and highly sensitive operations can be isolated
- Weaknesses of modular monoliths:
    - **Scalability**: may be easier to scale than layered architectures if particular modules need to be scaled, but there may still be bottlenecks in terms of how processing power is distributed between modules
    - **Fault Tolerance**: same as layered architecture (monoliths in general)

Microservice Architecture

- Microservices are single-purpose, individually deployed units.
- Each microservice should manage its own data and perform one specific function very well.
- Microservice architectures organise systems around these microservices, which communicate with each other over a network (can be sync/async).

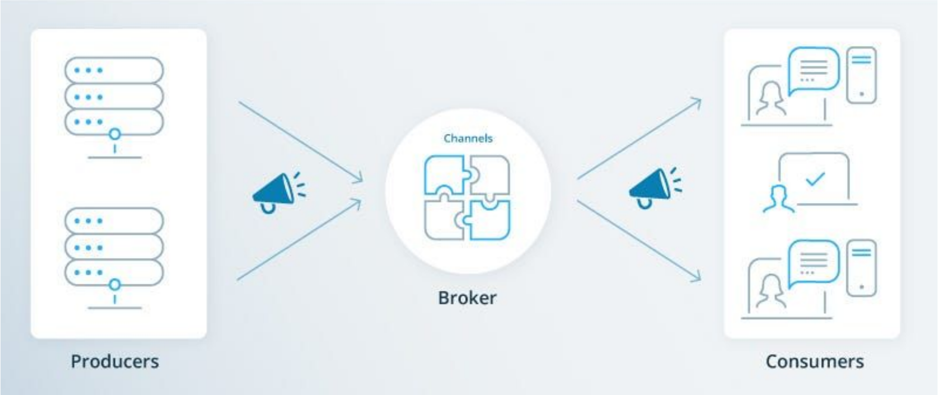


Microservice Architecture

- Strengths of microservice architectures:
  - **Scalability**: each microservice can be scaled independently
  - **Fault Tolerance**: a fault in one microservice does not mean the entire system will break down as each microservice is deployed independently
  - **Maintainability**: easier to isolate specific issues due to separated responsibilities
- Weaknesses of microservice architectures:
  - **Complexity** and **Cost**: a lot of infrastructure and networking is required compared to a monolith
  - **Data Consistency**: data within the same microservice is fine (each microservice manages its own data), but needs to be synchronised across different microservices
  - **Security**: distributed systems have more ‘access points’ for attacks (‘higher attack surface’) due to the network calls between microservices and inter-service communication, and particular microservices could be ‘weak spots’

Event-Driven Architecture

- Event-driven architectures structure systems around components that respond to and broadcast particular *events*, which notify of significant changes in system state (somewhat similar to the Observer Pattern).
- Most communication inside of the system occurs *asynchronously* - system components send messages without waiting for responses.



Event-Driven Architecture

- Strengths of event-driven architectures:
  - **Responsiveness**: reacts to real-time events very quickly
  - **Performance**: asynchronous messaging prevents services from having to ‘wait’ on each other to complete a request
  - **Scalability**: easy to scale, since more events → more publishers and subscribers
  - **Decoupling**: publishers don’t need to know anything about subscribers due to the broker
- Weaknesses of event-driven architectures:
  - **Complexity**: asynchronous messages can be difficult to understand and reason with, since actions don’t necessarily occur in pre-defined orders
  - **Testability**: debugging asynchronous code is also complicated, as errors aren’t immediate and it can be hard to localise particular problems.
  - **Data Consistency**: data across components may be inconsistent at a fixed point in time, and will take time before data ‘converges’ to an agreed state (*eventual consistency*)