

Advanced Software Engineering - Appunti

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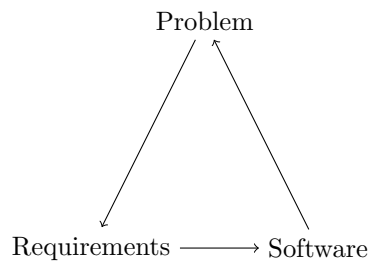
Chapter 1

Introduction

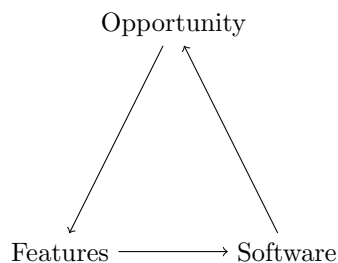
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1.1 Product based

In *Project-based SE* there is loop which nowadays cripples software since its early stages of development. This is due to mutable nature of requirements, which often change throughout time along the features implemented by the software.



Product-based SE is opposed to *Project-based SE* and the above pictures changes as follows.



1.2 Agile

Agile is a collection of principles and methods applied in the software development field.

Opposed to project-based SE, in Agile the client is requested to express the requirements not in technical terms but in features.

Agile suggests an incremental development model

Principles

1. Satisfy customer through early and continuous delivery of valuable software
2. Welcome changing requirement, even late in development. Agile processes harness change for the customer's competitive advantage
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale

4. Business people and devs must work together daily throughout the project
5. Build projects around motivated individuals and give them the environment and support they need
6. The most efficient and effective method of conveying information to and within a dev team is face-to-face conversation
7. Working software is the primary measure of progress
8. Agile processes promote sustainable dev
9. Continuous attention to technical excellence and good design enhances agility
10. Simplicity i.e. art of maximizing the amount of work not done is essential
11. The best architectures, requirements, and designs emerge from self-organizing teams.

Extreme Programming was proposed as part of the agile methodology

1.3 Scrum

Since requirements changes are rather frequent, long-term plans are unreliable, hence SE aims to formulate short-term plans.

Scrum is found on **empiricism** and **lean thinking**; it asserts that knowledge comes from experience, and that decisions should be made on observations.

Other key terms are code **Transparency** among the team and with the customer, **Inspection** of produced code and software (artifacts), **Adaptation** to changes in features and requirements.

The **Scrum Team** is composed by:

1. **Product Owner**: must ensure that the dev team is always focused on the goal
2. **Scrum Master**: Scrum expert which drives the team to apply properly the Scrum framework.
3. **Developers**: actual monkeys people which write code

In scrum SW is developed in **sprints**, i.e. fixed-length periods with a specific goal to be achieved.

- Product backlog: to-do list of items to be implemented
- Timeboxed sprints
- Self-organizing teams

... **Prod Backlog Revised**

PBI Estimation Metrics

1.3.1 Timeboxed Sprints

Even if at the end of a sprint the goal hasn't been reached, "no worries", the work stops anyway; there will be a new sprint which will include the work which has not been implemented in the previous one.

1.3.2 Scrum Meetings

1.3.3 Agile activities

Test automation Continuous integration

1.3.4 Sprint reviews

At the end of each sprint there is a review meeting which involves the *whole* team. The *product owner* has the ultimate authority to decide whether the sprint goal has been reached or not. The sprint review should include a process review, in which the whole team shares ideas on how to improve their way of working.

Team size

1.4 5 - Ottobre

Chapter 2

Features, Scenarios, Stories

2.1 3 - Ottobre

Which factor drive the design of SW products?

- Inspiration
- Business/consumer needs not met by existing products
- Dissatisfaction with existing products
- Technical changes making new product types possible

Product-based software engineering needs less *requirements documentation* than project-based SE, since the requirements are not set by customers and it is allowed for them to change. The focus is instead on **features** (fragments of functionality); to understand which features are needed, we must first understand which may be **potential users**, through interviews, surveys, informal user analysis and consultation.

Flow-chart

User representations — **personas** — and natural language descriptions — **scenarios** and **stories** — help driving the identification of product **features**:

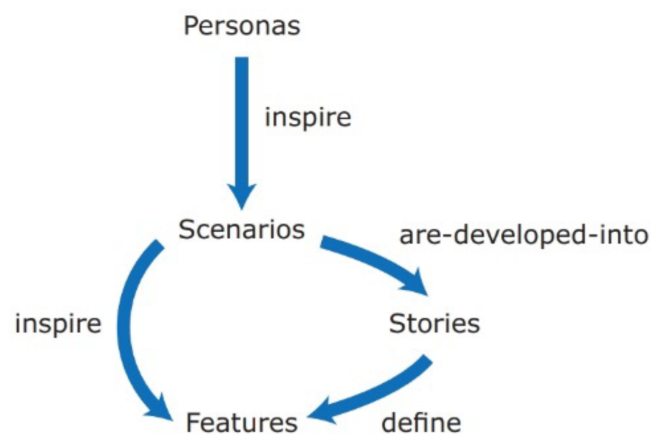
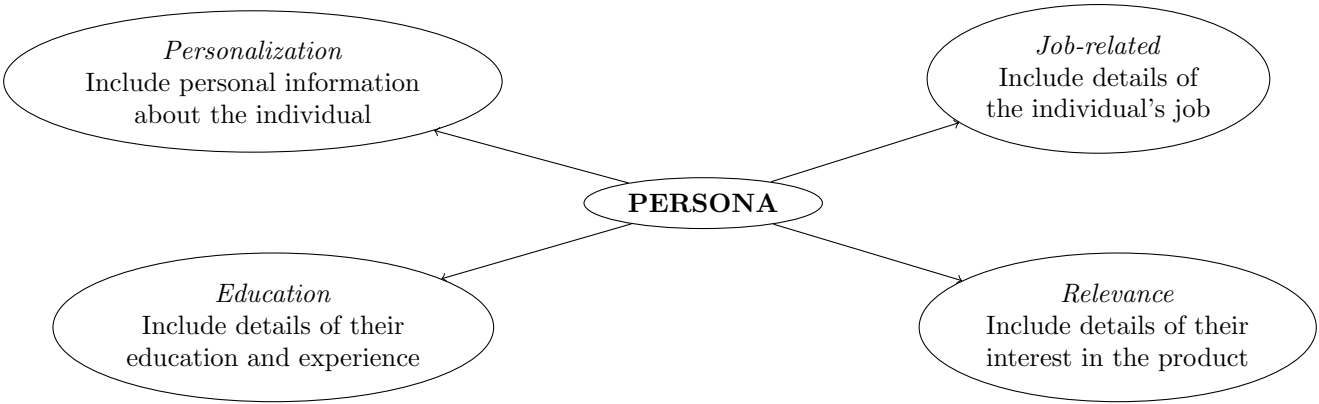


Figure 2.1: Features flowchart

2.2 Personas

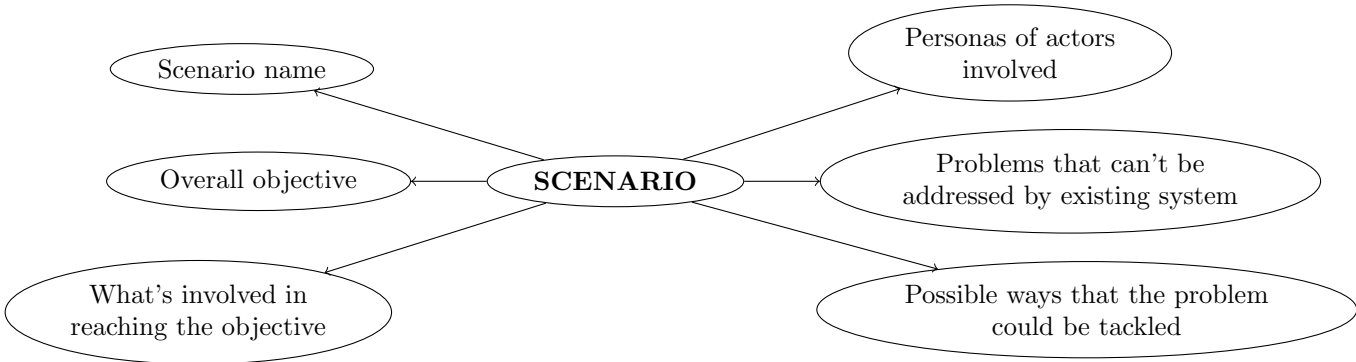
Personas represent the types of target users for our product. Each personas should highlight which are *background*, *skills* and *experience* of potential users. Usually only a couple of personas (max 5) are needed to identify **key product features**.



There are conflicting opinions about whether personas should include *photos* or not. Photos may be misleading, since *"personas are not about how users look, but what they do"* (Steve Cable). *"Detailed personas encouraged the team to assume that demographic information drove motivations"* (Sara Wachter-Boettcher).

2.3 Scenarios

Having defined personas, to discover product features, it would aid to define *user interactions* with the product: a **scenario** is a narrative written from *user's perspective* describing a situation in which a user is using our product's features to do something she wants to do. Scenarios are **not specifications**! They lack details and may be incomplete.



A proper amount of scenarios usually is 3-4 for each persona, aiming to cover the persona's main responsibilities. Each team member should create scenarios and discuss them with the rest of team and (possibly) users.

2.4 User Stories

As a	<role>
I want to	<do something>
So that	<reason/values>

Table 2.1: User Stories

Knowledge sources for feature design

You can use user scenarios and user stories to inform the team of what users want and how they might use the software features.

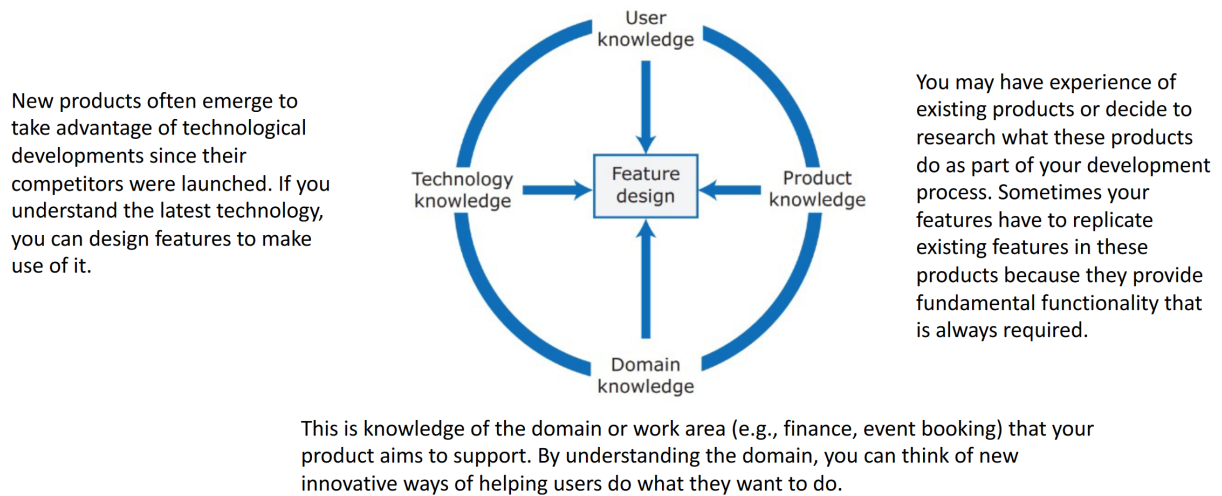


Figure 2.2: feature knowledge

While **scenarios** are high-level stories of product use, **User stories** are more fine-grained narratives. They allow to organize and chunk work into units which represent actual value to the customer, ultimately building software incrementally from the users perspective. Longer stories can be split into shorter stories, and to eventually prioritize them.

These words should recall 1. 3. 7. 10. agile principles described in Section 1.2.

In fact, usually *Scrum product backlog* is a set of *user stories* sorted according to priority.

Even though it is possible to express all functionalities describe in a *scenario* using *user-stories*, scenarios can read more naturally, make stories understanding easier, and provide more context.

2.5 Feature identification

Our goal is to get a list of features that define our product, keeping in mind some **properties**:

- **Independence** → a feat should not depend on how other system feats are implemented and should not be affected by the order of activation of other feats
- **Coherence** → feats should be linked to a single item of functionality. They should not do more than one thing and should never have side effects
- **Relevance** → systems feats should reflect the way users normally carry out some task. They should not offer obscure functionality that is rarely required.

To derive features from scenarios and user stories, the dev team should discuss these and start prototyping to demonstrate first novel and critical features.

2.5.1 Feature Creep

Number of product features grows as new potential users are envisaged. To avoid this, 4 questions should be considered:

1. Does this feature add something new or is it simply an alternative way of doing something already supported?
2. Can this feature be implemented by extending an existing feat rather than adding a new one?

3. Is this feat likely to be important and used by most software users?
4. Does this feat provide general functionality or is it a very specific feat?

Chapter 3

User Stories

Consider **TicTacToe** — aka *Tris* or *Tiro Filetto* — and its basic rules. Suppose you have to develop a software that allows playing TicTacToe, i.e. our *Product*.

Proceeding in steps, let's define the **Personas** who would use our product.

Chapter 4

Seminario - Imola informatica

4.1 Takeaway Messages

Performance per se is not an accurate measure, there are many factors when developing SW systems which affect performance, like usability and efficiency.

4.2 Project Path

$$\text{Demand} \longrightarrow \text{Plan} \longrightarrow \text{Design} \longrightarrow \text{Develop} \longrightarrow \text{Release} \quad (4.1)$$

This (sadly not) deprecated path 4.1 leads to *situation rooms* and subsequent performance degradation, unsatisfaction and possible skyrocketing costs.

Performance should drive the whole production process, it shouldn't be treated as a post-go live concern, otherwise it may lead to the so called *situation rooms*¹.

4.3 Fitness function

A **fitness function** provides a summarised measure of how close a given design solution is to achieving the set aims.

4.4 Performance Best practices

"Starbucks does not use two-phase commit": they aim to maximize throughput, by using an employee chain to serve customers, from ordering to delivering coffee.

Enforce business process performance with adequate fitness functions:

- involve key stakeholders
- automatically assess and evaluate
- continuously review and tune

It is important to design IT architectures and solutions with real-world requirements in mind. For example "a customer shouldn't have to wait for more than 2s to *order* a coffee".

In distributed architectures, network's technical aspects and metrics must be taken into account: latency, available

¹Often named also *war rooms*

bandwidth, dedicated or shared, network billing models...

Aside from requirements, also costs, performance and observability should be kept in mind.

To measure progress fitness function must be fed periodically with real-time data. Most of the times testing only in production is the only way to go, since mirroring the production environment and using/managing it during development would be hugely costful. However, precisely for this reason, production testing shouldn't be the only testing method.

4.5 Bad habits

- Worrying about performance only late in development
- Last minute testing
- Focusing only on performance as a technical POV, not user/business pov

Enable a culture for performance across your entire value stream and embed it in business processes as well as IT systems.

Takeaway message

Evolutionary architectures need **fitness functions** and it is mandatory to continuously refine **fitness functions**.

Chapter 5

Software Architecture

12 - Ottobre

Architecture is the fundamental organization of a software system embodied in its *components* their relationships to each other and to the environment, and the principles guiding its design and evolution.

5.1 Component

A **component** is the element of implementing a coherent set of features; it can be seen as a collection of services, possibly used by other components, either directly or through an API.

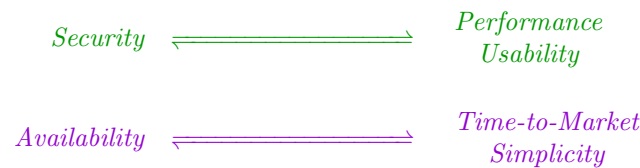
Architectural design issues

- Non-functional product characteristics: security, reliability, availability... These aspects are as important as functional properties, to develop a successful product.
- Product lifetime: in case of developing a hopefully long-term product, its architecture must be able to evolve and adapt: *microservices*, for instance, easily allow scalability increasing the lifetime of our product.
- Software compatibility: Usually there may be legacy modules in the system, thus compatibility may be crucial, and it may lead to limiting architectural choices.
- Number of users: Releasing software on the internet truly complicates the prediction of the number of users for a product, it may vary a lot, thus the architecture must allow scaling up and down according to it.
- Software reuse: reusing components from other products or open-source software might save a lot of *time* and *effort*, however it may force some architectural design choices.

5.2 Non-functional quality attributes

1. Responsiveness *Does the system return results in reasonable time?*
2. Reliability *Do features behave as expected?*
3. Availability *Can the system deliver services when requested by the users?*
4. Security *Does the system protect itself and user data from attacks and intrusions?*
5. Usability *Are the users able to access (quickly) the features they need?*
6. Maintainability *Can the system be easily updated with undue costs?*
7. Resilience *Can the system recover in case of failure or intrusion?*

This typically aren't *features attributes* (?) implemented in the mid-development **prototypes**, they usually refer to the **final product**. Implementing these in the prototypes would increase too much the time taken to develop such prototypes. Besides, note that optimizing one non-functional attribute might affect others, so, depending on our product and our resources, it must be considered whether to focus on one attribute instead of another one.



5.2.1 Maintainability

For example let's consider which design choices would improve *maintainability*. First, recall that indicates how difficult and expensive is to make changes after the product release.

Two good practices are **decompose** the system into small self-containing parts and to avoid **shared data-structures**. Speaking of *shared data-structures*, a shared and *centralized* DB, might act as a bottleneck or, even-worse, as a single point of failure.

Using smaller local DBs for each **component** which later synchronize with the main one would avoid these two issues, however it introduces the need for **consistency** techniques and rules.

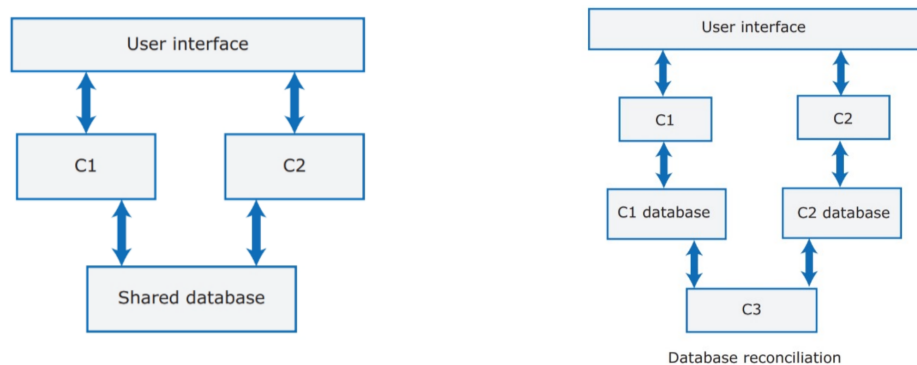


Figure 5.1: Centralized vs Component DBs

5.2.2 System Decomposition

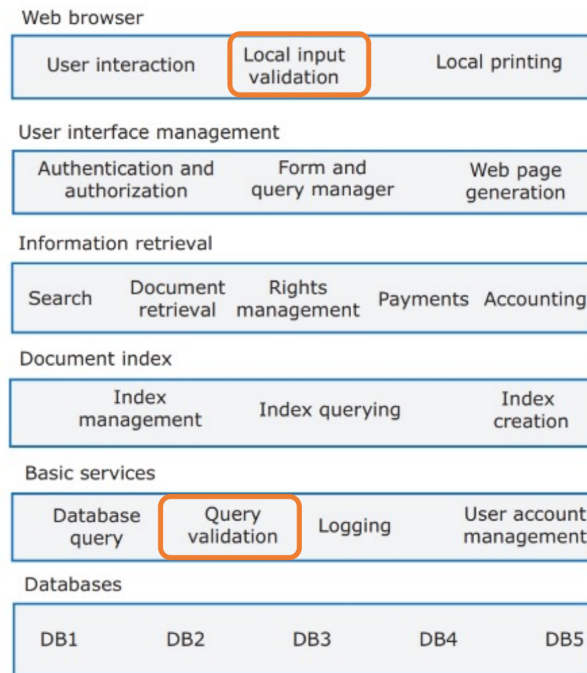
Let's dig in deeper into system decomposition, by first introducing some definitions:

- **Service:** coherent unit of functionality
- **Component:** software unit offering one or more services
- **Module:** set of components

The agile manifesto suggests that: *Simplicity is essential*; regarding decomposition this is particularly true since as the number of components increases, the number of relationships between them increases at a faster rate, thus it necessary to **manage complexity**; there are a few techniques to do so:

- **Separation of concerns**
- **Stable interfaces**
- **Implement once**

One way to implement this is to have a **layered architecture** where to each *layer* corresponds a *concern*, and the components within the same layer are independent and do not overlap in functionality. There are also some



(Concerns may not be always
100% separated in practice)

Figure 5.2: Layered architecture

"concerns", which are in fact non-functional attributes like *security*, *performance* and *reliability*, which are "*cross-cutting*" i.e. they affect the whole system in a "vertical way" (see Fig 5.2.2) and they define the interaction between layers.

System decomposition must be done in conjunction with choosing technologies for the system. In this there is a mixup happening between implementation and design, however it is necessary. For example, the choice of a particular type of DB affects components at higher levels, or choosing to support interfaces on mobile devices implies the need for mobile UI toolkits.

5.3 Distribution architecture

Now, how can we define servers and the allocation of components to servers?

A very common way is the **Client-Server architecture** aka Model-View controller where usually the communication between client and server happens with HTTP along with JSON (/XML). Client requests to a server are then muxed on many slave nodes which elaborate the requests.

There are some choices which must be made when designing the distribution architecture:

- **Data type and Data Updates:** whether the data should be centralized or spread around and later on synchronized.
- **Change frequency:** if frequent changes are foreseen it is advisable to isolate components as separate services to allow easy and uncostful changes
- **System execution platform:** the service being accessed over the internet or being a business system, leads to consistently different design architecture.

5.4 Technologies choices

It is difficult and costful to change technologies mid-development, thus it is important to the adequate considerations in advance and choose them properly. Let's consider first which aspects of the architecture are strongly technology-related:

- **Database** SQL \longleftrightarrow noSQL
- **Platform** Mobile app \longleftrightarrow web platform
- **Server** Dedicated in-house servers \longleftrightarrow cloud
- **Open-source** Any suitable *open-source* solutions to be incorporated?
- **Development tools** Any limitations on the architecture imposed by the chosen development tools?

Chapter 6

Enterprise Applications

In Enterprise applications there heterogeneous services, data sources and participants, all connected via network. In short, **Enterprise Applications** are *complex distributed multi-service applications* whose services must work together, them being suitably **integrated**.

6.1 Integration

The architectural question is how to integrate multiple different services to realize enterprise applications that are

- *coherent*
- *extensible*
- *maintainable*
- (reasonably) simple to *understand*

This is really what enterprise application integration was conceived for

- complexity management
- change management
- **pattern-based**

Pattern refers to high-level abstraction of accepted, reusable solutions to recurring problems.

When facing a problem, considering existing patterns that are applicable to solve such problem saves us from re-inventing the wheel and making the same mistakes as others

Typically, patterns are given in terms of

- **problem statement** including involved software components
- **context** including involved actors
- **forces** clarifying the problem rationale and importance
- **solution** given abstractly, and independent of its actual implementations

An **EIP** (*Enterprise Integration Pattern*) is a reusable abstraction of proven solutions to well-known problems raising while integrating the software components/services forming enterprise applications.

6.2 Messages and Communication Means

A **message** is a discrete piece of data sent from a service to another, typically structured into header and body, and generally sent through **one-way channels**. Thus by itself the communication is *asynchronous*, but it can be made *synchronous* by duplicating a channel and thus creating a bidirectional communication.

Channels supports extends to two main categories:

- **Point-to-Point** (1 : 1) channels ensure that only one receiver will receive a given message
- **Publish-Subscribe** (1 : N) channels deliver a copy of the message to each receiver

Channels generally require the data to be serialized in some way: to this extent **adapters** "translate" (*adapt*) application-specific data into a format suitable to be sent; note that adapters are placed between the *application* and the *channel*, not the *receiver*.

Besides, a **message endpoint** for each node/application is required, to handle channel connections and queue/handling the messages received before letting the application process them.

Message endpoints and **channels** provide the most trivial integration possible, however they do not solve the problem when the *receiver application* requires the data to be in a specific format e.g. JSON. **Message translators** are intermediary entities which can translate and eventually filter data.

6.3 Deeper message integration

Some problems are still not solved e.g. message *routing*, *splitting*, *aggregating*, etc.

That's where **pipes** and **filters** architecture style comes in.

Messages travel through many *filters* (and components) processing them. Components flush messages into **pipes** they are connected to.

Clearly this is (again) a flexible abstraction which can adapt to circumstances and environment.

This architecture, along with endpoints and channels, includes **Content Enrichers**, which add contextual information which the source may not have, **Routers** which may be *content-based* (header/body) or *context-based* (testing/production env).

Speaking of **routers**, such components are connected to multiple channels and contain the logic to discern which is the correct channel onto which a message should be sent.

6.3.1 Composite Patterns

Patterns may be composed to build other patterns. **Normalizers**, for instance, enable data received from different sources to be normalized and then sent in a proper format to receivers; behind the curtain, *normalizer* are nothing more than a router and a set of translators.

6.3.2 Parallelism

Sometimes some integration steps may be computed in **parallel** and then results from such processes may be **aggregated** to decide which actions to perform.

Splitters break out composite messages into a series of individual messages, which can be *processed independently*. **Aggregators** collect and store individual messages until a complete set of related messages has been received, ultimately publishing a single message which be processed as a whole.

6.4 Handling Problems

- **Validate** messages
- **Architectural smells** and **refactoring**
- **Security** issues
- **Isolate** features in integrated applications
- **Deploy serverlessly** integrated applications

Chapter 7

Cloud computing

19 - Ottobre

Powerful hardware and high-speed networking have made room for the development of cloud computing. **Cloud computing** allows virtual resources accessible **on demand**, and provides many advantages against the standard old-style scaling methods i.e. buying resources.

- *Scalability*
- *Elasticity*
- *Resilience*
- *Cost*

7.1 Virtualization and Containers

Virtual machines on a single physical machine are managed by hypervisor

App A bins/libs Guest OS	App B bins/libs Guest OS
Hypervisor	
Host OS	
Hardware	

Containers instead exclude one layer of abstraction, saving up a lot of resources

App A bins/libs	App B bins/libs
Container Manager	
Host OS	
Hardware	

7.2 Docker

Docker exploits container-based virtualization to run multiple isolated guest instances on the same SO. Software is packaged into **images** which are read-only templates to instantiate and run containers. External **volumes** can be mounted to ensure data persistence when used by multiple containers or by the host machine.

It is possible to **stack** multiple docker *images*, and if desired create a new image as a result of stacking other ones.

Chapter 8

* as a Service

In traditionally distributed software, customers had to configure, manage updates, while producers had to maintain different product versions; in **SaaS** instead, a product is delivered as a **service**, thus there's no need to install anything, and there is a form of monthly (and/or pay-per-usage) subscription, to use the service.

8.1 Benefits and cons

Producer point of view

- Regular cash flow
- Easier and less costful update management
- Continuous deployment: a new software version can be deployed as soon as it is tested
- Payment flexibility, making room for different subscription plans possibly attracting a wider range of users
- Try-before-you-buy options are easily available without fearing piracy, besides they'd make the product look more appealing to new customers
- Telemetry and data collection are way easier and hardly avoidable by customers

Consumer point of view

- Mobile, laptop and desktop access
- No **upfront costs** for software or servers
- Immediate and transparent software updates
- Reduced software **management costs**
- **Privacy** regulation conformance
- **Security** concerns
- Network constraints may limit the usability of the software
- Data exchange from/to services might be difficult if the service doesn't provide a suitable API
- No control over updates
- Service **lock-in**

8.2 Design issues

When designing SaaS there are some critical points the developers has to make decisions on:

- **Authentication** method: federated auth, personal auth, *Google/LinkedIn/...* credentials...

- Whether some features should be available **locally**
- **Info leakage**
- *Multi-tenant* vs *multi-instance* **DB management**: i.e. single repository vs separate copies of system and database

8.2.1 DB management

Multi-tenant

Multi-tenant systems foresee a single DB schema shared by all system's users, where DB items are tagged with a *tenant identifier* to provide some form of "logical isolation".

Mid-size and large businesses rarely want to use a generic multi-tenant software, they often prefer a customized version adapted to their own requirements. Generally it is of interest to have a custom UI mutating according to the user, along with custom optional fields accessible only by some classes of users. In case there's the need to expand the DB schema to achieve such results, **storage waste** becomes a major concern.

Security is the major concern of corporate customers with multi-tenant systems, since a centralized DB may represent a single point-of-failure for data leak or damage.

A common solution is to implement **multilevel access control**, checking data access both at the organizational level and at individual level. A technology which can clearly help in this matter is **encryption**, however it might cripple performance.

Multi-instance

Multi-instance may mainly be **VM-based** or **Container-based**.

With *containers*, each user has an **isolated** version of software and database running in a set of container, defining a solution perfect for products whose users work onto independently from others. Besides, since there is no direct sharing of a single data structure, many security aspects are easy to manage.

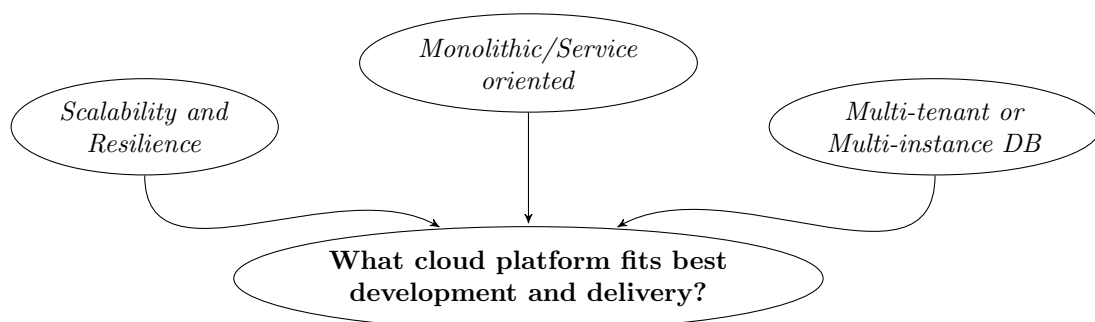
With the other solution instead, for each **customer** there is a VM running an instance of the DB **shared** and accessible to all customer's users.

Let's consider *pros and cons* of such a solution. Flexibility, security, scalability and resilience are clearly some key points of *multi-instance DBs*. However update management difficulty and cloud VMs renting costs are not negligible.

Wrapping up, there are three possible ways of providing a customer **database** in a *cloud-based* system:

1. As a **multi-tenant** system, *shared by all customers* for your product. This may be hosted in the cloud using large, powerful servers.
2. As a **multi-instance** system, with *each customer database* running on its own *virtual machine*.
3. As a **multi-instance** system, with *each database* running in its own *container*. The customer database may be distributed over several containers.

8.3 Architectural decisions



8.3.1 Scalability

To allow scalability on cloud-based systems, the product implementation must be organized so that the individual software components can be replicated and run in parallel, besides, also a load-balancing mechanism must be implemented.

8.3.2 Resilience

Achieving resilience can be done through *hot/cool standby*. The difference lies in the fact that while cool standby relies restarting the system using backup copies of the data, hot standby forseees a clone-instance running at the same time of the main one with a mirrored DB: in case of system failure, there is an entire backup system which can take its place while the main recovers. This is clearly more costful, but more effective.

8.4 Choosing cloud platform

