

# Service Oriented Architecture

## Application Design – Tenancy and SaaS

Lecture 6

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# Agenda

01 | Tenancy

02 | Software As a Service



A grayscale photograph of a person's hand pointing their index finger towards a large, white, stylized cloud icon. The background is a dark, textured gray.

## Application Tenancy

Architecture Considerations

# Cloud solution architecture

## CONCEPTS

### Introducing tenants and multi-tenancy

01

#### TENANT

*A “tenant” is a group of users that share the same view on the application they use. This includes the data they access, the configuration, user management, particular features and related non-functional properties. Very often this group of user is tied to a legal entity or organisation.*

02

#### MULTI-TENANCY

*“Multi-tenancy” is an approach to share an application instance between multiple tenants by providing every tenant a with dedicated “share” of the instance, which is isolated from other shares with regard to performance and data privacy.*

*Connected is the notion of “tenant space”, which refers to the situation where customers rent predefined space of resource in which they run multiple application instances.*

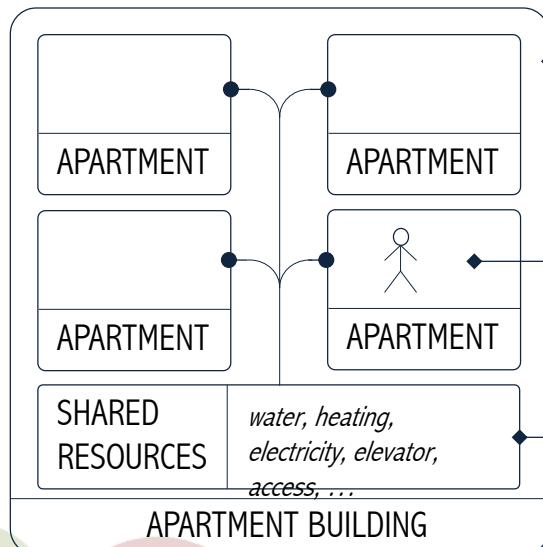
R. Krebbs, C. Momm, S. Kounev. “Architectural Concerns in Multi-Tenant SaaS Applications”, CLOSER 2012  
<https://sdqweb.ipd.kit.edu/publications/pdfs/KrMoKo2012-closer-multitenant-sass.pdf>

# Cloud solution architecture

## CONCEPTS

### Introducing tenants and multi-tenancy (...continued)

*A very simple analogy, to understand these concepts is to refer them back to their original meaning:*



The apartment building is the application instance, shared by multiple tenants.

The single apartment is the “application view” that is made available to the renter (tenant) where it enjoys privacy and isolation

Utilities and other apartment services are the shared resources that come with the cost of living in the building.

# Cloud solution architecture

## CONCEPTS

### Introducing tenants and multi-tenancy (...continued)

*Multi-tenancy are another example of resource sharing, which is a very well known pattern in cloud computing environment (and distributed systems in general).*

#### SaaS

*A single application instance and related resources are shared across multiple tenants, which run unaware of each other. In this scenario sharing occurs at the finest granularity level.*

#### PaaS

*A distributed runtime environment is shared across multiple applications, which run unaware of each other. During development, project management, source control, and devops services are shared across multiple projects.*

#### IaaS

*A datacenter is a physical infrastructure that is shared across multiple customers (i.e. ASPs) and within a single server, virtualisation enables sharing a single machine resources across multiple VMs, which run in isolation.*

# Cloud solution architecture

## CONCEPTS

### Multi-tenant vs multi-instance single tenant

*Multi-tenancy, is not the only method to share common resources across customers.*

*Another way of sharing capabilities is replicating the same application instance for each tenant. This is the case of a “multi-instance single tenant scenario”.*

#### MULTI-INSTANCE SINGLE TENANT

*In this scenario the application instance (and related resources) is replicated for each tenant. Tenants are completely isolated from each other not by the application logic, but by the application instance boundaries.*

*Each tenant is the single user of the application instance, and what is “shared” is the set of capabilities characterising the application, that has been provisioned by a common core.*

# Cloud solution architecture

## CONCEPTS

### Multi-tenant vs multi-instance single tenant (...continued)

*Considerations:*

01

*Multi-tenancy can be either single-instance and multi-instance, and the latter is a natural evolution of the former when scaling out to meet increased demand. Conversely, there is no interest in conceiving a “single instance single tenant” solution since that implies that we’re serving only one organisation.*

02

*Multi-instance single tenancy is the less sophisticated solution to ensure isolation, since there is no sharing of the application instance. Therefore, the application code does not need to be developed to be “tenant aware”. Multi-tenancy, implies a more sophisticated logic but allows achieving better utilisation of resources and has more potential for the reduction of costs.*

03

*Which one is better? There is no definitive answer, even though multi-tenancy is a more popular solution because it is more common that the resource costs are directly born by the SaaS provider. Moreover, a single solution can include both models for different application components.*

# Cloud solution architecture

## SHARING MODEL

01

### PROS

### CONS

Which strategy do we use for “Your Events” ?

*As discussed before we have three possibilities:*

#### MULTI-INSTANCE SINGLE-TENANCY

*This solution implies replicating for each customer application runtime, object storage, and database for each customer (either subscribed or requesting a trial).*

- very simple to implement, automation provides isolation “out of the box”*
- application code is tenant unaware and therefore easier to develop*
- pricing and chargeback are simple to compute, as they are directly given by the provider used to implement the solution*
- customisation, performance isolation, and differentiated service level are easier to implement*
- the solution can be very resource inefficient*
- the solution can be very expensive for Cloud Dynamics, unless the customer brings its own subscriptions for the underlying services.*

# Cloud solution architecture

## SHARING MODEL

02

### PROS

### CONS

Which strategy do we use for “Your Events” ?  
*(... continued)*

#### MULTI-TENANCY

*This solution implies using a single application instance and related resources to serve multiple customers and scaling out (in) in number as the demand increases (decreases).*

- *very effective use of resources*
- *underlying infrastructure/platform costs are more likely to be kept at minimum*
- *being the application code “tenant aware” there are no constraints imposed by the provider in how we implement service level differentiation*
- *there are more opportunities to fine tune system*
- *the application instance, being “tenant aware” is significantly more complex*
- *customisation might be harder to achieve especially with regards to database schemas*
- *performance isolation and data segregation must be explicitly coded in the application*
- *billing and chargeback are more complex to derive*

# Cloud solution architecture

## SHARING MODEL

03

### PROS

### CONS

Which strategy do we use for “Your Events” ?  
*(... continued)*

### MIXED TENANCY

*This solution implies the use of different sharing strategies (01 or 02) per application component. As a result, different components scale out differently.*

- *the decision of the sharing strategy can be assessed per component*
- *as we further breakdown our application we have more changes to optimise resource use*
- *the solution can lead to a better trade-off than the previous two*
- *the level of system tuning is extremely granular, yet flexible*
- *there are more opportunities to fine tune system*
- *billing and chargeback can be more effectively juggled, by balancing effectiveness and sophistication*
- *the application instance need to be “tenant aware”, even though potentially only part of it*
- *the overall complexity of the solution increases, as it leverages a mixed model*

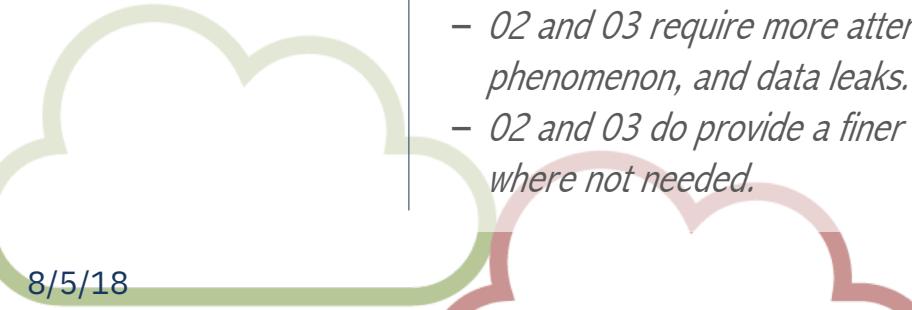
# Cloud solution architecture

## SHARING MODEL

## COSTS

## MAINTENANCE

## ISOLATION



Which strategy do we use for “Your Events” ?  
*(... continued)*

*The decision needs to take into account different aspects:*

- Cloud Dynamics is directly bearing the costs of anything below the SaaS offering. Therefore, any solution making an inefficient use of resources (i.e. 01) is excluded.*
- Complexity leads to systems harder to maintain, debug, and fix. From this perspective 01 is the preferred choice.*
- Both 02 and 03 come second. 03 allows Cloud Dynamics to use replication where appropriate thus simplifying the architecture of a full multi-tenancy approach, but implies the use of non-uniform approach, which might pose additional challenges.*
- 01 ensures isolation out of the box both from a data and performance perspective.*
- 02 and 03 require more attention to detail and care to prevent the “noisy neighbours” phenomenon, and data leaks.*
- 02 and 03 do provide a finer degree of control, with 03 giving the opportunity to relax complexity where not needed.*

# Cloud solution architecture

## SHARING MODEL

## SERVICE LEVEL DIFFERENTIATION

## DECISION...

03

### MIXED TENANCY

*Despite the increased complexity, this solution is the one that provides the best compromise between efficiency, effectiveness, and returns. Moreover, it allows Cloud Dynamics to be more flexible towards future plans for expanding “Your Events”.*

# Cloud solution architecture

## LEARNINGS

### What did we learn ?

01

#### ASSESSING DIFFERENT CLOUD OFFERINGS FOR SaaS DEVELOPMENT

*We discussed which of the three traditional cloud market offerings (SaaS, PaaS, IaaS) could be more appropriate as the implementation platform for the SaaS example application, "Your Events". We also explored some of the benefits of a mixed approach.*

02

#### ARCHITECTURAL DECISIONS AND THEIR IMPLICATIONS

*We sketched a reference architecture for "Your Events" and started to reflect on the implications that this design brings in relations to goals of the application itself.*

03

#### SHARING MODELS AND THEIR IMPLICATIONS

*We introduced the concepts of tenant, multi-tenancy, multi-instance single tenancy, and mixed tenancy. We discussed benefits and drawbacks of each model and used the "Your Events" application in order to provide a practical example about how to assess which is the best model to use with a given scenario.*



# **Introduction to Software As A Service**

# Software as a Service

## CLOUD REFERENCE MODEL

	At the top of the stack...	COMPLEXITY
SaaS	<i>Applications and services that can be used directly by the end user or integrated into applications to increase their capabilities. Examples are emails, word processors, presentations.</i>	
PaaS	<i>Environment for building applications in the cloud and fundamental application building blocks available as services to implement core capabilities. These both include runtime and development environment supporting applications.</i>	
IaaS	<i>Infrastructure in terms of networking, raw compute, and storage that build up that hardware on top of which applications and systems are installed and deployed.</i>	



# Software-as-a-Service

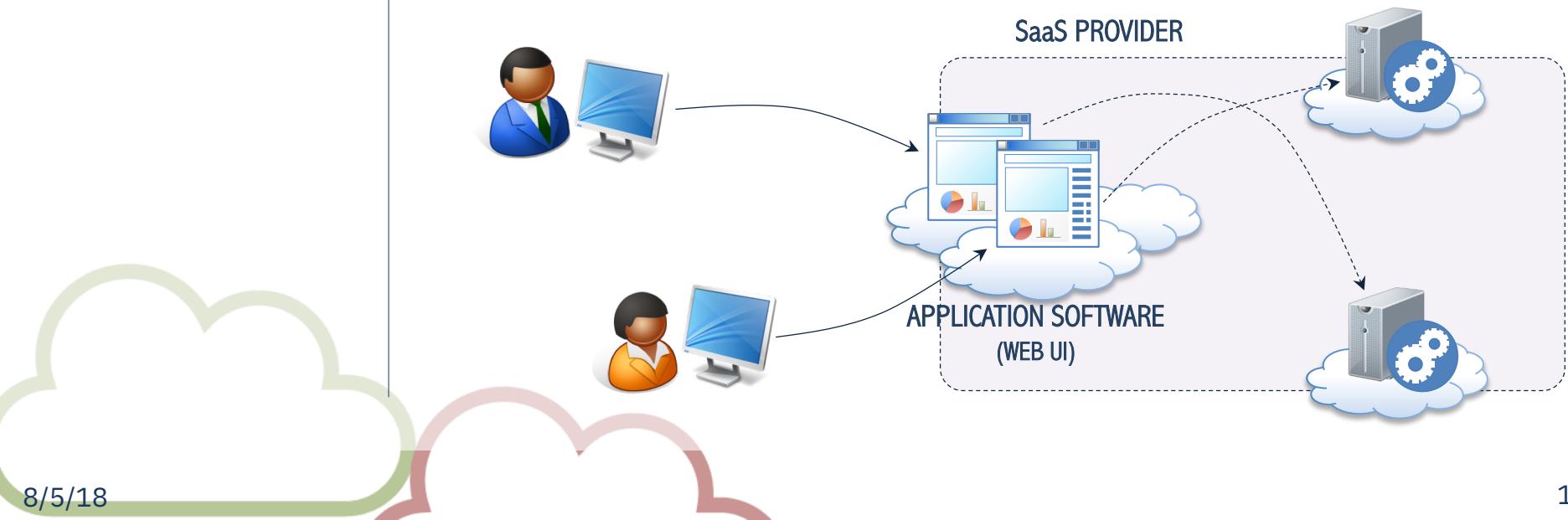
## DEFINITION

At a glance

### SaaS

*“Software-as-a-Service (SaaS) is a software delivery model that provides access to application through the Internet as a Web-based service.”*

Ref. R. Buyya, C. Vecchiola, T. Selvi – Mastering Cloud Computing: Foundations and Application Programming



# Software as a Service

## DEFINITION

### A view from NIST

NIST

*“The capability provided to the consumer is to use the provider’s applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.”*

*P. Mell, T. Grance, “NIST working definition on cloud computing.” National Institute of Standard and Technology (NIST)*  
*<http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf>*



# Software as a Service

## KEY FEATURES



### Advantages of a SaaS offering

#### IT FREES USERS FROM HW AND SW INSTALLATIONS/MAINTENANCE

*Because the entire application is serviced through the cloud the only things that a user need to have is a browser and an Internet connection.*



#### FASTER ROLLOUT OF RELEASES

*Because the software is run and administered by the provider, updateds, patches are applied centrally and transparently applied.*



#### MORE ACCESSIBLE LICENSING COSTS

*Because the provider can share costs at scale, subscriptions can be offered at a cheaper price.*



#### REDUCED LEAD TIMES

*Because the software is provisioned on the cloud, users can access system capabilities almost immediately. This also applies when there is need to scale out the installed base.*

# Software as a Service

## CONCEPTS

### SaaS applications

*SaaS applications cover a very large range of heterogeneous applications.*

*There is one characteristic that different applications have in common:*

01

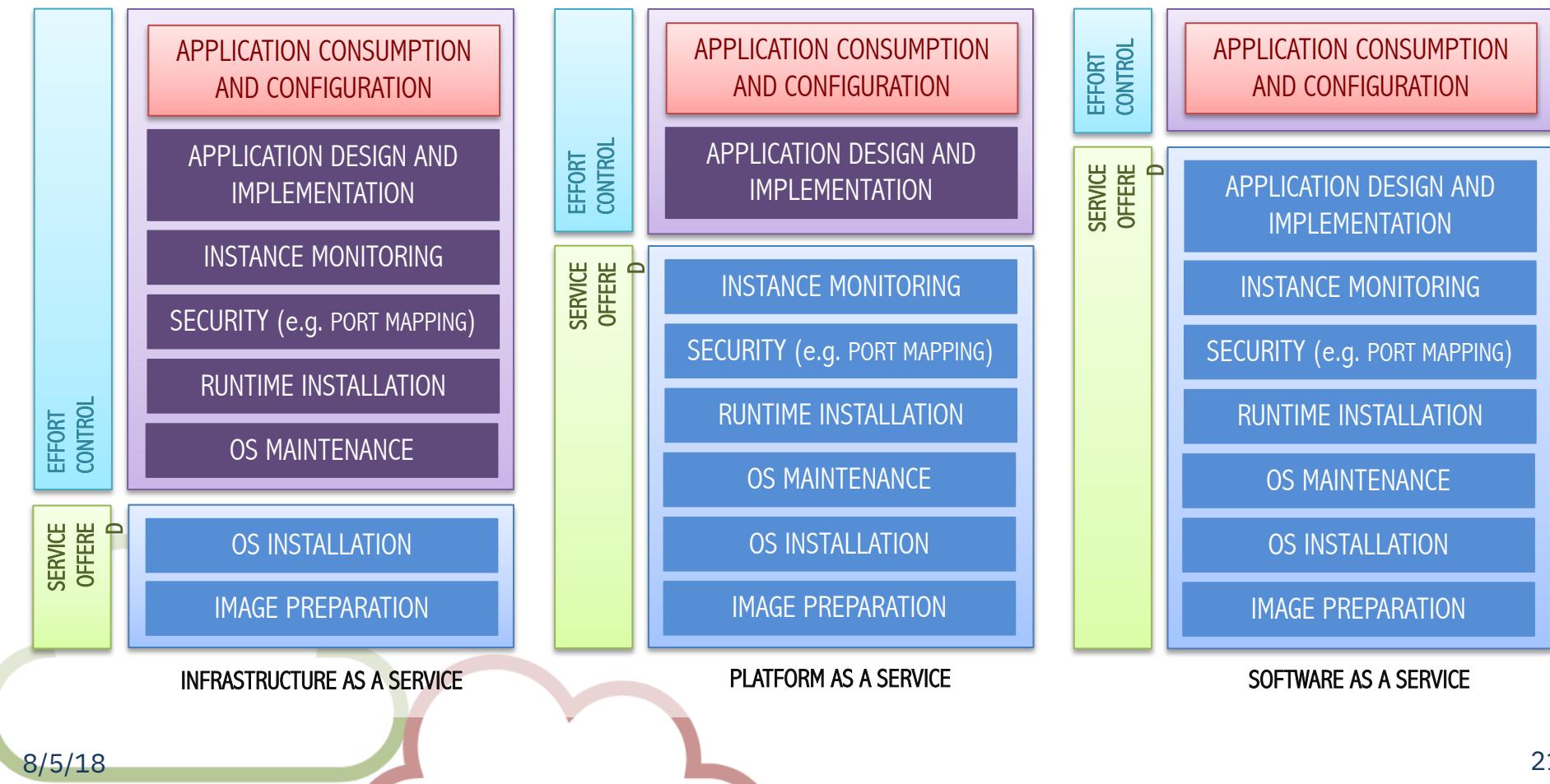
#### DELIVER SOLUTIONS FOR IMMEDIATE USE

*SaaS applications, once provisioned, are ready for immediate use or do require little further customisation. Differently from IaaS and PaaS offering, which are used to build systems and applications, SaaS deliver solutions for direct use.*



# Software as a Service

## CONCEPTS | Comparing SaaS, PaaS, and IaaS



# Software as a Service

## CONCEPTS

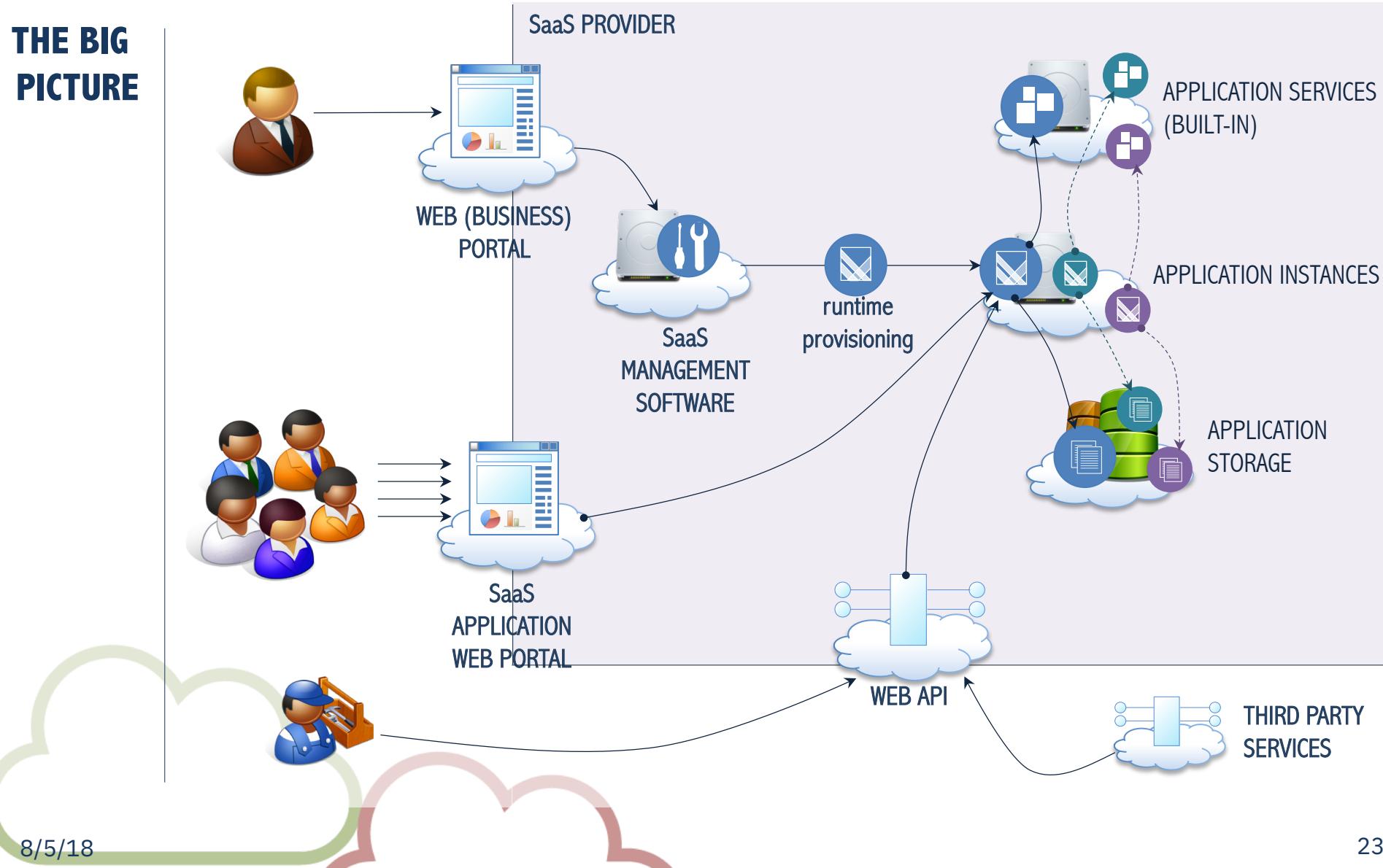
Some SaaS example applications

*Here are the most common types of SaaS offerings:*

- 
- 01 CUSTOMER RELATIONSHIP MANAGEMENT (CRM)
  - 02 ENTERPRISE RESOURCE PLANNING (ERP)
  - 03 OFFICE AUTOMATION (SPREADSHEET, EMAIL, WORD PROCESSING ...)
  - 04 VIDEO CONFERENCING
  - 05 TALENT AND HUMAN CAPITAL MANAGEMENT
  - 06 SOCIAL MEDIA CAMPAIGNING
  - 07 PROJECT MANAGEMENT AND COLLABORATION TOOLS

# Software as a Service

## THE BIG PICTURE



# Software as a Service

## HISTORY

### SaaS & cloud computing

*The concept at the foundation of Software-as-a-Service, pre-dates cloud computing and even though put into practice since the late 90s, SaaS became defined in 2001:*

**SIIA  
2001**

### SOFTWARE INFORMATION & INDUSTRY ASSOCIATION

*In the software as a service model, the application, or service, is deployed from a centralized datacenter across a network—Internet, Intranet, LAN, or VPN—providing access and use on a recurring fee basis. Users “rent,” “subscribe to,” “are assigned,” or “are granted access to” the applications from a central provider. Business models vary according to the level to which the software is streamlined, to lower price and increase efficiency, or value-added through customization to further improve digitized business processes.*

*SIIA – Software as a Service: Strategic Backgrounder (2001-2002)*

# Software as a Service

## HISTORY

### Meet ASPs: the precursor of SaaS

*The analysis of SIIA was primarily focused towards the Application Service Providers (ASPs), which already captured the concept of software applications consumed as a service in a broader sense.*

*Key characteristics were:*

01 THE PRODUCT “SOLD” IS APPLICATION ACCESS

02 THE APPLICATION IS CENTRALLY MANAGED

03 THE SERVICE IS DELIVERED ONE-TO-MANY

04 INTEGRATED SOLUTION DELIVERED “ON THE CONTRACT”<sup>1</sup>

<sup>1</sup> *the solution is delivered as promised on the contract*

# Software as a Service

## HISTORY

### Transition to the SaaS model

#### ASP ERA

- HOSTING SOLUTIONS FOR PACKAGED APPLICATIONS
- SERVED TO MULTIPLE CUSTOMERS
- ASP “OWNS” THE INFRASTRUCTURE NOT NECESSARILY THE APPLICATION

#### WEB 2.0

- WEB AS INTEGRATION PLATFORM
- FULL-FLEDGED APPLICATIONS IN THE BROWSER
- MATURITY TO DELIVER COMPLEX CAPABILITIES OVER THE WEB
- WEB PAGES AS MASH-UP OF SERVICES

#### SaaS ERA

- FULL ACCESSIBILITY THROUGH THE BROWSER
- RAPID IMPLEMENTATION, BUT RUDIMENTARY DATA INTEGRATION
- CUSTOMISATION OF THE APPLICATIONS
- THE PROVIDER “OWNS” THE APPLICATION
- THE SOLUTION CAN MEET A LARGER VARIETY OF CUSTOMER NEEDS
- SUBSCRIPTIONS AND PAY AS YOU GO PRICING MODEL



# Software as a Service

## HISTORY

### Transition to the SaaS model

SaaS ERA

- (... see previous slide)

CLOUD COMPUTING

- THE FULL IT STACK DELIVERED “AS A SERVICE”
- MORE CONFIDENCE ON “DELIVERY MODEL”
- REDUCTION OF COST THROUGH INFRASTRUCTURE LEASING

SaaS “2.0”

- NOT “ESSENTIAL” NEW TECHNOLOGY
- FOCUS ON BUSINESS GOAL, SERVICE QUALITY, AND ADDED VALUE
- ABILITY TO INTEGRATE THIRD PARTY SERVICES
- MORE VENDORS AND OPPORTUNITIES
- CONSOLIDATION OF THE SaaS OFFERING
- FIT INTO THE CLOUD COMPUTING VISION



# Software as a Service

## LEARNINGS

### What did we learn?

01

#### WHAT IS SaaS AND HOW IT COMPARES TO IaaS AND PaaS

*Software-as-a-Service is a market offering that provides access to applications and systems “ready to use” over the Internet through a pricing mechanism based on subscription. The provider sells access to the application and takes responsibility of application installation, deployment, maintenance, and upgrades. The consumer uses the application, with no further development.*

02

#### RELATION TO SaaS, ASP, AND CLOUD COMPUTING

*The concept of Software as a Service pre-dates cloud computing. It developed as an evolution of the services offered by application service providers (ASPs), who offered hosting solutions for packaged applications to many customers. Cloud computing and its core technologies provided further drive and the technical capabilities to transform SaaS into what we know it today.*



# **Business Of SaaS (Home Study)**

# The business of SaaS

## CHARACTERISING SaaS

Who's the target customer?

### IaaS

#### SYSTEM ADMINISTRATOR

*IaaS offerings facilitate system administration and maintenance. It streamlines infrastructure management.*



### PaaS

#### DEVELOPER

*PaaS offerings provide agility and services for those who build and develop applications and systems.*



### SaaS

#### END USER

*SaaS offerings, provide solutions ready to use. The end user is the one who benefits from it by leasing instead of buying software.*



# The business of SaaS

## CHARACTERISING SaaS

Who's the target customer?

*Even though they cover a large range of applications and systems, the most popular are those implementing business functions.*

*Remember the examples we mentioned before?*

- |    |   |
|----|---|
| 01 | CUSTOMER RELATIONSHIP MANAGEMENT (CRM)                      |
| 02 | ENTERPRISE RESOURCE PLANNING (ERP)                          |
| 03 | OFFICE AUTOMATION (SPREADSHEET, EMAIL, WORD PROCESSING ...) |
| 04 | VIDEO CONFERENCING  |
| 05 | TALENT AND HUMAN CAPITAL MANAGEMENT                         |
| 06 | SOCIAL MEDIA CAMPAIGNING                                    |
| 07 | PROJECT MANAGEMENT AND COLLABORATION TOOLS                  |

# The business of SaaS

## CHARACTERISING SaaS

### When to look for a SaaS offering?

*SaaS offering are the most advantageous options when:*

01

#### YOU NEED STANDARD SOLUTIONS TO BUSINESS FUNCTIONS

*Even though different SaaS offerings have different degrees of customisation, the real advantage of this approach comes with the ability of performing the business function as soon as the offering is accepted, without lead times.*

02

#### REDUCED IT ADMINISTRATION CAPABILITIES AND STAFF

*Your organisation does not have a large IT administration team that can support the deployment, installation, troubleshooting, and maintenance of an on premise option.*

03

#### LIMITED UPFRONT CAPITAL AND INCREMENTAL GROWTH

*SaaS solutions are usually offered through cheaper monthly subscriptions and with different service plans that can include different features.*

# The business of SaaS

## CHARACTERISING SaaS

### When SaaS is not appropriate?

*Because they focus on delivering “a completed solution” a SaaS offering might not be appropriate when:*

01

#### MULTI-TENANCY AND SHARED INFRASTRUCTURE ARE A “NO GO”

*SaaS solutions can be sold at a cheaper price because they rely on economies of scale to make profit. This is often achieved by exploiting at best the underlying infrastructure and platform to serve multiple customers.*

02

#### DATA SOVEREIGNTY AND PRIVACY REQUIREMENTS ARE NOT MET

*If the SaaS vendor does not allow you to control “where (which country)” your data will be stored or does not met your privacy and compliance constraints, you don’t have control on the underlying infrastructure to solve the problem.*

# The business of SaaS

## CHARACTERISING SaaS

### When SaaS is not appropriate? *(continued...)*

03

#### HIGH DEGREE OF CUSTOMISATION AND CONTROL

*SaaS solutions come with different degrees of flexibility but there is a limit to the ability of customising the feature of the offering or their integration they provide with existing systems. If your requirements are not met, the additional effort can be pricy.*

04

#### IT CAPACITY AND LONG TERM COMMITMENTS

*If your organisation has already a large installed base and the capacity to support the additional IT administration effort to run a similar option on premises, a SaaS offering can become less attractive especially if priced per user/month. In case of a long term commitment a yearly or perpetual license could potentially be cheaper.*

# The business of SaaS

## CHARACTERISING SaaS

### What to look for in SaaS offering?

01

#### SUBSCRIPTION PLAN AND PRICING

*SaaS solutions are commonly offered through subscriptions. These can provide different level of service and features available with the purchased option.*

04

#### USER ACCESS LIMITS

*Number of users is a very common metric for pricing the access to SaaS applications.*

03

#### SERVICE LEVEL AGREEMENTS

*SLAs define the quality of service offered and a minimum performance standard that the provider agrees to deliver. The primary metric is availability but other elements such as responsiveness can be defined.*

# Software as a Service

## LEARNINGS

What did we learn?

01

### TARGET CUSTOMER FOR A SaaS OFFERING

*SaaS offering target the end user, who needs an application to perform a business function.*

02

### ADVANTAGES AND DISADVANTAGES OF A SaaS OFFERING

*Software-as-a-Service is an attractive option because of its small upfront investment and capability of delivering “ready to use” applications for both business organisation and the individual. While this model is overall attractive it might not be optimal in scenarios where more control is needed or the scale of an organisation makes subscription costs the same or higher than perpetual licenses.*

03

### ASPECTS TO CONSIDER FOR EVALUATING SaaS OFFERING

*We briefly overviewed some of the key aspects to consider when evaluating the suitability of a SaaS offering for an organisation.*



# Case Studies

# Business cases

## EXERCISE

Which one of these is a SaaS offering?



### ON-LINE TRAVEL BOOKING

*They offer the ability to browse for different hotels, flights, and hire cars on line.*



### SOLUTIONS FOR DOCUMENT EDITING OVER THE WEB

*Web applications such as Google documents, which enable the creation and editing of documents, spreadsheets, and presentations from within the browser.*



### WEB HOSTING

*Application service providers manage data centers and provide you hosting for your web site.*



### CUSTOMER RELATIONSHIP MANAGEMENT ON THE CLOUD

*Solutions like SalesForce.com enabling organisations to manage their customer base, products, and sales over the web.*

# Business cases

## EXERCISE

### Tomato Inc. – Grocery to your doorstep

#### MEET THE STARTUP

*Tomato Inc. is a newly formed startup whose business is to connect local producers to the customers that operates in Bendigo, Victoria and surroundings.*

*Jordan Kale, Tomato's Inc. CEO is a local and over the years has established good relationships and can now tap into a large network of local farmers.*

*In his previous job Jordan has realised that the customer demand of fresh produce in Bendigo was constantly rising, but very often people did not have the time to shop.*

*Jordan decided to seize the opportunity and started a business in grocery delivery, directly from the farmer to your doorstep.*



# Business cases

## EXERCISE

### Tomato Inc. – Grocery to your doorstep

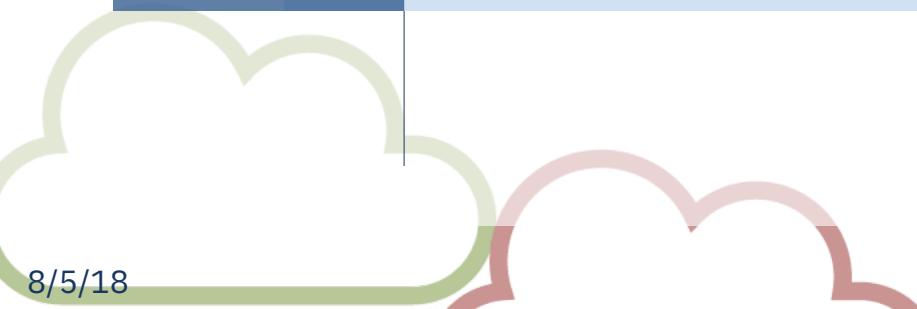
#### BUSINESS CHALLENGE

*Three months after its debut, Tomato Inc. has developed a profitable business and now accounts for 10 employees committed to the delivery of goods to more than 100 customers and working on a tight schedule.*

*Because of the positive season the business is thriving and the number of customer is rising. The size of the customer base has made it imperative to rely on IT support the daily operations of Tomato Inc.*

#### QUESTION

Can you articulate whether any of the cloud computing offering might be of most value to Tomato Inc. and how it will help to sustain and grow his business?



# Business cases

## EXERCISE

### Market Insights – License renewal dilemma

#### MEET THE COMPANY

*Market Insights is a large nation wide established company operating in Australia and New Zealand, providing market projections, advice to several enterprises in the two countries.*

*With more than 50 offices located in strategic cities in the two countries Market Insights is able to service several hundreds of organisations. The key service offering of the company is to conduct market research and produce specialised reports that are tailored to the single customer.*

*In order to perform its key function Market Insight leverages an on premise integrated solution for document management purchased under a 3-year license term. Because of the sensitive nature of the customer data it is imperative to keep reports securely and within the countries boundaries.*



# Business cases

## EXERCISE

### BUSINESS CHALLENGE

#### Market Insights – License renewal dilemma

*With five years of profitable business the company has grown and established several departments including the IT department that tooks care of all hardware and software the company needs to operate.*

*The IT department has effectively managed the maintenance of every systems including the office automation and document management solution that is essential to Market Insights business. Now at the end of the three-year license period, Market Insights is assessing the best path to go forward to continue its business.*

*After a careful assessment of the available options, Market Insights has shortlisted three alternatives:*

1. *Renew the license for another three years*
2. *Transit to the cloud-based solution hosted in the United States*
3. *Implement their own document management system on a A/NZ PaaS platform.*

### QUESTION

Which is the best choice for Market Inisights and why?