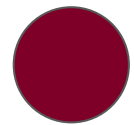


# SLA-driven governance for RESTful systems

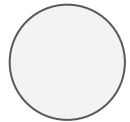
Antonio Gámez Díaz

ISA Research Group - University of Seville

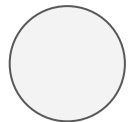
# Agenda



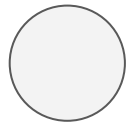
**Where do I come from?**



What is my research focus?



What am I currently doing?



Why am I in Lugano?

# Who am I ?



## Antonio Gámez Díaz

*Soft. Eng. MSc. Predoctoral researcher*

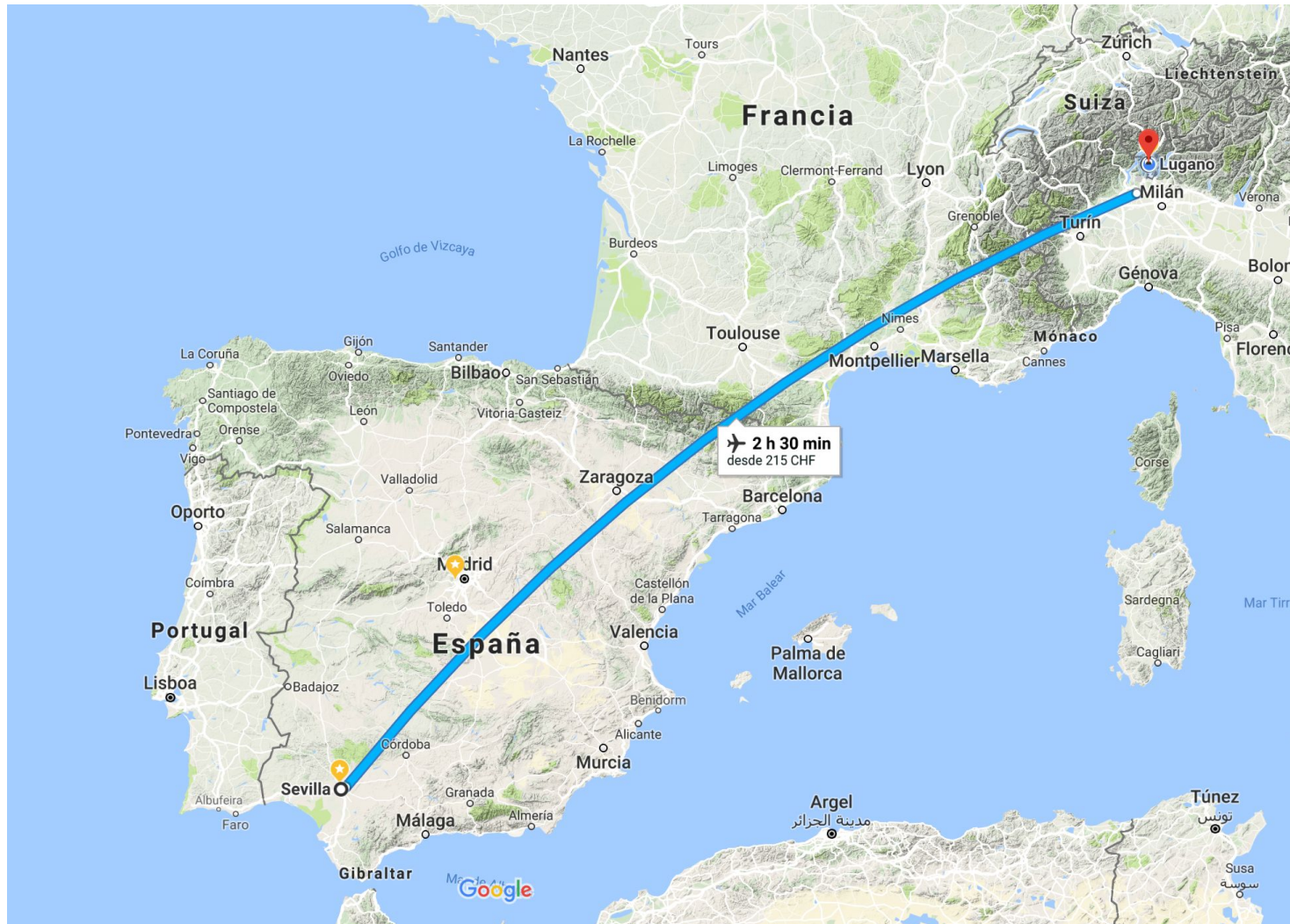
- > *Applied Software Engineering (ISA) Research Group*
- > Universidad de Sevilla
- > Docker Campus & Auth0 Ambassador

>> **mailto:** [agamez2@us.es](mailto:agamez2@us.es)

>> **href:** [personal.us.es/agamez2](http://personal.us.es/agamez2)



# Where am I from?



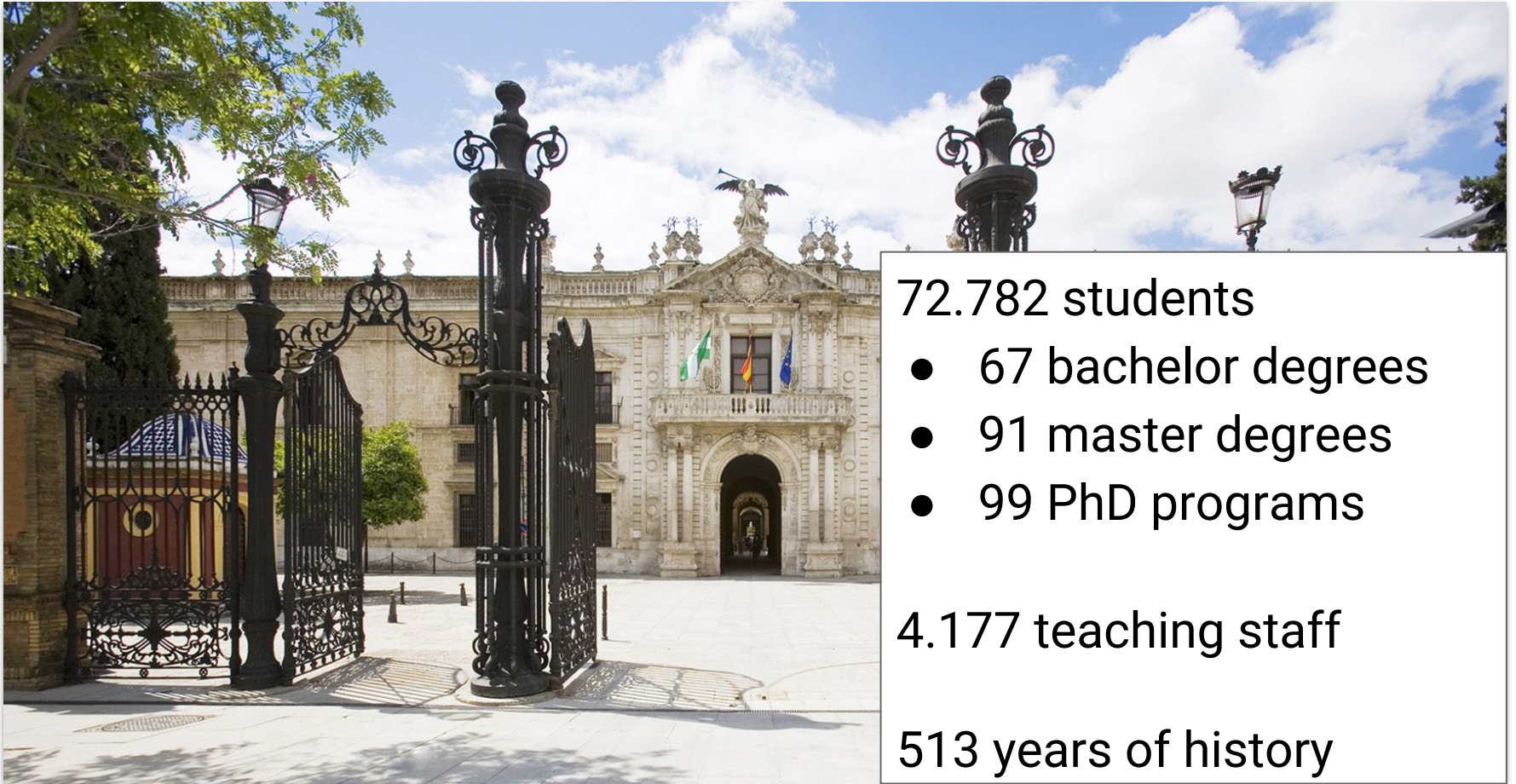


# Seville





# University of Seville



# High Technical School of Computer Engineering



725 new students annually

- 5 bachelor degrees
- 3 master degrees
- 1 PhD program

294 teaching staff

33 years of history

 Escuela Técnica Superior de  
**Ingeniería Informática**

# ISA Research Group

22 members

- 18 senior research staff
- 4 predoctoral researchers
- 8 research assistants

- + 200 publications
- + 8200 citations
- 3 international patents
- + 16 software tools
- 5 european research projects
- + 10 national projects
- 5 research networks
- + 35 ICT contracts
- 2 spin-offs





# ISA members



Antonio Ruiz

HEAD



José A. Galindo



Javier Troya



Ana B. Sánchez



Adela del Río



Amador Durán



Beatriz Bernárdez



Carlos Müller



David F. Benavides



Joaquín Peña



Jose A. Parejo



Alfonso E. Márquez



José M. García



Manuel Resinas



Octavio Martín



Pablo Fernández



Pablo Trinidad



Sergio Segura

## 18 senior researchers

# ISA members



Antonio M. Gutiérrez



Bedilia Estrada



Margarita Cruz



Antonio Gámez

**Predoctoral  
researchers team!**

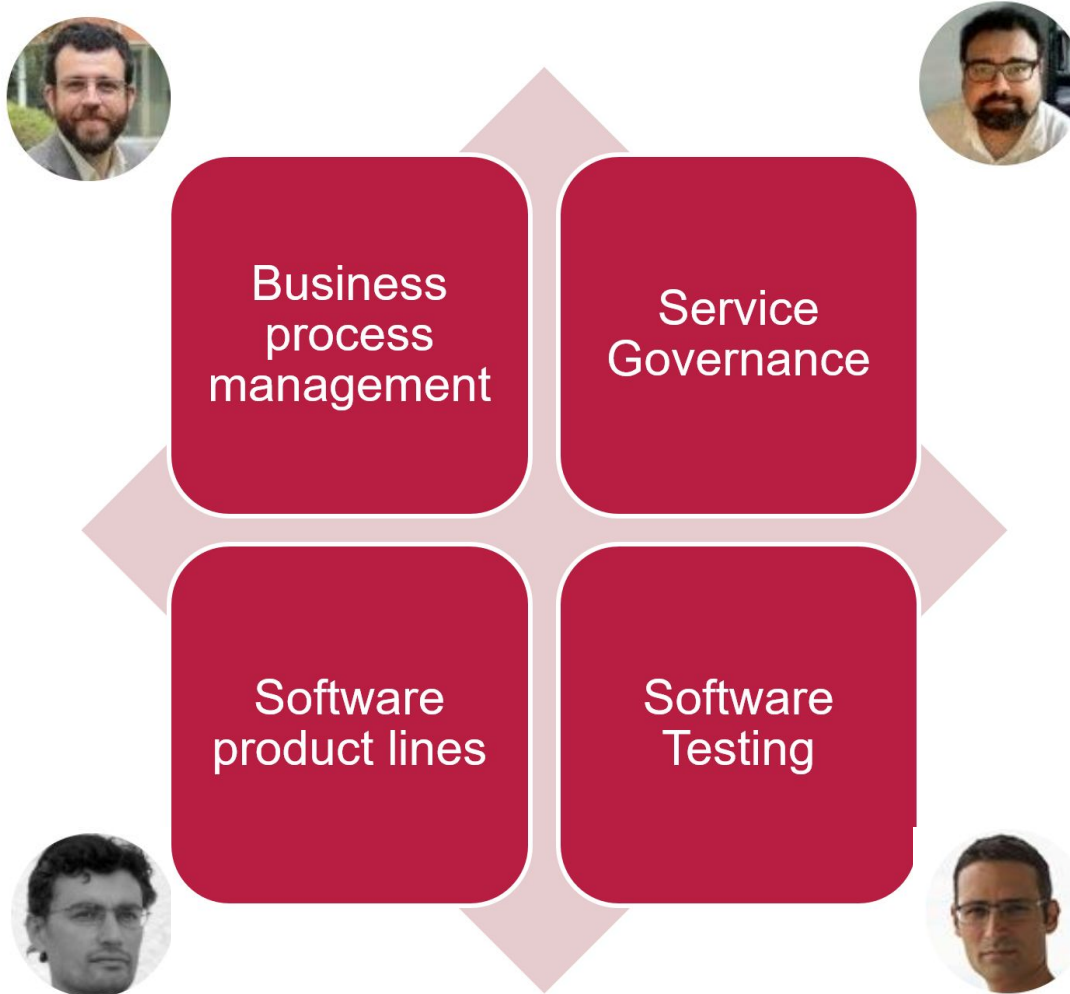
and many international  
co-advised PhD students



**8 research assistants  
and 24 former ones**

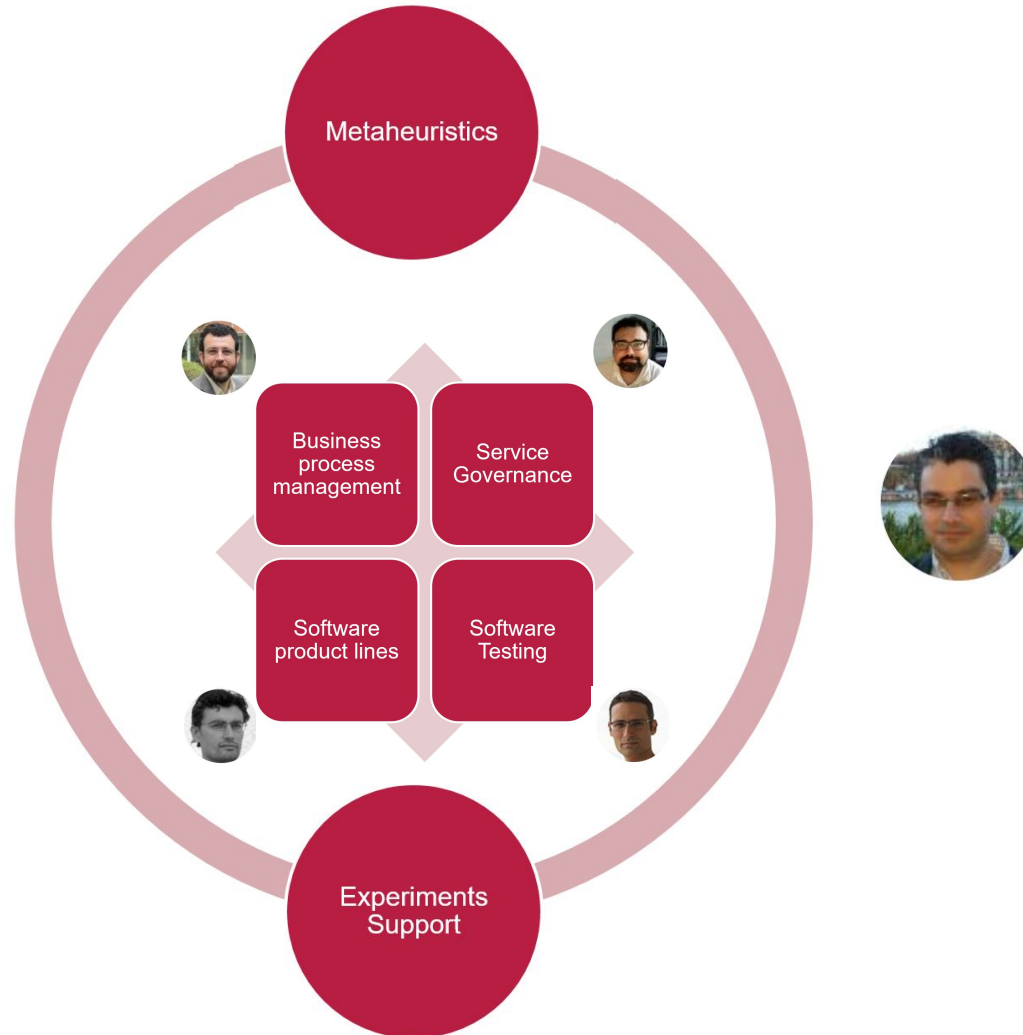
now working for Amazon, as CTOs and other  
important positions in national companies.

# ISA research areas






# ISA Research areas




# ISA tools



**ADA Tool Suite**  
Registered Tool

View more


i



**BeTty**  
Registered Tool

View more

i



**CRISTAL**  
Registered Tool

View more


i



**FaMa Tool Suite**  
Registered Tool

View more


i



**FAST**  
Registered Tool

View more


i



**PPINOT**  
Registered Tool

View more


i



**REM**  
Registered Tool

View more

i

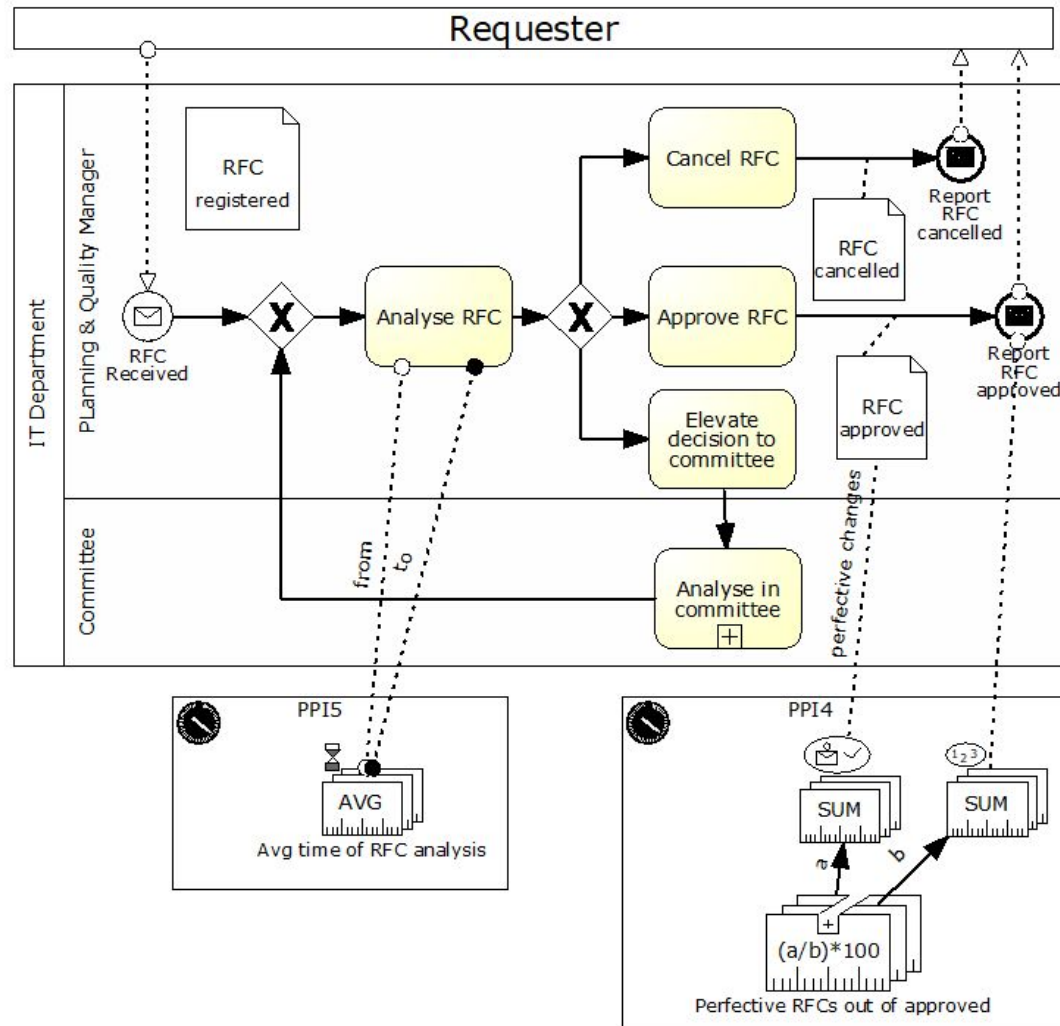


**STATService**  
Registered Tool

View more

i

# ISA Tools - PPINOT





# ISA Tools - EXEMPLAR

## EXperiments Management PLAtfoRm

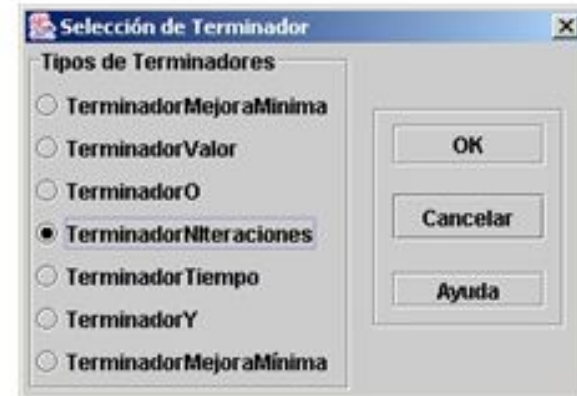
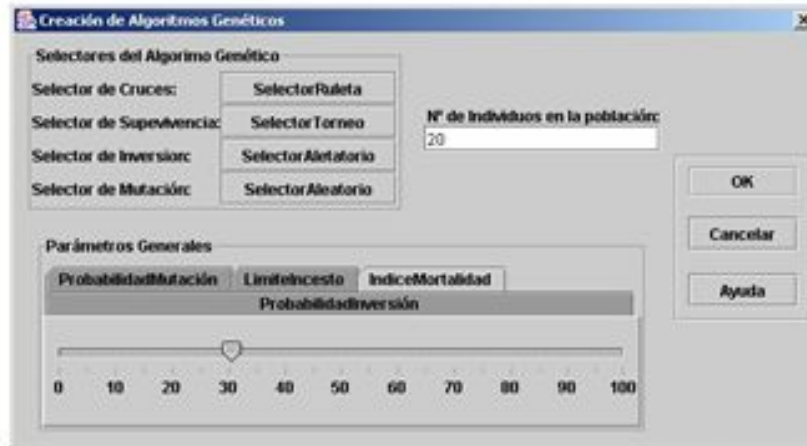


# ISA Tools - SMARTTEST

- A suite of statistical analysis tools that comprises of:
  - A web portal (that support online analysis of datasets).
  - A set XML/SOAP Web Services.
  - A plugin for MS Excel



# ISA Tools - FOM

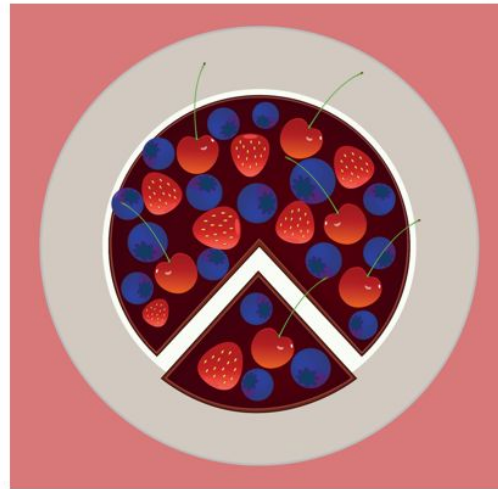
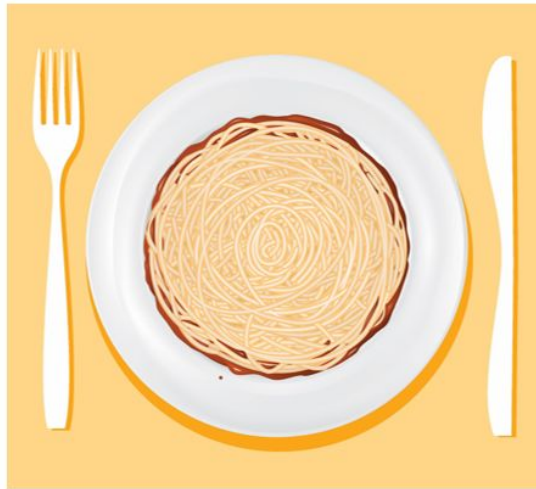




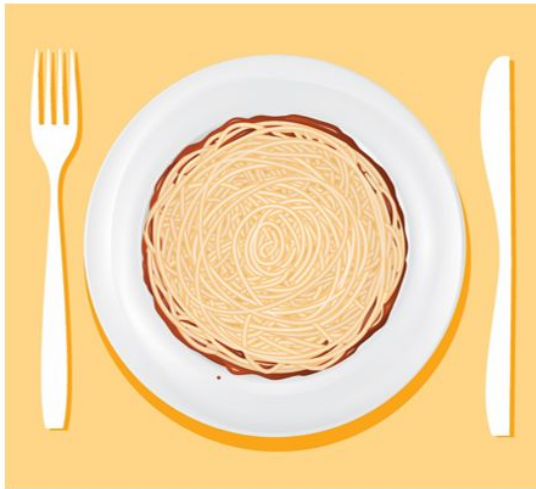
# Agenda

- ☐ Where do I come from?
- ☒ **What is my research focus?**
- ☐ What am I currently doing?
- ☐ Why am I in Lugano?

# Evolution of software architectures



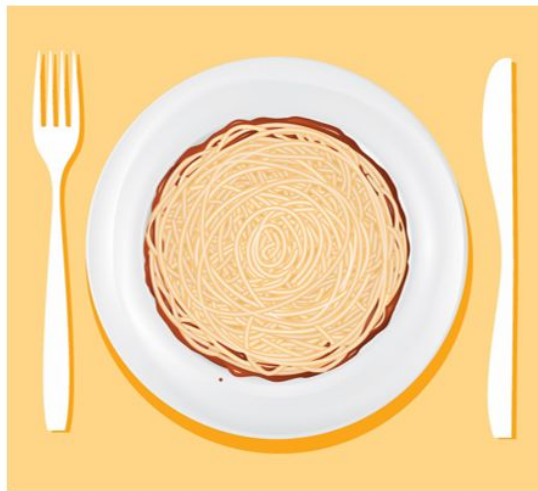
# Evolution of software architectures



90's



# Evolution of software architectures



90's



00's

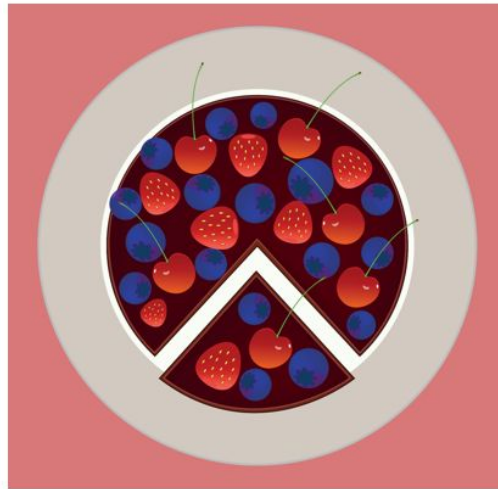


Illustration by [Kanban Solutions](#)

# Evolution of software architectures



90's



00's



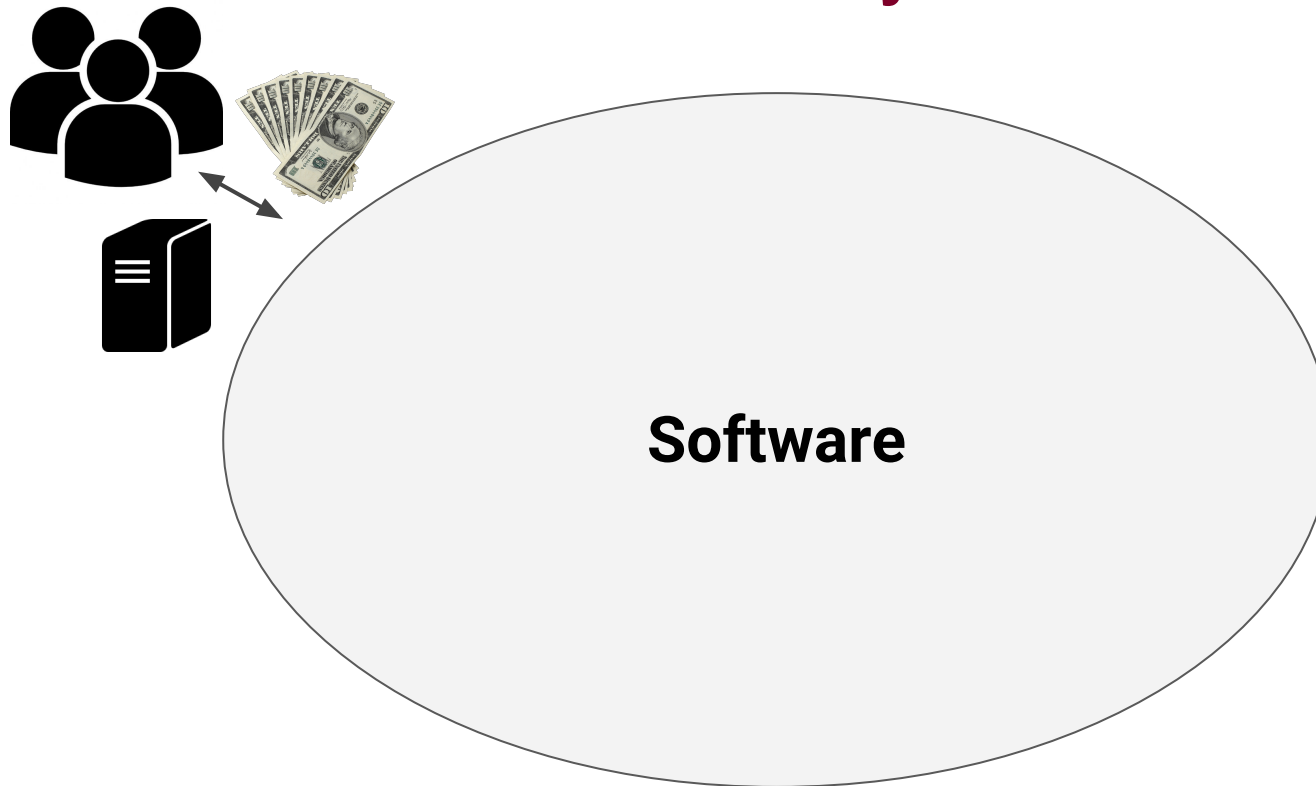
10's



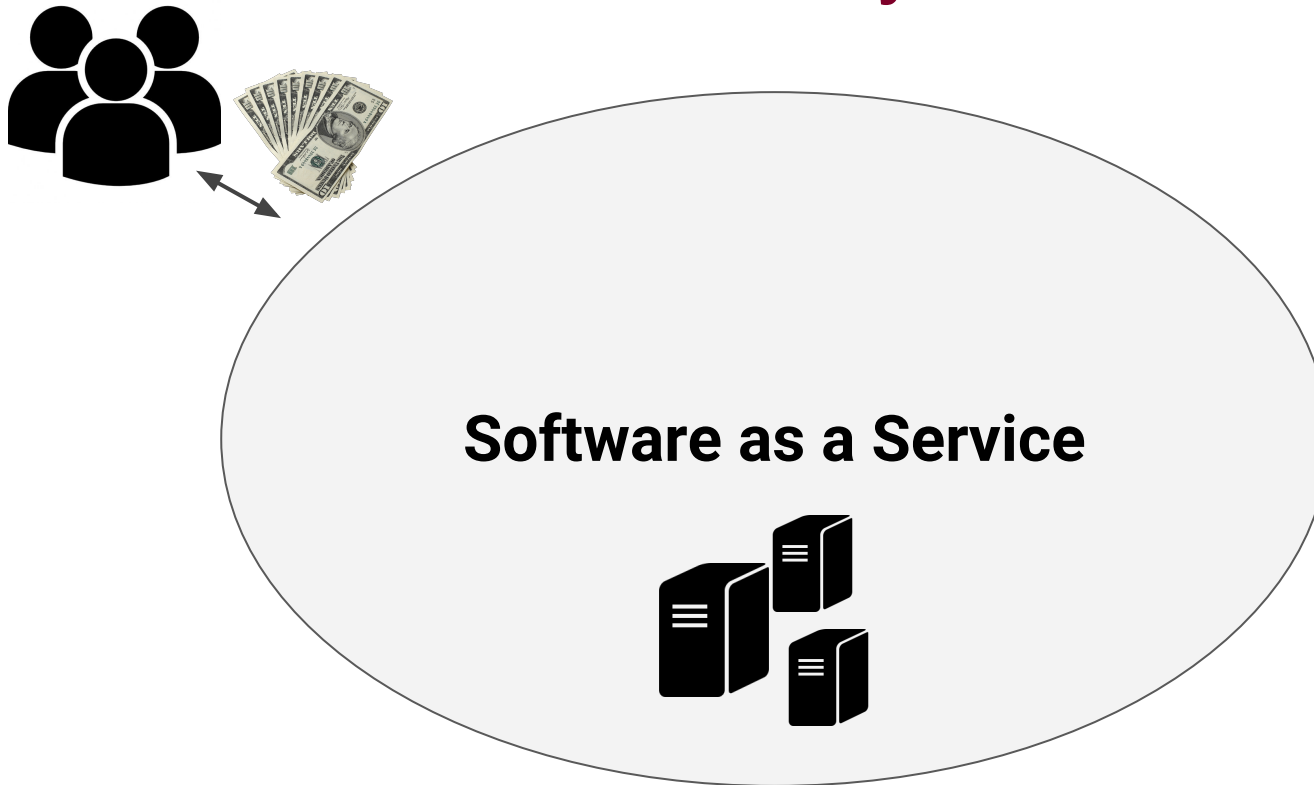
Illustration by [Kanban Solutions](#)



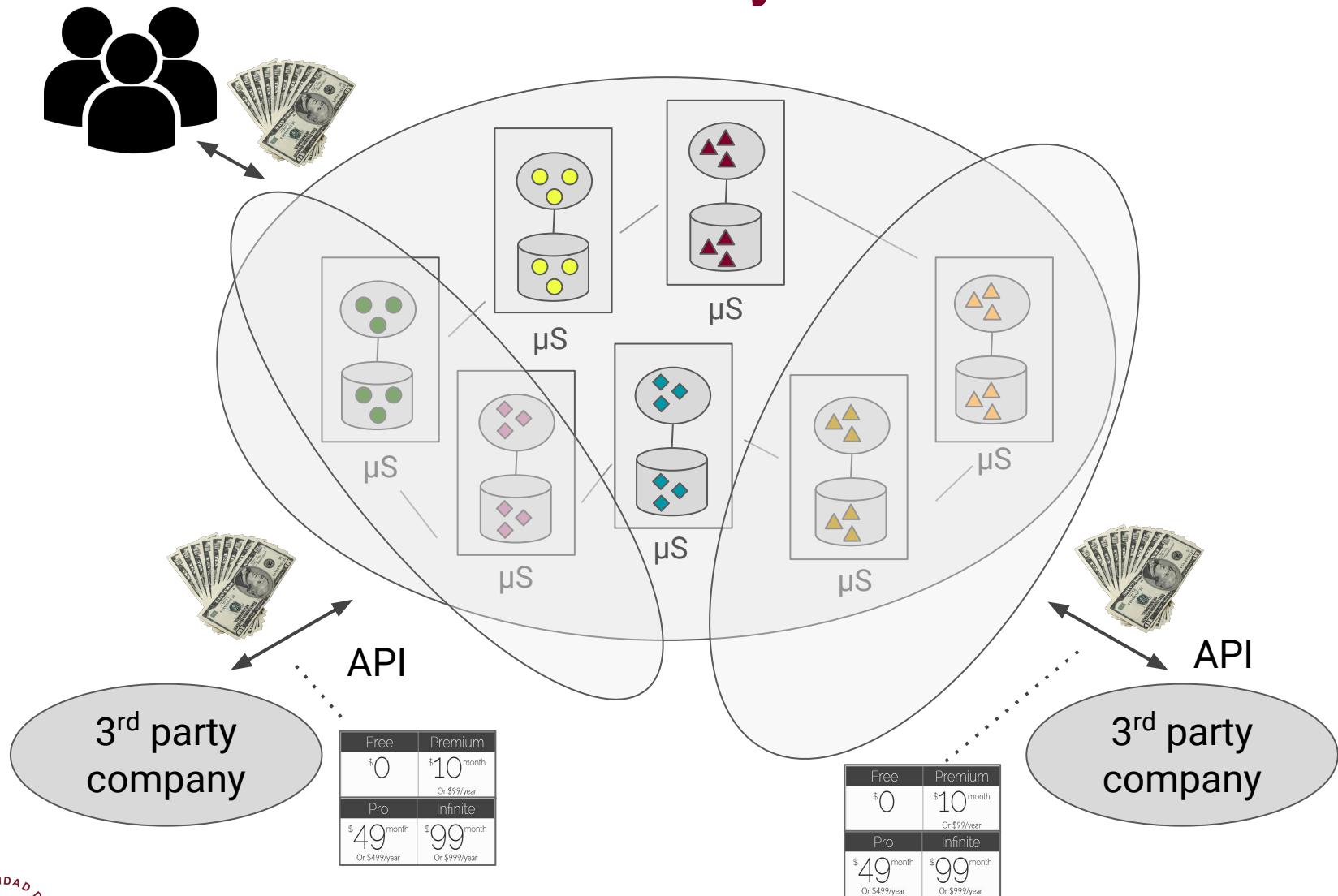
# Software delivery evolution



# Software delivery evolution



# Software delivery evolution



# SLAs in APIs

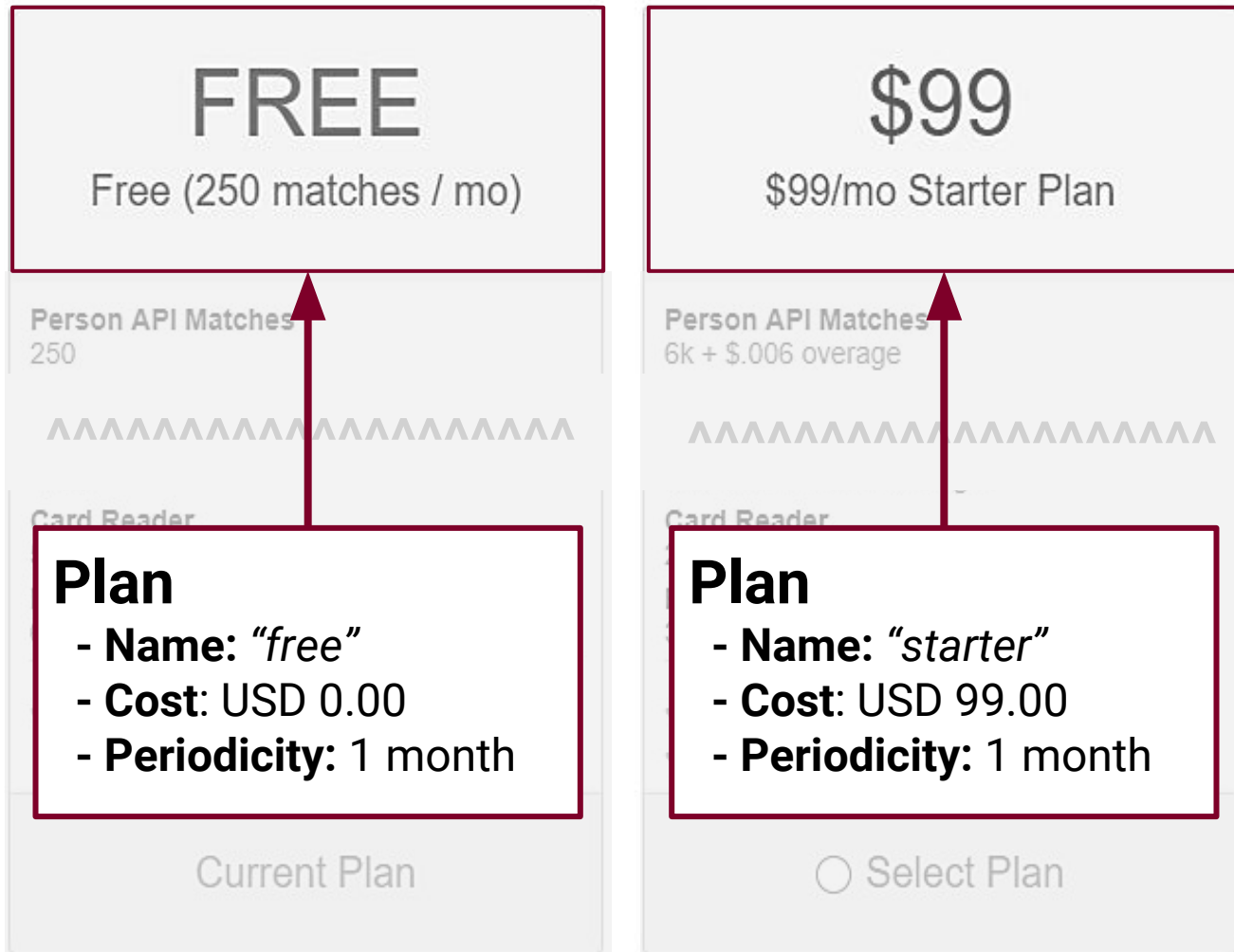
FREE	\$99	\$199
Free (250 matches / mo)	\$99/mo Starter Plan	\$199/mo Basic Plan
Advanced SLAs		
<b>Name/Location/Stats API Matches</b> 100k	<b>Name/Location/Stats API Matches</b> 15k each + \$.001 overage	<b>Name/Location/Stats API Matches</b> 50k each +.001
<b>Card Reader</b> 50 (Low Quality)	<b>Card Reader</b> 25 cards + \$.015 overage	<b>Card Reader</b> 25 cards + \$.015 overage
<b>Rate Limit</b> 60 queries / min.	<b>Rate Limit</b> 300 queries / min.	<b>Rate Limit</b> 300 queries / min.
✓ Basic Contact Information	✓ Basic Contact Information ✓ Licensed for Business Use	✓ Basic Contact Information ✓ Licensed for Business Use
Current Plan	<input type="radio"/> Select Plan	<input type="radio"/> Select Plan

# SLAs in APIs

<div>FREE</div> <div>Free (250 matches / mo)</div> <div>Person API Matches 250</div> <div>AAAAAAAAAAAAAAAAAAAA</div> <div>Card Reader 50 (Low Quality) Rate Limit 60 queries / min.</div> <div>✓ Basic Contact Information</div> <div>Current Plan</div>	<div>\$99</div> <div>\$99/mo Starter Plan</div> <div>Person API Matches 6k + \$.006 overage</div> <div>AAAAAAAAAAAAAAAAAAAA</div> <div>Card Reader 25 cards + \$0.15 overage Rate Limit 300 queries / min.</div> <div>✓ Basic Contact Information ✓ Licensed for Business Use</div> <div><input type="radio"/> Select Plan</div>
--	--



# SLAs in APIs



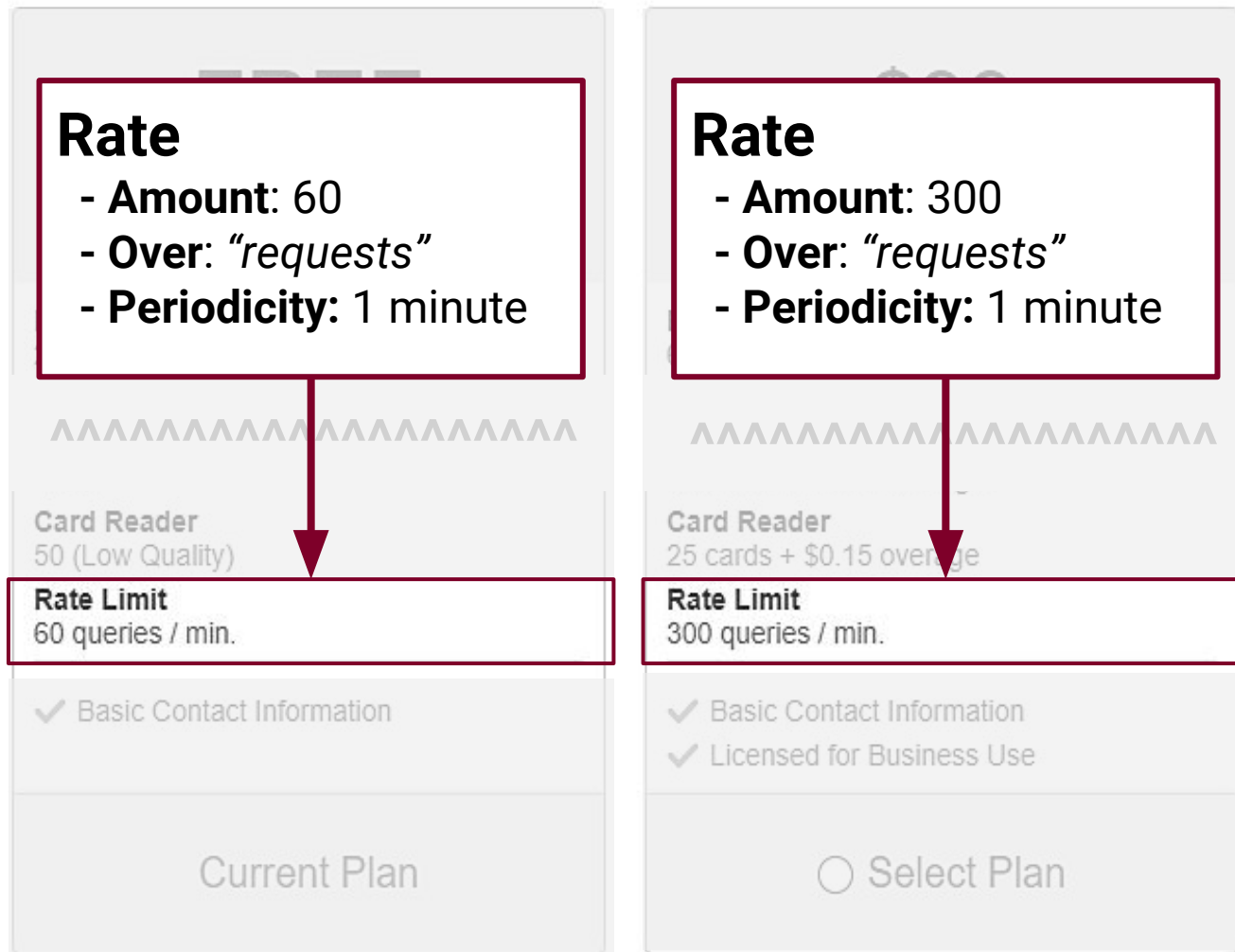
# SLAs in APIs

FREE	\$99
Free (250 matches / mo)	\$99 (6k matches / mo)
<b>Person API Matches</b> 250	<b>Person API Matches</b> 6k
Card Reader 50 (Low Quality)	Card Reader 25 cards + \$0.15 overage
Rate Limit 60 queries / min.	Rate Limit 300 queries / min.
✓ Basic Contact Information	✓ Basic Contact Information ✓ Licensed for Business Use
Current Plan	Select Plan

**Quota**

- **Amount:** 250
- **Over:** "requests"
- **Periodicity:** 1 month

# SLAs in APIs



# SLAs in APIs

**FREE**  
Free (250 matches / mo)

**\$99**  
\$99/mo Starter Plan

**Quota**

- **Amount:** 25
- **Over:** "cards"
- **Periodicity:** 1 month
- **Overage:** 1 month
  - **Cost:** USD 0.15
  - **Periodicity:** 1 card

**Person API Matches**  
6k + \$.006 overage

**Card Reader**  
25 cards + \$0.15 overage

**Rate Limit**  
300 queries / min.

✓ Basic Contact Information  
✓ Licensed for Business Use

Current Plan

Select Plan

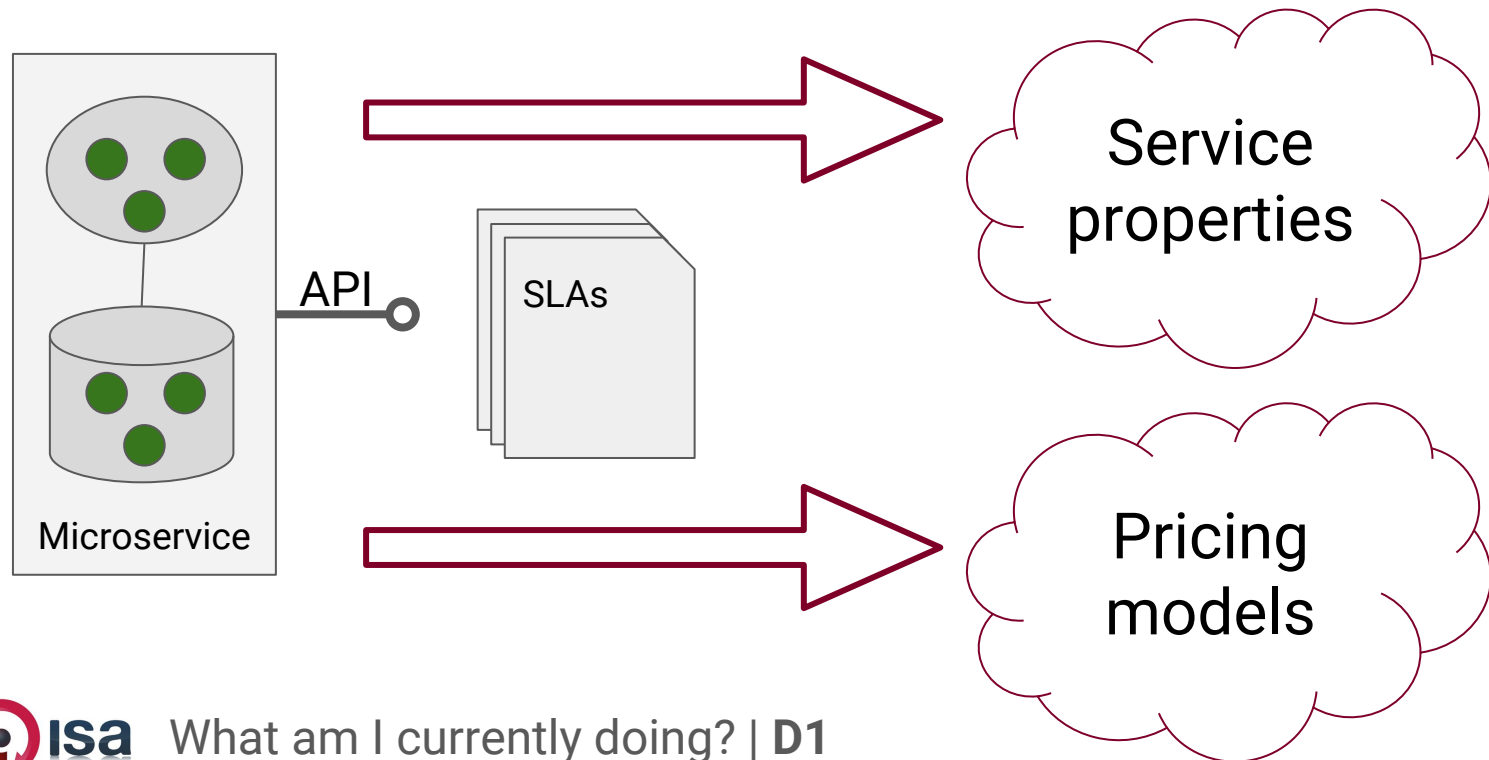
# Agenda

- ☐ Where do I come from?
- ☐ What is my research focus?
- ☒ **What am I currently doing?**
- ☐ Why am I in Lugano?



# Research challenges - D1

**D1:** Establishing a sufficiently **expressive specification** for the description of **RESTful microservices** regulated by advanced **SLAs**



## Research challenges - D1

- A systematic analysis of **69 APIs** in the industry from **two API data sources**:

**ProgrammableWeb**: largest API directory.

*+ 137 K APIs in 477 categories.*

**Mashape**: largest API marketplace.

*+ 7.5K APIs in 18 categories.*

- Generating an open dataset of **40 attributes** distributed in **7 areas**.

# Research challenges - D1

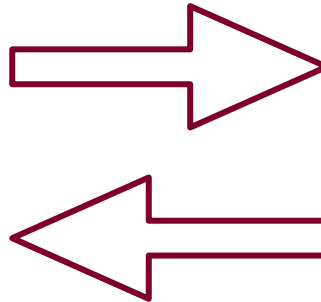
[github.com/isa-group/SLA4OAI-Specification](https://github.com/isa-group/SLA4OAI-Specification)

```
openapi: 3.0.0

info:
  title: Scopus API
  version: 1.0
  description: See elsevier.com
  x-sla: ./scopus-sla4oai.yaml

paths:
  /search/affiliation:
  /search/author:
    ...
  /search/scopus:
  /abstract/doi/{doi}:
  /abstract/eid/{eid}:
  /abstract/pii/{pii}:
  /abstract/pubmed_id/{pubmed_id}:
  /abstract/pui/{pui}:
  /abstract/scopus_id/{scopus_id}:
  /affiliation/affiliation_id/{
    affiliation_id}:
  /affiliation/eid/{eid}:
  /author/eid/{eid}:
  /author/author_id/{author_id}:
  /abstract/citation-count:
  /abstract/citations:
  /serial/title:
  /serial/title/issn/{issn}:

components:
  schemas:
    scopus:
    affiliation:
    author:
    stream:
```



```
plans:
  non-subscriber:
    pricing:
      cost: ...
    rates:
      ...
      /search/author:
        get:
          requests:
            - max: 3
              period: secondly
    quotas:
      ...
      /search/author:
        get:
          requests:
            - max: 5000
              period: weekly
  subscriber:
    pricing:
      cost: ...
    rates:
      ...
      /search/author:
        get:
          requests:
            - max: 3
              period: secondly
    quotas:
      ...
      /search/author:
        get:
          requests:
            - max: 5000
              period: weekly
```



## Research challenges - D2

**D2:** Develop a catalog of **SLA analysis and management operations** to support the governance of microservice architectures.



## Research challenges - D2

**But... how can we make decisions without having the full picture?**

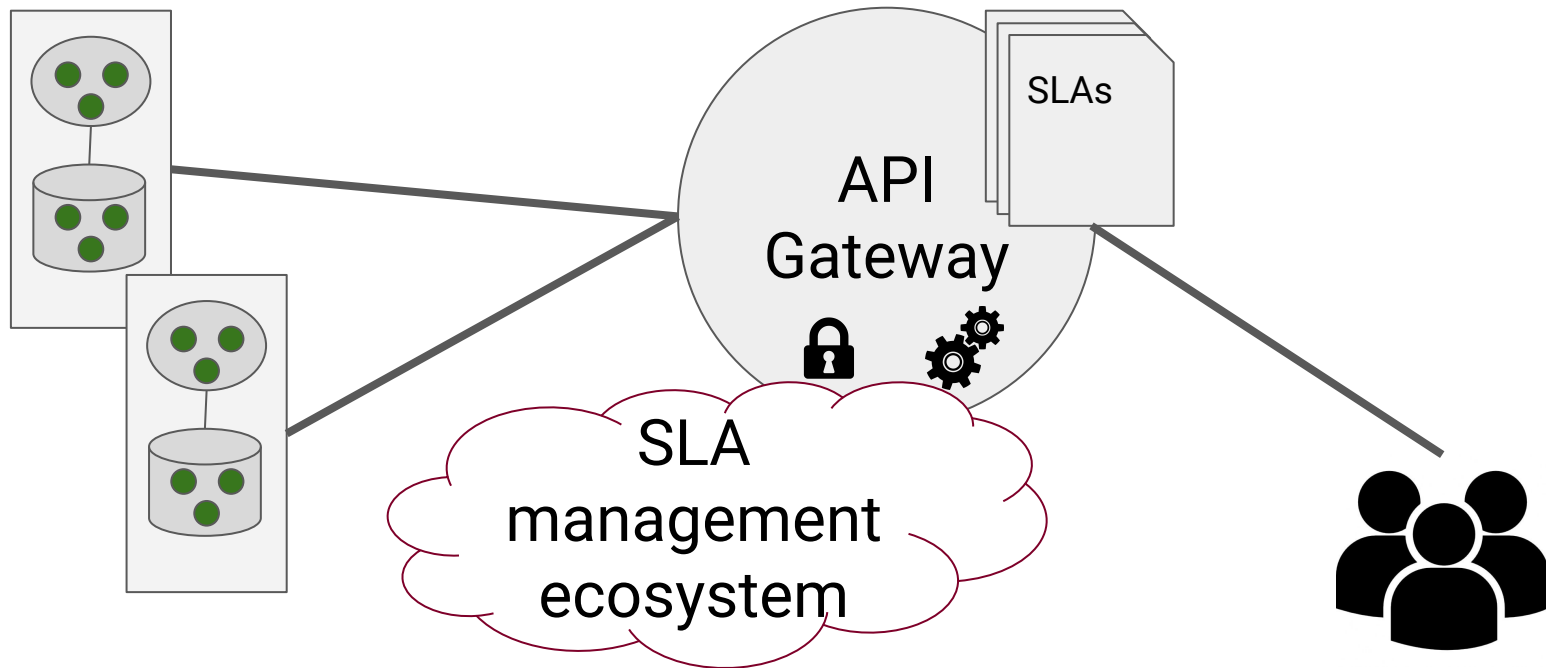


**Comprehensive  
RESTful API modeling**



## Research challenges - D3

**D3:** Implement a **SLAs management ecosystem** to support the government of RESTful microservices



# Research challenges - D3

gateway.oai.governify.io



You are not logged in

Log In

## Scopus API <sup>2.0</sup>

[/api-docs](#)

See [https://dev.elsevier.com/api\\_key\\_settings.html](https://dev.elsevier.com/api_key_settings.html) for detailed information.

Schemes

HTTPS

### Scopus\_Search Scopus Search API

GET /scopus/search/scopus Scopus Search API

### Affiliation\_Search Affiliation Search API

GET /scopus/search/affiliation Affiliation Search API

## NON-SUBSCRIBER

0 € / month

Quotas

100 weekly

1000 weekly

75 weekly

Rates

1 secondly

BUY

## SUBSCRIBER

9.99 € / month

Quotas

5000 weekly

20000 weekly

1000 weekly

Rates

3 secondly

BUY

## Research challenges - D4

**D4:** Consolidation of the **Governify** platform to **validate the proposal** in industrial environments.

# GOVERNIFY



# Agenda

- ☐ Where do I come from?
- ☐ What is my research focus?
- ☐ What am I currently doing?
- ☒ **Why am I in Lugano?**

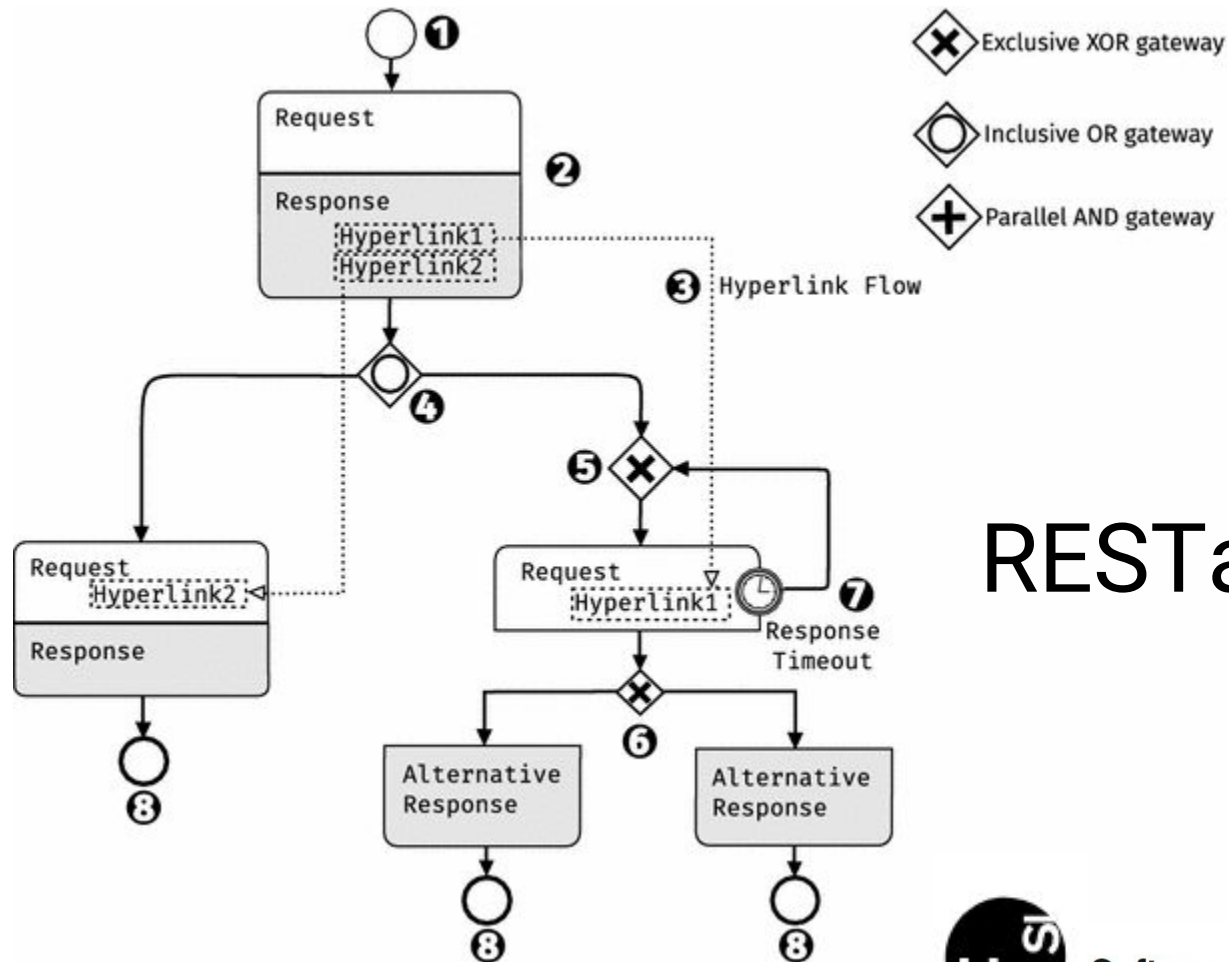


## My research stay in Lugano

1. What is the **best API usage plan** given a conversation?
2. How many instances of conversations can I invoke **until I reach the quota**?
3. How much time should I wait to **not to exceed rates**?
4. How to **set limitations to my clients** if I depends on 3rd party APIs



# My research stay in Lugano

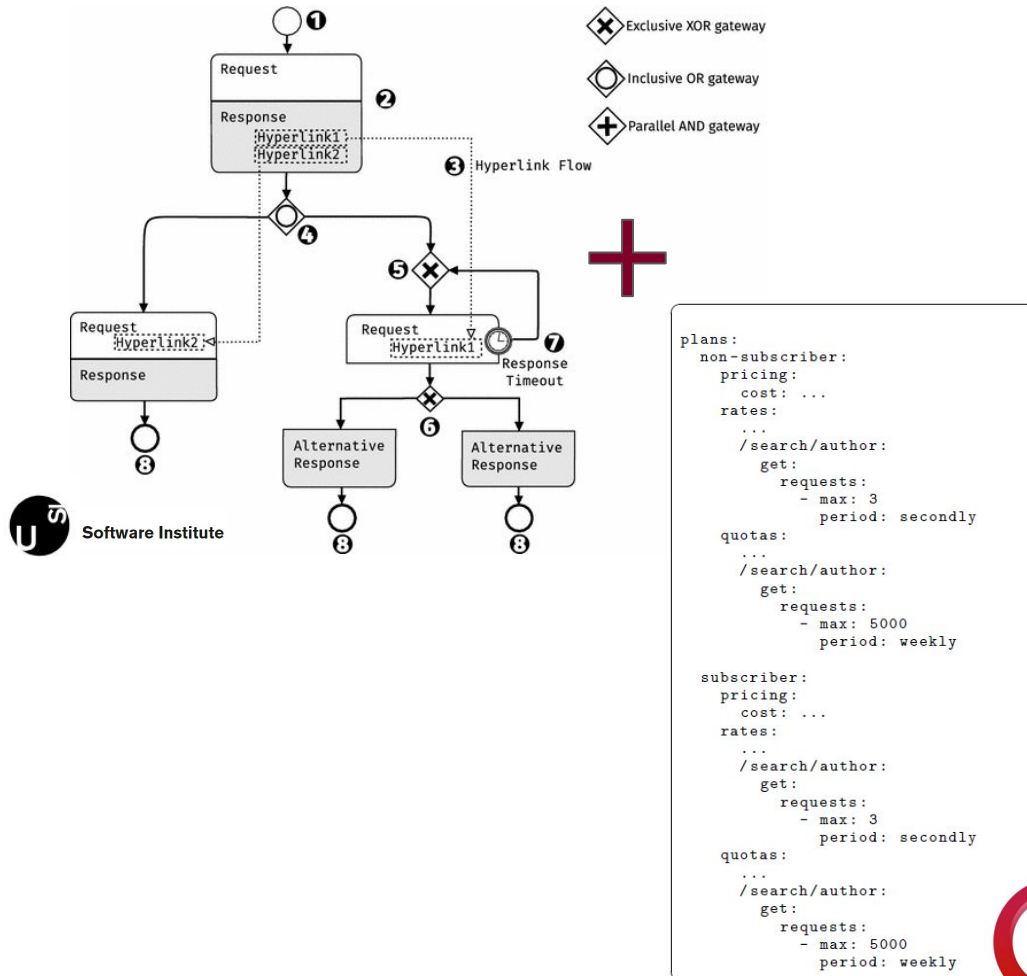


## RESTalk



Software Institute

# My research stay in Lugano



```
openapi: 3.0.0

info:
  title: Scopus API
  version: 1.0
  description: See elsevier.com
  x-sla: ./scopus-sla4oai.yaml

paths:
  /search/affiliation:
  /search/author:
    ...
  /search/scopus:
  /abstract/doi/{doi}:
  /abstract/eid/{eid}:
  /abstract/pii/{pii}:
  /abstract/pubmed_id/{pubmed_id}:
  /abstract/pui/{pui}:
  /abstract/scopus_id/{scopus_id}:
  /affiliation/affiliation_id/{
    affiliation_id}:
  /affiliation/eid/{eid}:
  /author/eid/{eid}:
  /author/author_id/{author_id}:
  /abstract/citation-count:
  /abstract/citations:
  /serial/title:
  /serial/title/issn/{issn}:

components:
  schemas:
    scopus:
    affiliation:
    author:
    stream:
```

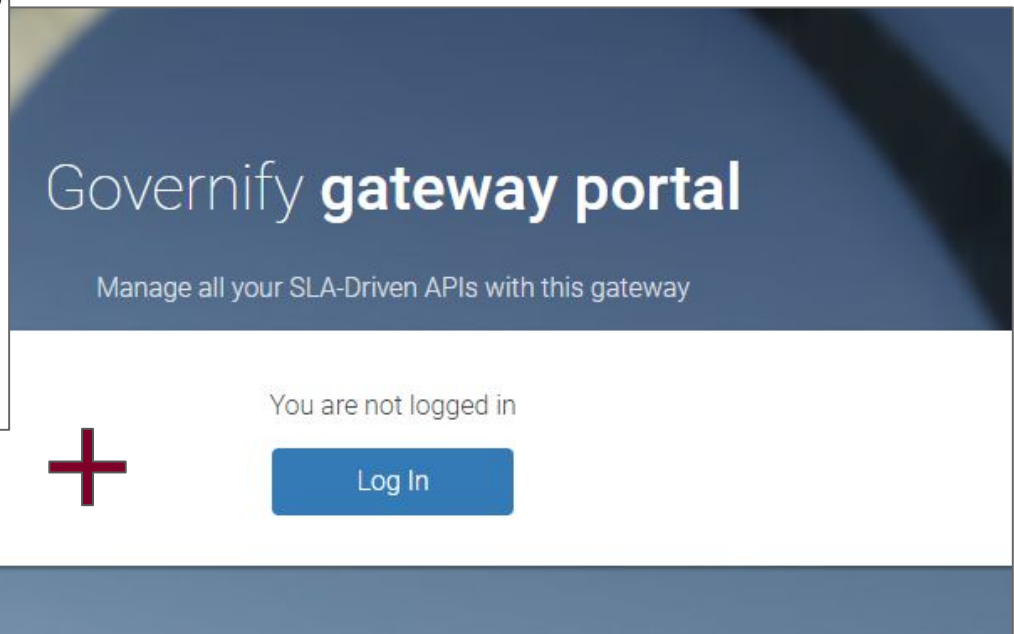
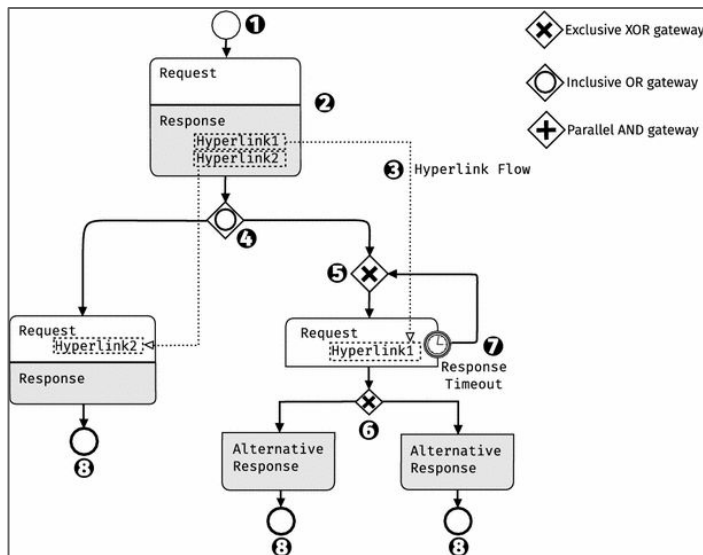
```
plans:
  non-subscriber:
    pricing:
      cost: ...
    rates:
      ...
      /search/author:
        get:
          requests:
            - max: 3
              period: secondly
    quotas:
      ...
      /search/author:
        get:
          requests:
            - max: 5000
              period: weekly

  subscriber:
    pricing:
      cost: ...
    rates:
      ...
      /search/author:
        get:
          requests:
            - max: 3
              period: secondly
    quotas:
      ...
      /search/author:
        get:
          requests:
            - max: 5000
              period: weekly
```





# My research stay in Lugano



# SLA-driven governance for RESTful systems

Thank you  
Questions?

**Antonio Gámez Díaz**

ISA Research Group

Depto. Lenguajes y Sistemas Informáticos

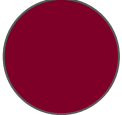
ETSII, Universidad de Sevilla, España

✉ >> [agamez2@us.es](mailto:agamez2@us.es)

📱 >> [personal.us.es/agamez2](http://personal.us.es/agamez2)



## Extra slides

 Results of the ICSOC study

 OAI in a nutshell

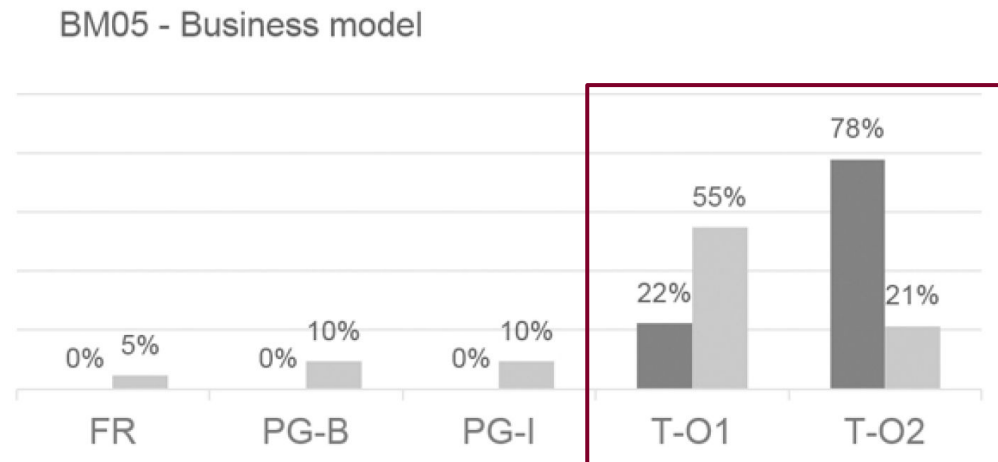
 Governify in a nutshell

## Results: conclusions

 **RQ-01** What are the most common **business models**?



Most APIs offer a **tiered** plan with or without **overage**.



## Results: conclusions



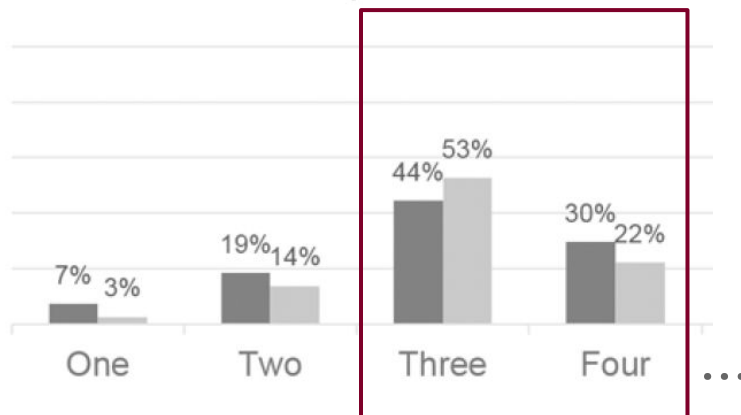
RQ-02

How are the plans in terms of the characteristics they have?

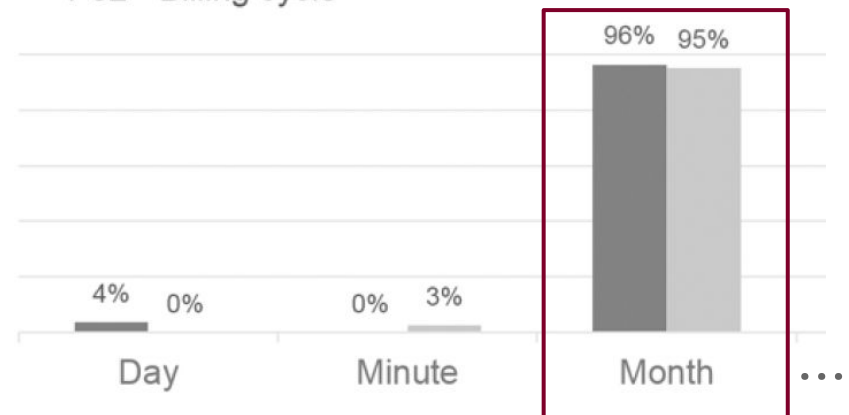


Most APIs define between **2-4 plans**, with a **monthly** billing cycle.

BM06 - Number of plans



P02 - Billing cycle



## Results: conclusions



**RQ-03**

Which **regulations** do the providers state over the RESTful APIs?

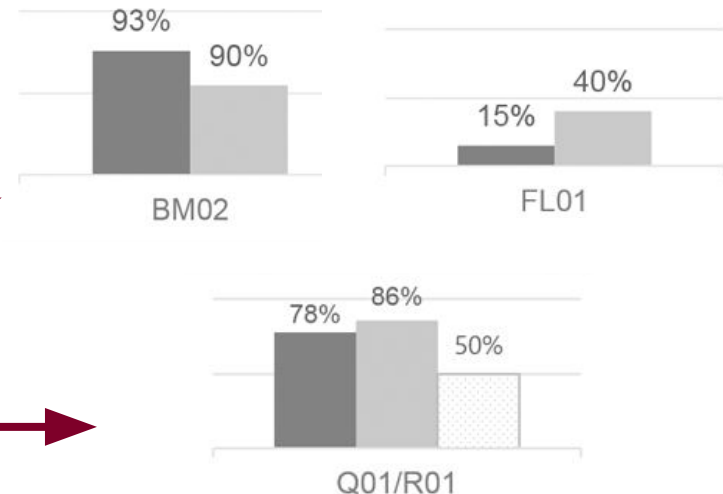


Most API providers **apply limitations** in somehow:

- **Type** of limitations:

- **Free tier:** restricting the allowed **operations**.

- **Paid plans:** both **quotas** and **rates** definition.



## Results: conclusions



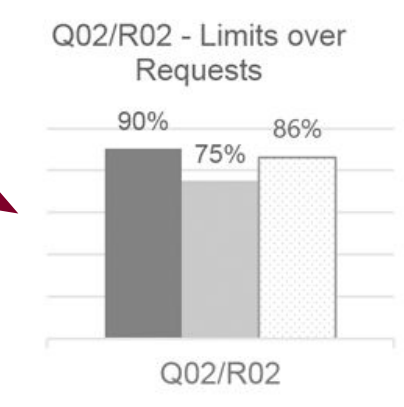
**RQ-03**

Which **regulations** do the providers state over the RESTful APIs?



Most API providers **apply limitations** in somehow:

- **Limitations** are usually **scoped** over the number of **requests**.





## Results: conclusions



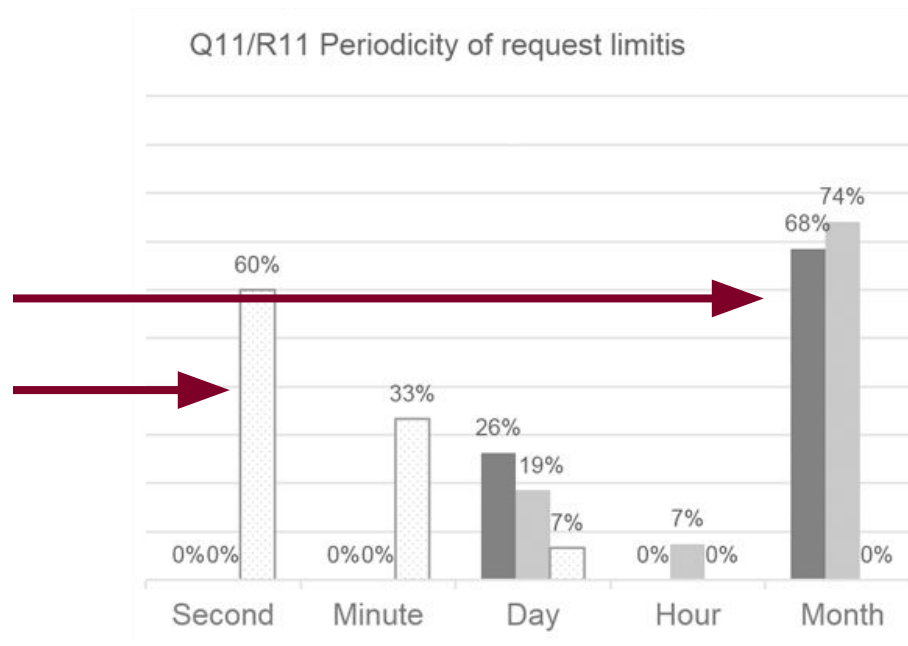
**RQ-03**

Which **regulations** do the providers state over the RESTful APIs?



Most API providers **apply limitations** in somehow:

- Periodicity **intervals**:
  - **Quotas**: monthly
  - **Rates**: secondly.



## Results: conclusions



**Extra**

Is there any **difference** between the APIs selected from a **marketplace** and the ones selected from a **general directory**?

API plans from general directories have a **higher level of expressivity**.

- For instance:
  - **Rates** definition.
  - **Combined** business models.
  - **Mixing** periodicity for limitations.
  - **Fine-grained** limitations and billing.

# Final remarks

## What did we do?

- We have **systematically** studied, in an **open** dataset, **40 attributes** in **3 main areas** in **69 real-world APIs** from the **2 main API sources**.

## What did we find?

- There **exists a wider expressivity** in the **plans** when the **API is not explicitly regulated** by API marketplaces.
- The results can also be useful for **practitioners** who have to **design a new API plan**.

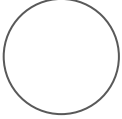
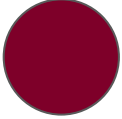
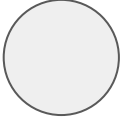
# Future work

## What do we plan to do?

- Identify a **correlation** between the **plan** offered and the **types of limitations**.
- Extend the **analysis** and enlarge the open **dataset**.

Identify a specific **set of requirements** to define a **formal model** to describe **API non-functional** aspects

## Extra slides

-  Results of the ICSOC study
-  **OAI in a nutshell**
-  Governify in a nutshell

# OAI in a nutshell



```
▼ object {5}
  openapi : 3.0.0
  ► info {3}
  ► servers [1]
  ► paths {2}
  ► components {1}
```

```
▼ paths {2}
  ▼ /pets {2}
    ► get {5}
    ► post {4}
  ▼ /pets/{petId} {1}
    ▼ get {5}
```



# OAI in a nutshell



```
▼ /pets/{petId} {1}
  ▼ get {5}
    summary : Info for a specific pet
    operationId : showPetById
    ► tags [1]
    ▼ parameters [1]
      ▼ 0 {5}
        name : petId
        in : path
        required : ☒ true
        description : The id of the pet
        ▼ schema {1}
          type : string
    ▼ responses {2}
```

```
▼ responses {2}
  ▼ 200 {2}
    description : Expected response to a valid
    ▼ content {1}
      ▼ application/json {1}
        ▼ schema {1}
          $ref : #/components/schemas/Pets
    ► default {2}
```



# OAI in a nutshell



## OAI Petstore <sup>1.0.0</sup>

[ Base URL: [petstore.openapis.org/v2](http://petstore.openapis.org/v2) ]

This is a sample server Petstore server.

**pet** Everything about your Pets

Find out more: <http://openapis.org> ✓

**POST**

**/pet** Add a new pet to the store



**PUT**

**/pet** Update an existing pet



**GET**

**/pet/findByStatus** Finds Pets by status



**GET**

**/pet/findByTags** Finds Pets by tags



## Extra slides

- Results of the ICSOC study
- OAI in a nutshell
- **Governify in a nutshell**

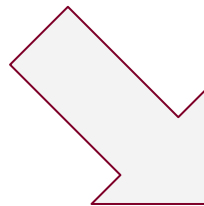


01/04/2017 - 30/04/2017

## Incidencias cerradas

INDICADOR INCIDENCIAS	PRIORIDAD	UMBRAL	SATISFACCIÓN			OCURRENCIAS	EVALUADOS	INCUMPLIDOS	FALSOS POSITIVOS	RESULTADO (media)
			Exigida	Alcanzada	Alcanzada x Indicador x Prioridad					
Tiempo de resolución	Crítica (P1)	8h / 72h	90,00%	100,00%	100,00%	1	1	0	0	0h 13min (13min)
	Alta (P2)	30d (240h)			100,00%	1	1	0	0	7h 50min (470min)
	Media (P3)	40d (280h)			100,00%	7	7	0	0	24h 43min (1483min)
	Baja (P4)	40d (280h)			100,00%	9	9	0	0	32h 5min (1925min)
Tiempo de respuesta	Crítica (P1)	2h	90,00%	100,00%	100,00%	1	1	0	0	1h 5min (65min)
	Alta (P2)	7h			100,00%	1	1	0	0	0h 46min (46min)
	Media (P3)	24h			100,00%	7	7	0	0	0h 41min (41min)
	Baja (P4)	24h			100,00%	9	9	1	1	0h 53min (53min)
Pendiente de usuario	Crítica (P1)	3h	50,00%	31,25%	N/A	1	0	0		N/A
	Alta (P2)	6h			100,00%	1	1	0		2h 58min (178min)
	Media (P3)	12h			42,86%	7	7	4		233h 38min (14018min)
	Baja (P4)	24h			12,50%	9	8	7		431h 54min (25914min)

- Response time (TRS)
- Resolution time (TRL)
- User time (PU)



- SCO\_TRS  
% Tickets closed in time vs total tickets.

# ISA Tools - DESIGNER

The image shows the 'DESIGNER' tool interface. On the left, a YAML configuration for a plan named 'plans.oai-at' is displayed. The configuration includes context, infrastructure, metrics, and pricing details. A green checkmark is visible next to the pricing section. Below the YAML editor are tabs for 'FORM', 'JSON', and 'YAML', and a 'Generate Governify' button. The right side of the interface shows a plan configuration for '0 € / mo'. It includes a 'Plan name' input field and a '+ PRO' button. Below this, there are two sections: 'Quotas' and 'Rates'. Each section has a '+ Over resource:' button and a list of quotas/rates. The 'Quotas' section lists '10 GETs / requests / minutely' and '10 POSTs / requests / minutely'. The 'Rates' section lists '1 GET / requests / secondly' and '1 POST / requests / secondly'. A console window at the bottom left shows 'console was cleared'.

```
1 context:
2   id: plans
3   sla: '1.0'
4   type: plans
5   api: >-
6     http://repo.designer.governify.io:10880/antgambia/ap
7   provider: ISA Group
8   infrastructure:
9     supervisor: 'http://supervisor.oai.governify.io/api/v2'
10    monitor: 'http://monitor.oai.governify.io/api/v1'
11   metrics:
12     requests:
13       type: integer
14       format: int64
15       description: Number of requests
16       resolution: consumption
17     responseTime:
18       type: integer
19       format: int64
20       description: Time in ms spent by request
21       resolution: consumption
22   pricing:
23     cost: 0
24     currency: EUR
25     billing: monthly
26     availability: '18/00:00:00Z/15:00:00Z'
27
```

FORM JSON YAML

Generate Governify

console was cleared

0 € / mo

Plan name +

FREE PRO

+ Quotas

+ Over resource: /api/v2/models/mzn/operations/executeDocument

10 GETs / requests / minutely

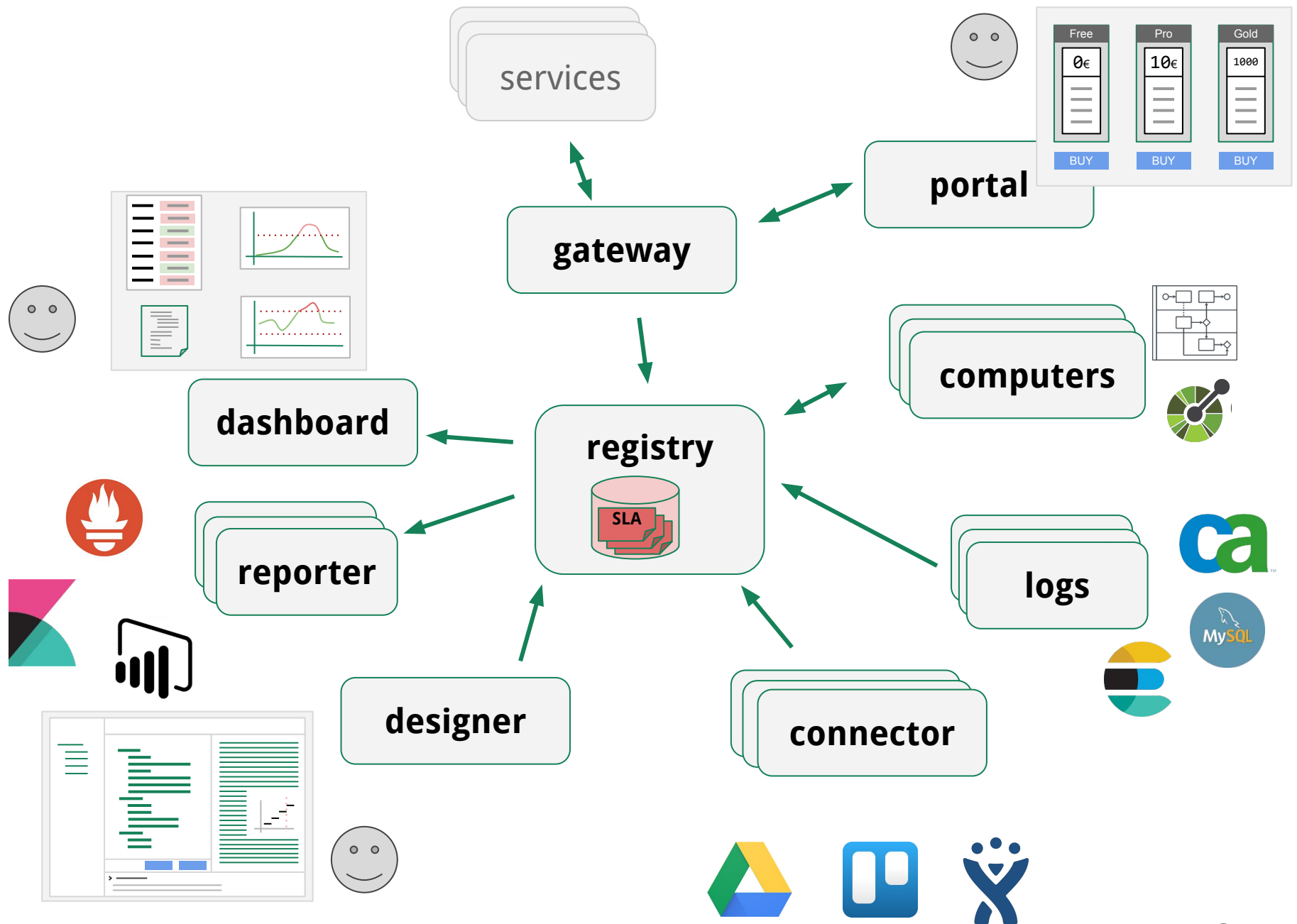
10 POSTs / requests / minutely

+ Rates

+ Over resource: /api/v2/models/mzn/operations/executeDocument

1 GET / requests / secondly

1 POST / requests / secondly



# SLA-driven governance for RESTful systems

Thank you  
Questions?

**Antonio Gámez Díaz**

ISA Research Group

Depto. Lenguajes y Sistemas Informáticos

ETSII, Universidad de Sevilla, España

✉ >> [agamez2@us.es](mailto:agamez2@us.es)

📱 >> [personal.us.es/agamez2](http://personal.us.es/agamez2)

