

# Reference Architecture

---

Brauner Oliveira

Tiago Volpato

SSC5944 - Software Architecture

Prof. Dra. Elisa Yumi Nakagawa

April 18, 2016



# Agenda

1. Introduction
2. Definition
3. A Model for Reference Architecture
4. Reference Architectures Engineering
5. A Software Reference Architecture for Governmental Information Systems
6. Additional Topics

# 1. Introduction



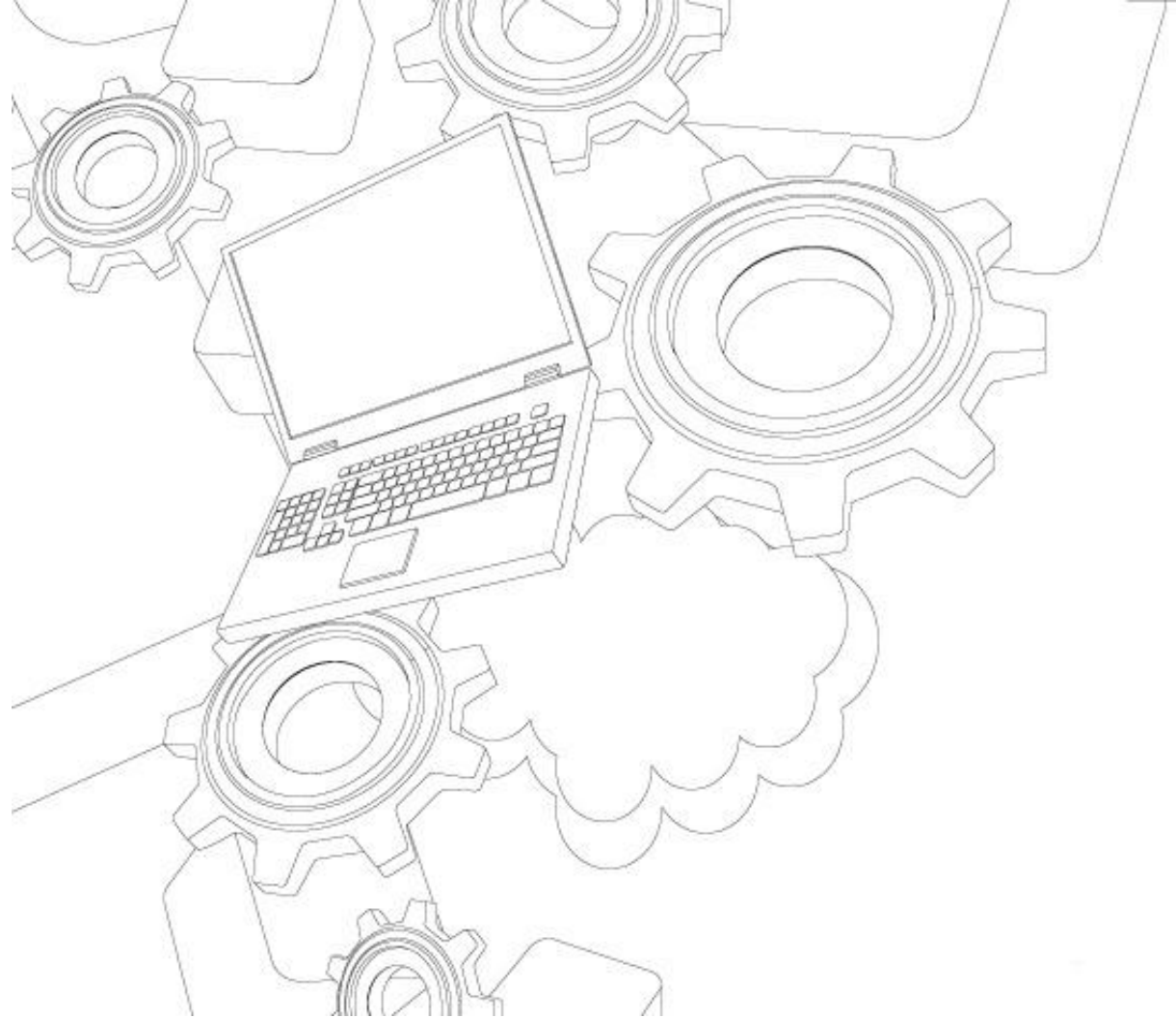
Application Domains

# 1. Introduction

Challenge in the:

- Complexity
- Diversity
- Scope
- Size

of Software Systems



## 2. Definition

"A reference architecture refers to an architecture that encompasses the **knowledge** about how to design **concrete architectures** of systems of a given **application domain**; therefore, it must address the **business rules, architectural styles** (sometimes also defined as architectural patterns that can also address quality attributes in the reference architecture), **best practices** of software development (for instance, architectural decisions, domain constraints, legislation, and standards), and the **software elements** that support development of systems for that domain. All of this must be supported by a unified, unambiguous, and widely understood **domain terminology**." [Nakagawa, 2014]

## 2. Definition

The Reference Architectures provides [Muller 2008]:

- a common lexicon and taxonomy, for example by a domain model;
- a common (architectural) vision;
- modularization and the complementary context.

## 2. Definition

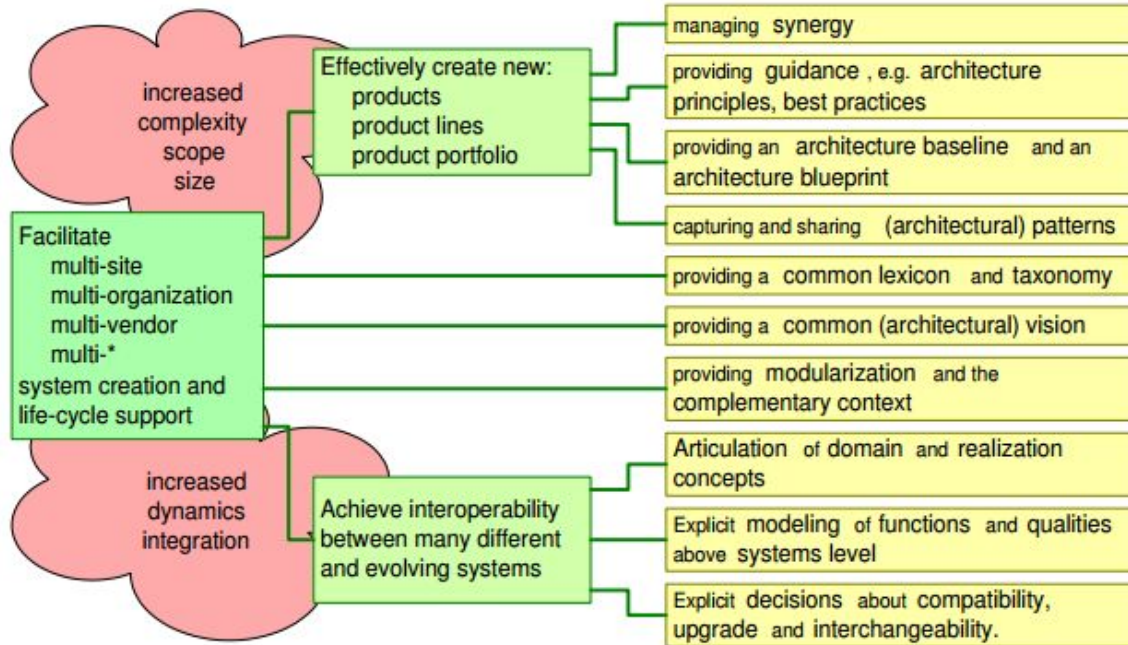


Figure 1: Objectives of Reference Architecture [Muller, 2008].

## 2. Definition - Why not Reference Model?

Reference Model:

- A set of concepts, axioms, and relationships within a particular problem domain
- Independent of specific standards, technologies, implementations, or other concrete details
- More abstract than reference architectures
- In general, it can be:
  - Conceptual models
  - Ontologies of a given domain



## 2. Definition - Why not Reference Model?

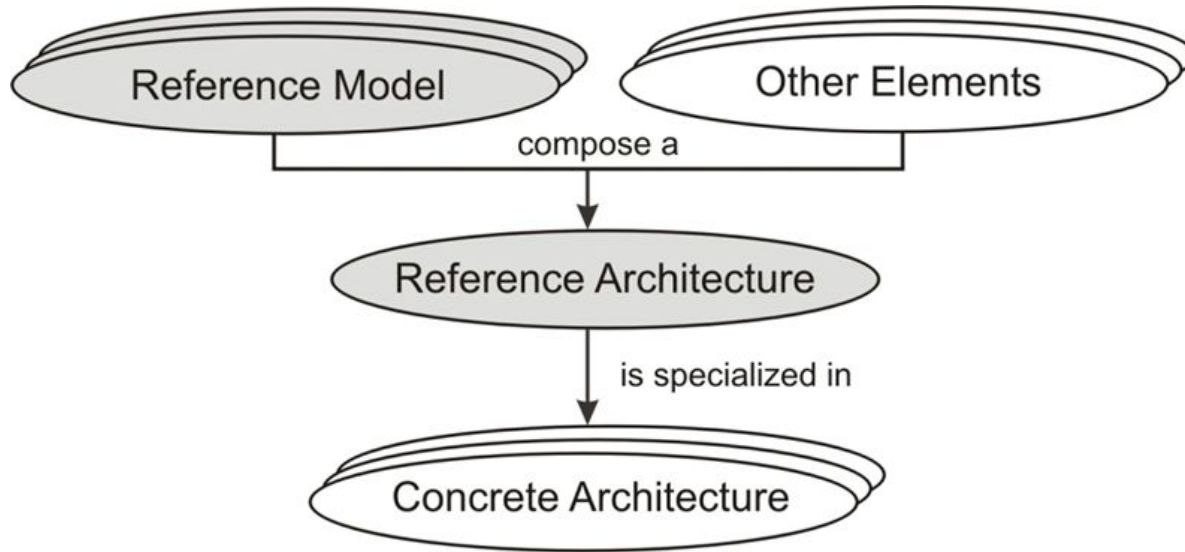


Figure 2: Relationship between Reference Model and Reference Architecture [Nakagawa, 2014]

## 2. Definition - Why not Software Product Line Architecture?

### Product Line Architecture

- One of the main asset of Software Product Line (SPL)
- Architecture with a required degree of flexibility
- Focusing sometimes on a specific subset of the software systems of a domain
- Providing standardized solutions for a smaller family of systems.
- RA focuses on common points while SPLA is concerned with variability among products

## 2. Definition - Why not Software Product Line Architecture?

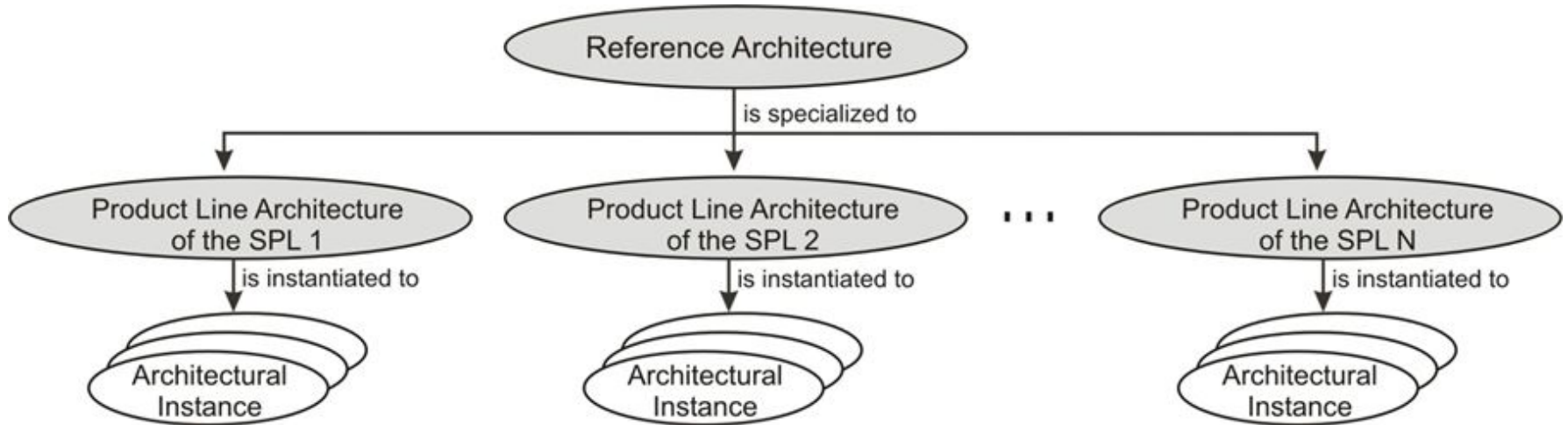


Figure 3: Relationship between Product Line Architecture and Reference Architecture [Nakagawa, 2014]

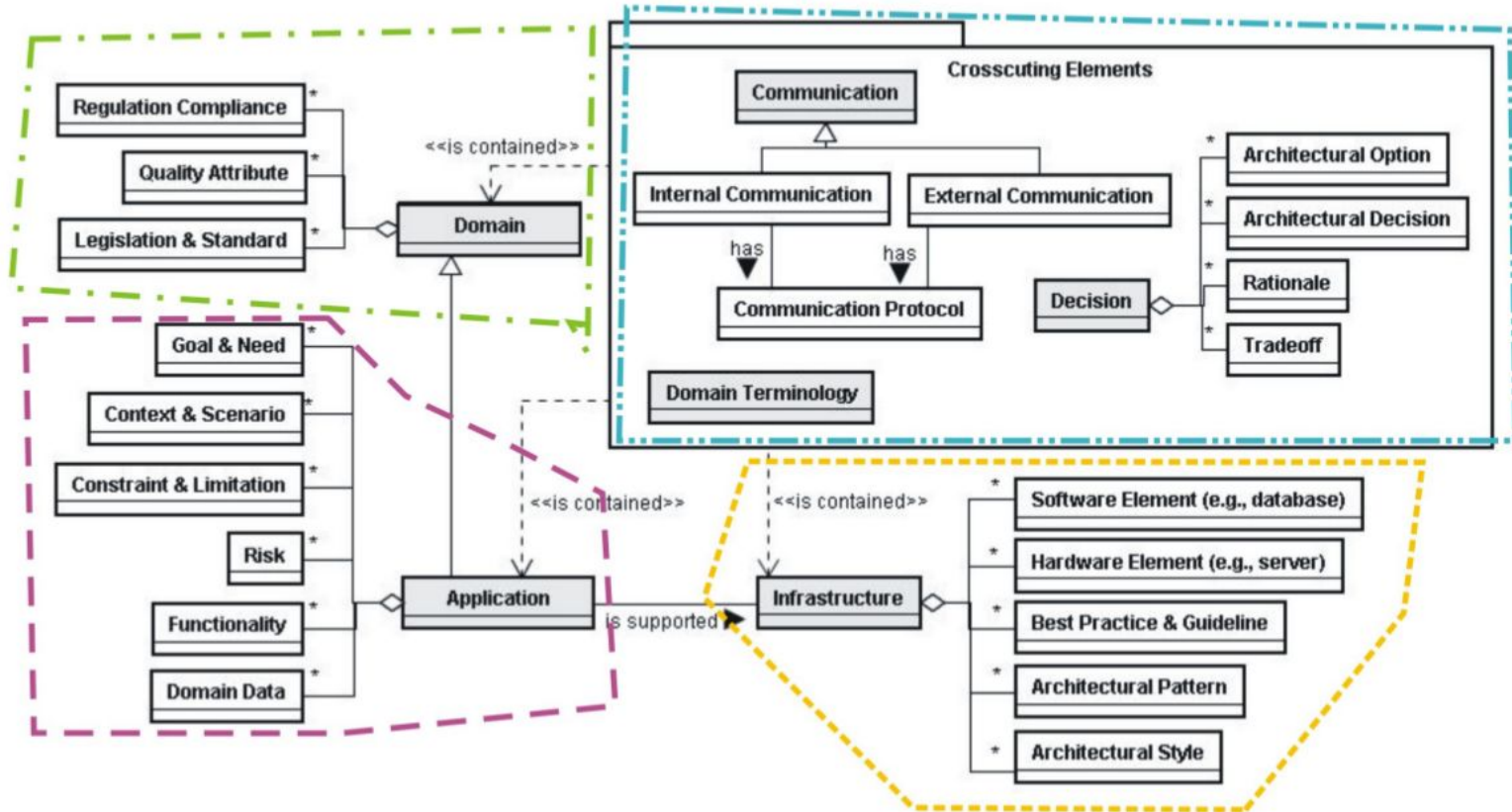
# Characterizing Reference Architectures

### 3. A Model for Reference Architecture

Which elements could be contained in reference architectures?

# 3. A Model for Reference Architecture

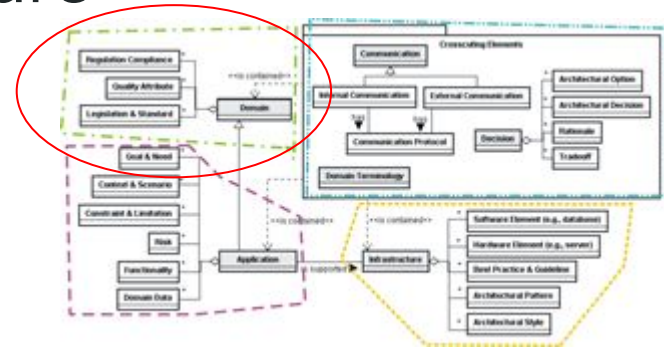
- RAModel:
  - reference model for reference architectures;
  - elements and their relationships;
  - independent from the application domains or purpose of the reference architectures.



Structure of RAModel [Nakagawa et al., 2014]

# 3. A Model for Reference Architecture

RAModel: Domain



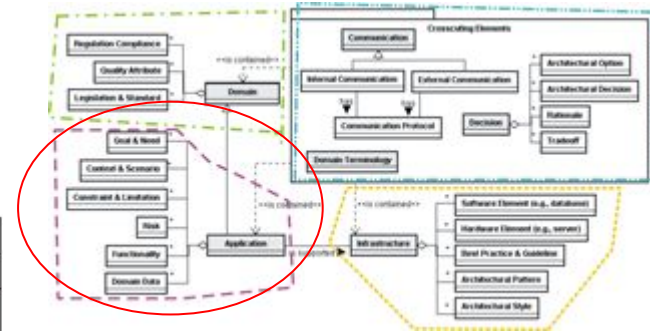
Elements of the group Domain	
Element	Description
Legislations, standards, and regulations	Laws, standards, and regulations existing in the domain that should be present in systems resulted from the reference architecture.
Quality attributes	Quality attributes, for instance, maintainability, portability, and scalability, that are desired in systems resulted from the reference architecture.
System compliance	Means to verify if systems developed from the reference architecture follow existing legislations, standards, and regulations.



# 3. A Model for Reference Architecture

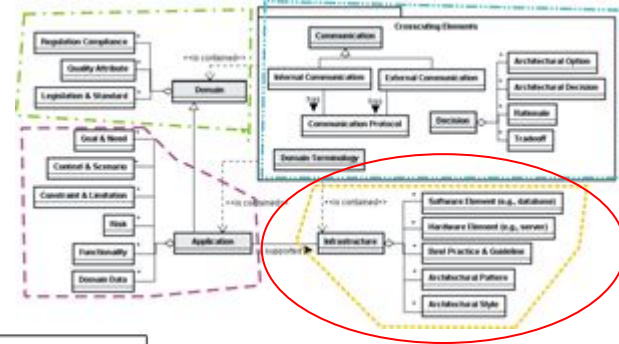
## RAModel: Application

Elements of the group Application	
Element	Description
Constraints	Constraints presented by the reference architecture and/or constraints in specific part of a reference architecture.
Domain data	Common data found in systems of the domain. These data are presented in a higher level of abstraction, considering the higher level of abstraction of the reference architecture.
Functional requirements	Set of functional requirements that are common in systems developed using this architecture.
Goal and needs	Intention of the reference architecture and needs are covered by the reference architecture.
Limitations	Limitations presented by the reference architecture and/or limitations in specific part of a reference architecture.
Risks	Risks in using the reference architecture and/or risks in using some part of such architecture.
Scope	Scope that is covered by the reference architecture, i.e., the set of systems developed based on the reference architecture.



# 3. A Model for Reference Architecture

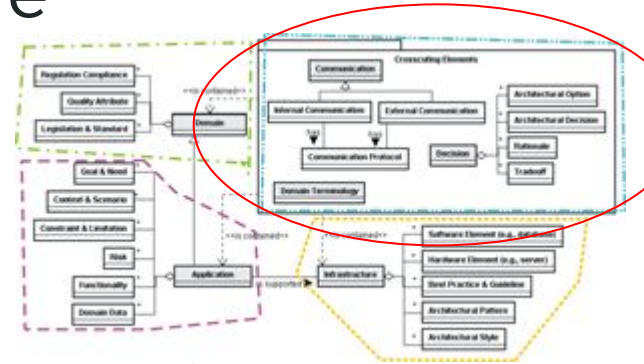
RAModel: Infrastructure



Elements of the group Infrastructure	
Element	Description
Best practices and guidelines	Well-experimented practices to develop systems of the domain, These practices are accompanied by guidelines describing how to apply these practices.
General structure	General structure of the reference architecture, represented sometimes by using existing architectural styles.
Hardware elements	Elements of hardware, such as server and devices, which host systems resulted from the reference architecture.
Software elements	Elements of software present in the reference architecture, e.g., subsystems and classes, which are used to develop software systems.

# 3. A Model for Reference Architecture

## RAModel: Crosscutting Elements



Elements of the group Crosscutting Elements	
Element	Description
Decisions	Decisions, including description of the decision, options (alternatives), rationale, and tradeoffs, must be reported during the development of the reference architecture.
Domain Terminology	Set of terms of the domain that are widely accepted by the community related to that domain and are, therefore, used in the description of the reference architecture.
External communication	Means by which occur exchange of information between the systems resulted from the reference architecture and the external environment.
Internal communication	Means by which occur exchange of information among internal parts of systems resulted from the reference architecture.

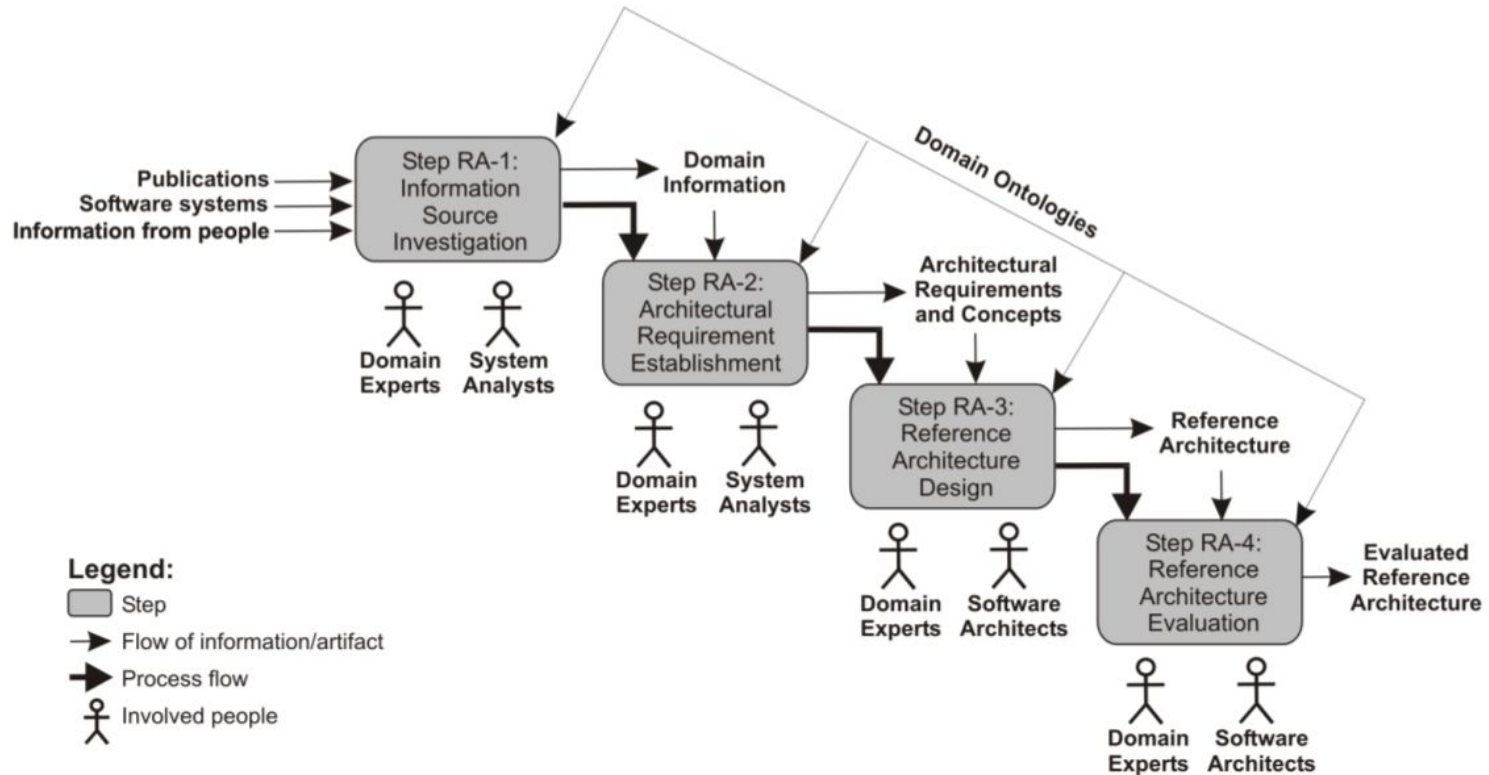
### 3. A Model for Reference Architecture

- Using RAModel:
  - Basis for the establishment of reference architectures;
  - Basis for the evolution of existing reference architectures;
  - Analysis of specific reference architectures;
  - Comparative analysis of reference architectures;
  - Support to the design of SPL (Software Product Line)

# Reference Architecture Engineering

## 4. Reference Architecture Engineering

- Reference architectures have been built using an ad-hoc approach
- Some recommendations
- Systematization → more effective reference architectures
  
- ProSA-RA: 4 steps process
  - Result of experience
  - Directed to a set of systems to be developed

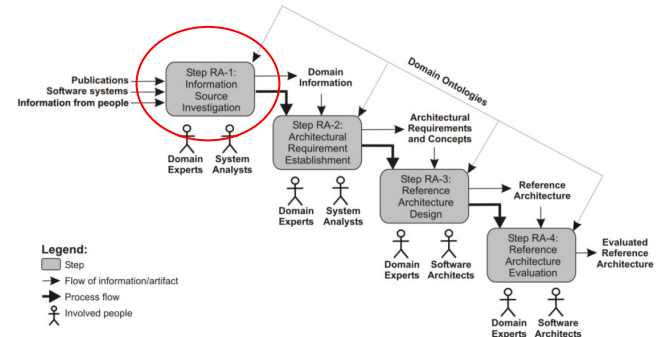


## Overall Structure of ProSA-RA [Nakagawa et al., 2014]

# 4. Reference Architecture Engineering

## ProSA-RA: Step 1 → Information Source Investigation

- Aim: establish the main sources from which information will be gathered
- Information: activities, processes, tasks, etc.
- Sources: people, software systems, publications, domain ontologies
- People involved: domain experts and system analysts

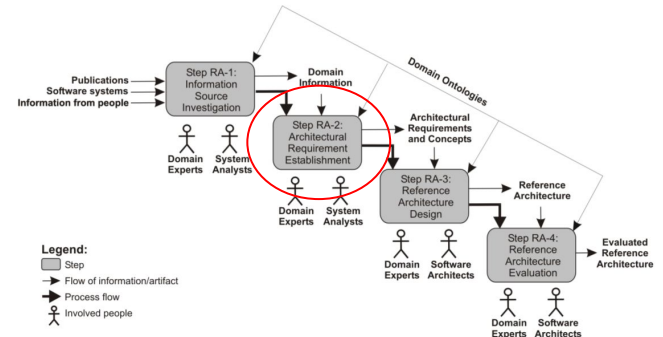




# 4. Reference Architecture Engineering

## ProSA-RA: Step 2 → Architectural Requirements Establishment

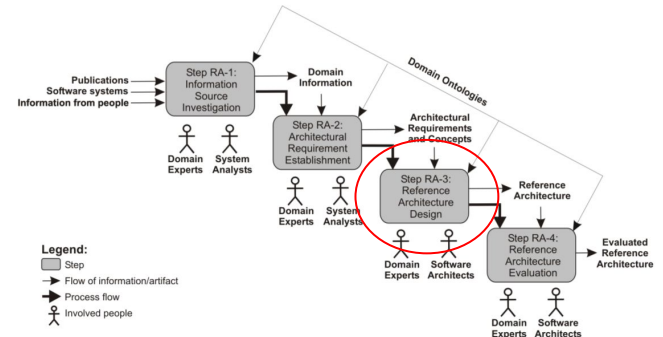
- Aim: establish concepts and requirements based on Step 1
- Main tasks
  - 1) identification of system requirements
  - 2) establishment of RA requirements
  - 3) identification of domain concepts
- People involved: domain experts and system analysts



# 4. Reference Architecture Engineering

## ProSA-RA: Step 3 → Reference Architecture Design

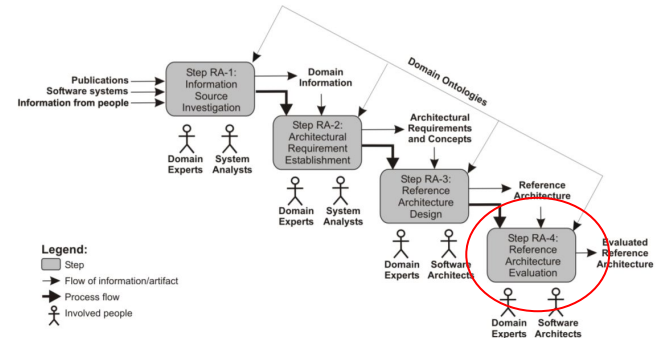
- Aim: design and represent the RA based on requirements and concepts
- Documentation must facilitate communication among stakeholders
- UML or other ADLs
- Suggested views: module, runtime, deployment, conceptual
- People involved: Software architects and domain experts



# 4. Reference Architecture Engineering

## ProSA-RA: Step 4 → Reference Architecture Evaluation

- Aim: quality assessment of the established RA
- Quality attributes: completeness, applicability, understandability
- Domain quality attributes
- Evaluation methods: FERA, ATAM, DCAR
- People involved: domain experts, software architects



# A Software Reference Architecture for Governmental Information Systems

## 5. An RA for Governmental Information Systems

- Arquitetura de Software de Referência para Sistemas de Informação Governamentais
- Brazilian Symposium on Information Systems (SBSI)
- 2015
- University of Brasilia (UnB)

# 5. An RA for Governmental Information Systems

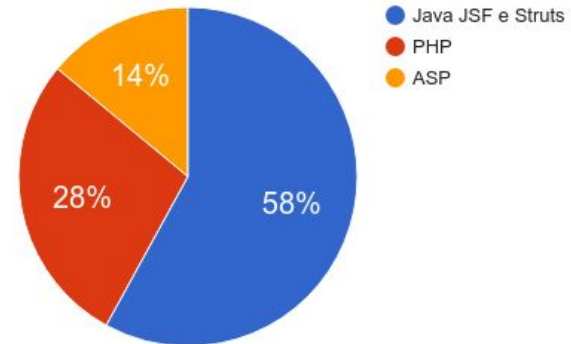
- Context
  - High complex organizations (e.g., Ministries, ANATEL, ANS)
  - Huge impact on the society
  - Manage very relevant information for internal and external purposes
- Problem (lack of many qualities)
  - Availability
  - Integrity
  - Confidentiality
  - Authenticity
  - Manutenability
- Solution → Standardization of Software Architecture

# 5. An RA for Governmental Information Systems

- Efficiency of public services requires
  - Intense cooperation of organizations
  - Exchange of information
- Rigorous adherence to norms and standards
  - ePING (SISP) → planning for hiring, acquisition, and maintenance of information systems
  - Current proposal
- Partnership between UnB and a government organization
  - Authors head software architecture front
  - Portfolio analysis
  - RA v1.0
  - Training for outsourcing companies to develop systems based on the RA
  - Support during development

## 5. An RA for Governmental Information Systems

- Portfolio analysis
- 50 systems
- Meetings and interviews
- Introspection and observation
- Stakeholders: IT members of the minister and outsourcing companies (development, quality, and infrastructure)
- Lot of problems
- Some concerns and restrictions

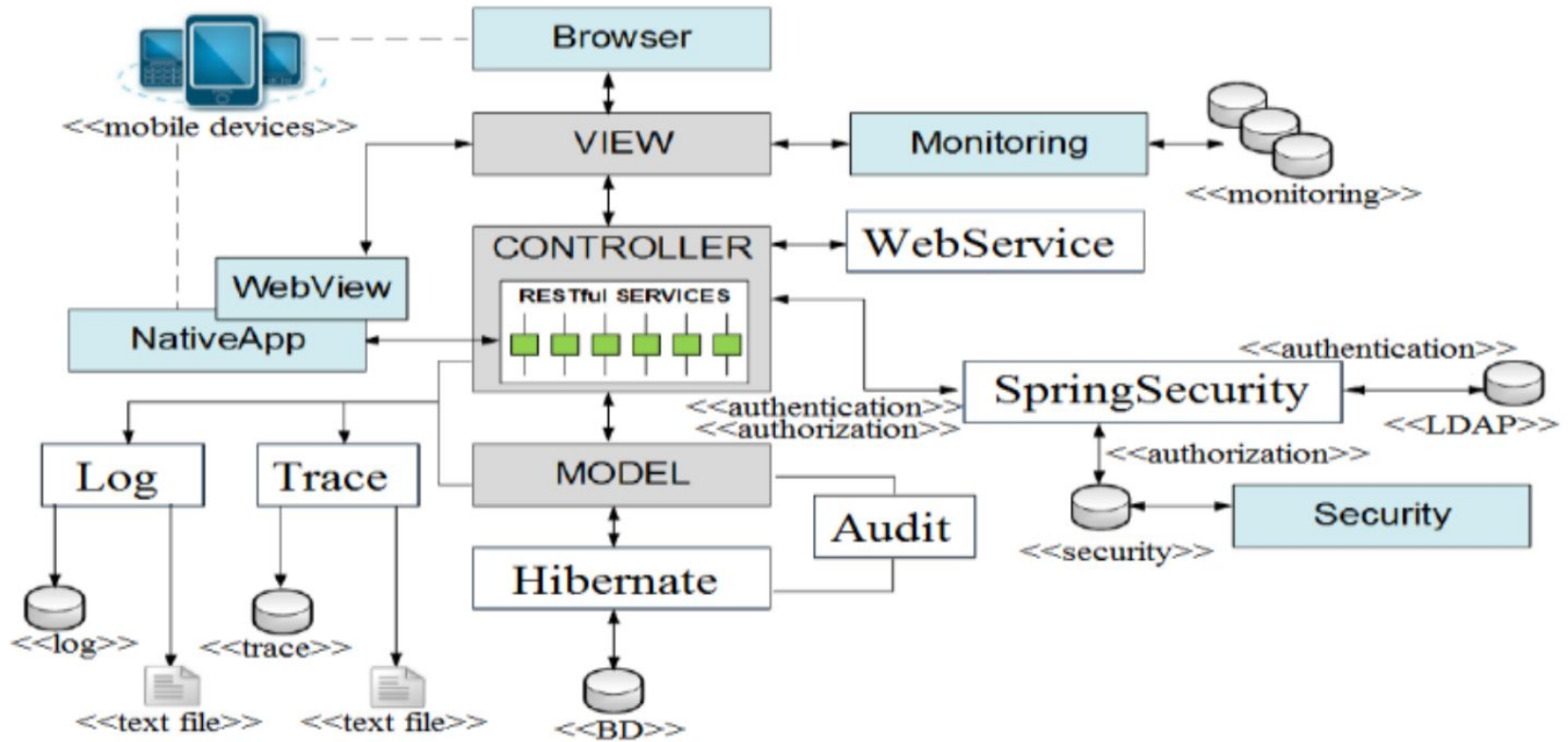




# 5. An RA for Governmental Information Systems

## Architecture Establishment

- Convention over configuration
  - Employs standards and configuration
  - Only non-conventional decisions
  - Improvements: less efforts, easier standardization, higher productivity, better maintainability
- Technological support
  - Convention over configuration framework (Grails)
  - (i) Keep java
  - (ii) Provides support for auditability, logging, tracing, and monitoring → Spring security, Log4J, AuditLogging, JavaMelody
  - (iii) Extensibility: PC and Mobile (RESTFul)
  - (iv) Facilitates the use of RESTFul (ePING requirement)



“Logical View”: Software Reference Architecture

# 5. An RA for Governmental Information Systems

Gains reported

- Robustness in load test
- Adequacy to vulnerability tests
- Greater productivity
- Customer satisfaction
- Improvement of code quality
- Quality of deliverables based on architectural specifications

# 5. An RA for Governmental Information Systems

## Criticism

- RA establishment did not follow a systematic approach
- Representation (logical view) made with no standardization
- Lack of details
- No reference of external resources
- No quality model employed
- Qualities are not systematic treated

# Additional Topics

# 6. Additional Topics

## Uses of Reference Architectures

- Building software systems
- Domain standardization
- Evolution of existing software systems
- Deriving new reference architectures
- Support the building of SPLs

## 6. Additional Topics

### Examples of Reference Architectures

- AUTOSAR → <http://www.autosar.org/>
- Continua → <http://www.continuaalliance.org/>
- UniversAAL → <http://universaal.sintef9013.com/entry/>

# 6. Additional Topics

## Reference Architecture Research

- Developing Sustainable Reference Architectures
- Measuring the Sustainability of Reference Architectures
- Reference Architecture for AAL, Robotic Systems
- Variability viewpoint to describe reference architectures



# References

[Nakagawa et al., 2014] Nakagawa, E. Y.; Oquendo, F.; Maldonado, J. C. **Reference Architectures**. John Wiley & Sons, Ltd. 55-82. Software Architecture 1. 2014.

[Serrano et al., 2015] Serrano, M.; Serrano, M.; Cavalcante, A. C.; **Arquitetura de Software de Referência para Sistemas de Informação Governamentais**. In 11th Brazilian Symposium on Information Systems, Goiânia, GO, May 26-29, 2015.

[Muller, 2008] Muller, G.A.; **Reference Architecture Primer**. In:17th International World WideWeb Conference (WWW 2008), Beijing, China, 2008.

# Reference Architecture

---

Brauner Oliveira

Tiago Volpato

SSC5944 - Software Architecture

Prof. Dra. Elisa Yumi Nakagawa

April 18, 2016

