# RELATE FP7 ITN

Samuel Kounev
(on behalf of RELATE Project Consortium)

HotTopiCS 2013, Prague, April 21, 2013

RELATE FP7 Marie Curie ITN

**Trans-European Research Training Network on Engineering and Provisioning of Service-Based Cloud Applications**

# Project Consortium

RELATE FP7 Marie Curie ITN

Trans-European Research Training Network on Engineering and Provisioning of Service-Based Cloud Applications

- Interdisciplinary Research Training Network
- 21 Fellows (18 Early Stage and 3 Experienced Researchers)

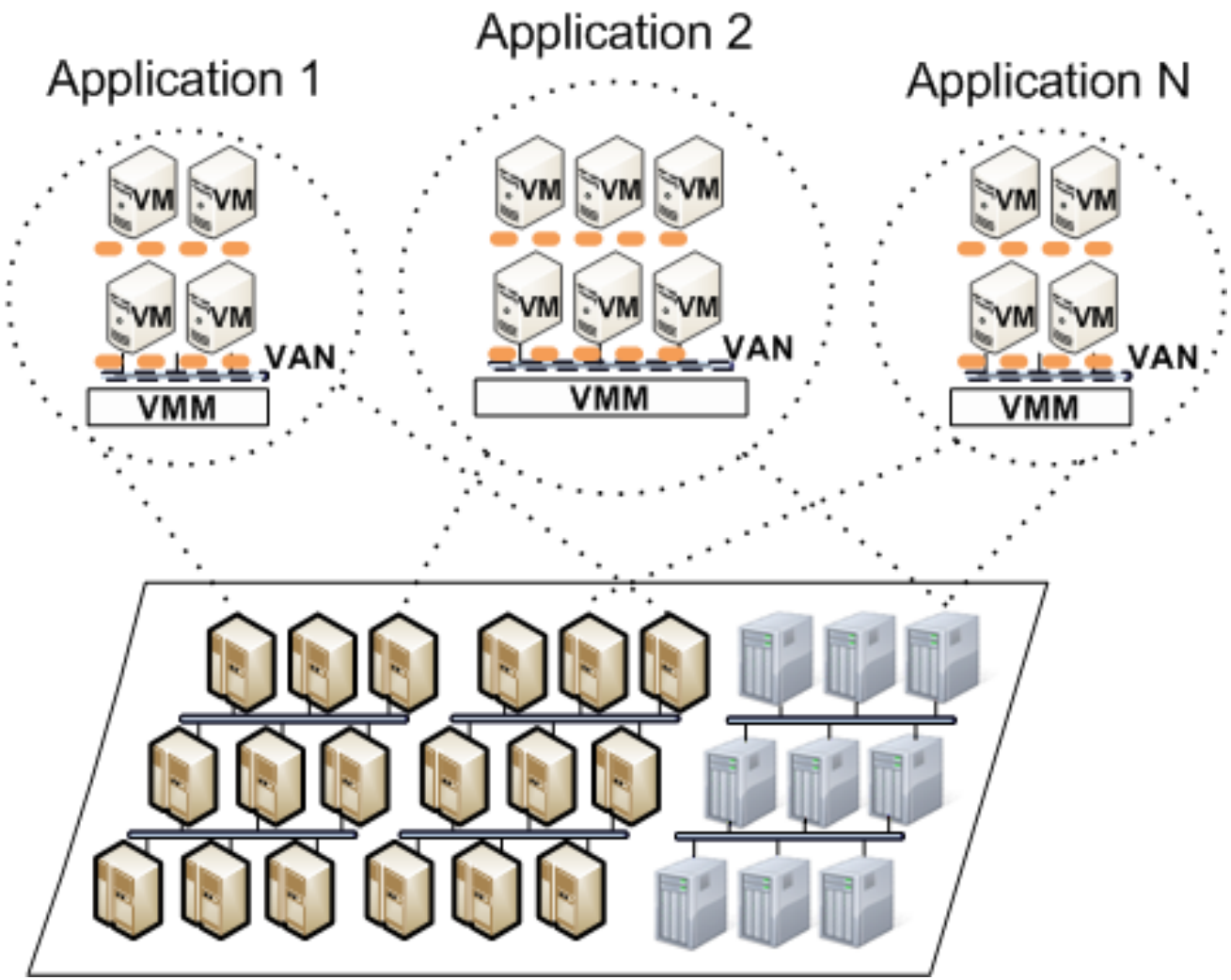
Associated Partners

# RELATE Fellows and Supervisors

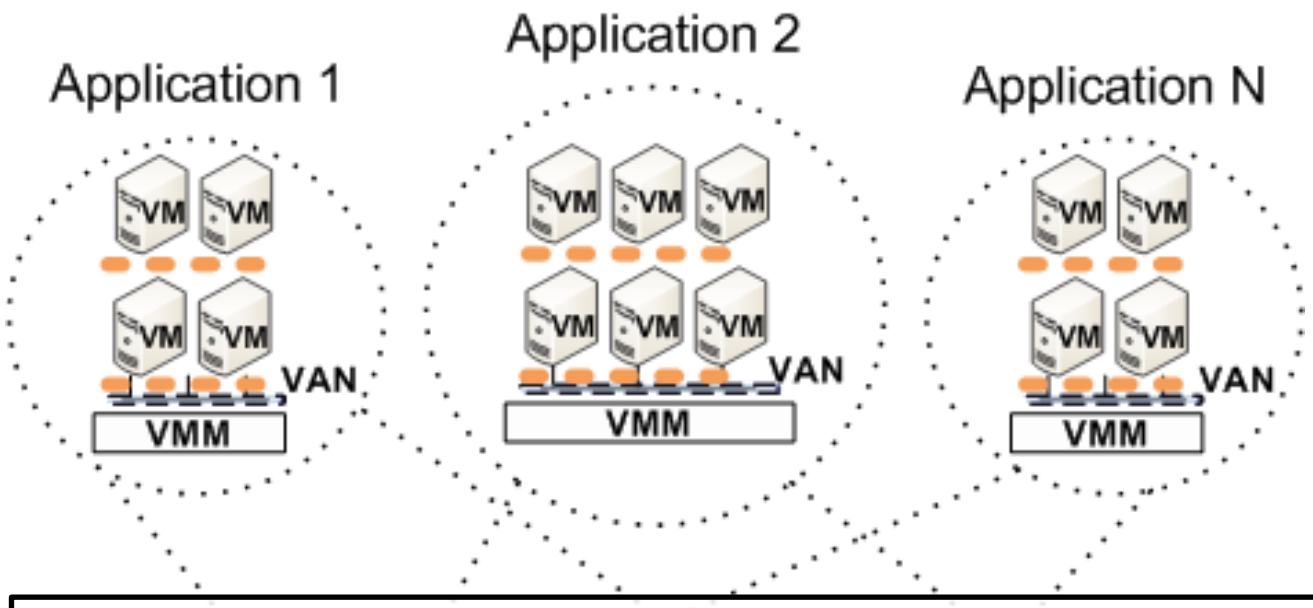
# Agenda

- Motivation
- Overview of Research Topics
- Cross-Cutting Concerns
- Service Engineering
- Service Management
- Service Evaluation and Selection

# Motivation



# Motivation




Applications running in a virtualized environment
Shared physical infrastructure
Flexible mapping of logical to physical resources
Higher resource utilization & energy efficiency (Green IT)
Lower operating costs, pay-per-use pricing model

# A Matter of Trust

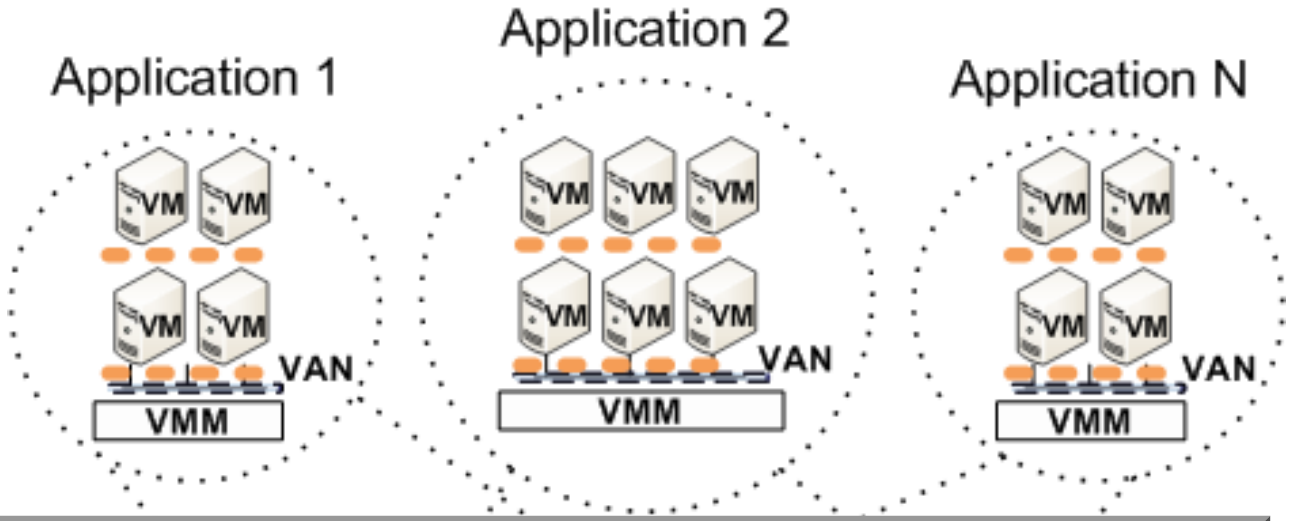
Why Cloud Computing will never be free,

Communications of the ACM, Vol. 53 No. 4, Pages 50-58

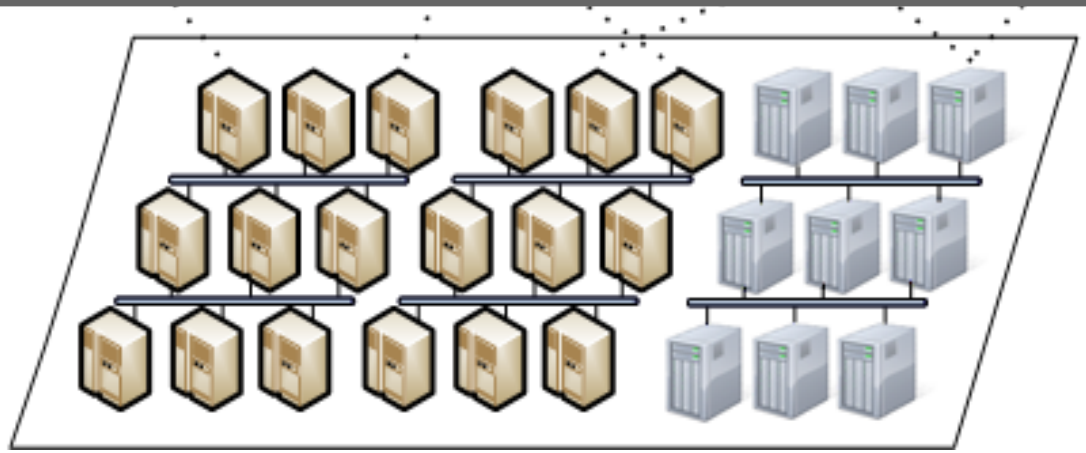
- By offering value beyond simply providing CPU cycles, the cloud provider is becoming a part of the end customers' business. This **requires a level of trust** that is commensurate with hiring an employee or outsourcing your operations.

# Cloud Computing Infrastructures

**Cloud Users**



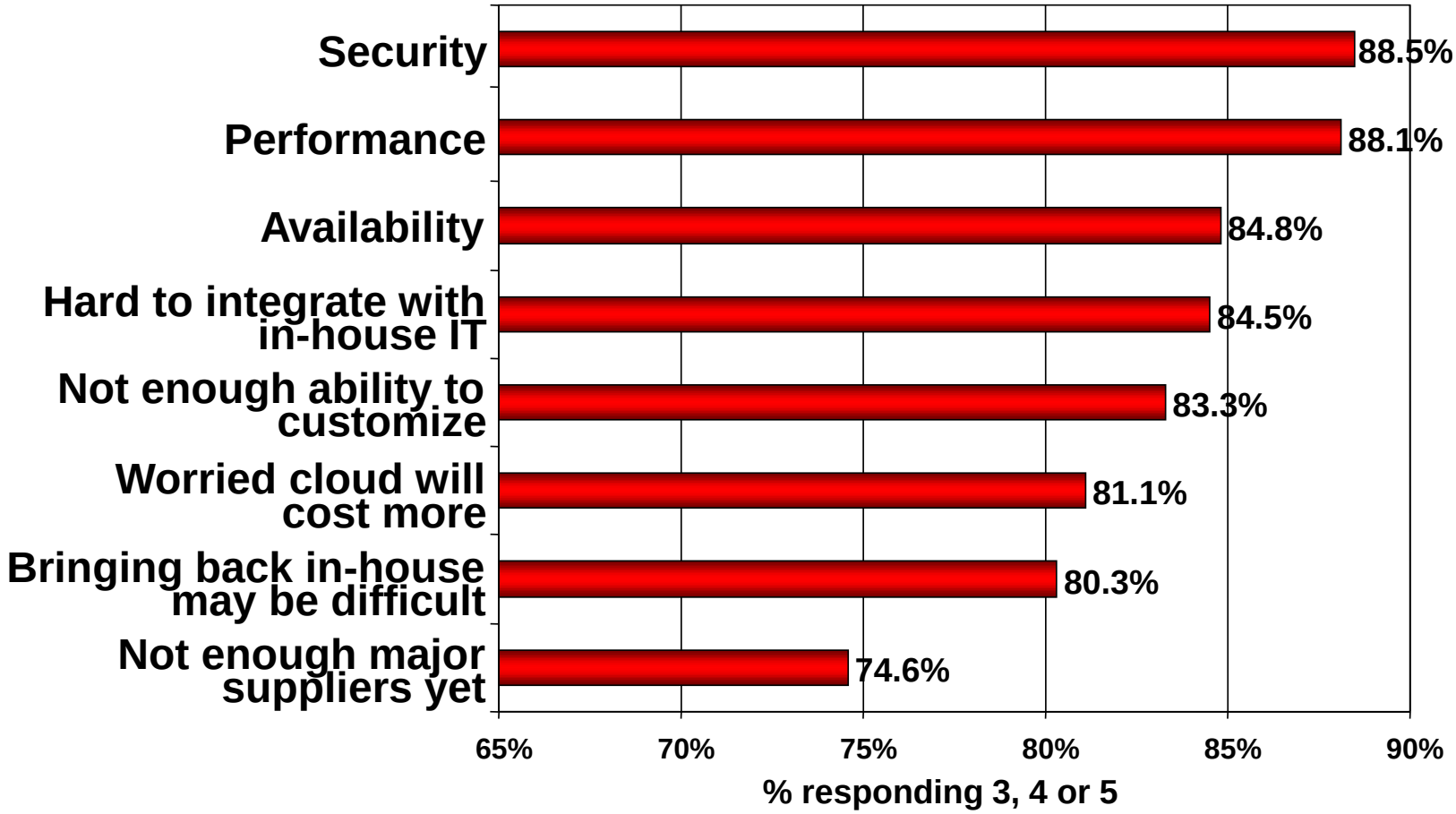

**Cloud Providers**



# Showstoppers

***Q: Rate the challenges/issues of the 'cloud'/on-demand model***

(1=not significant, 5=very significant)




Source: IDC Enterprise Panel, August 2008 n=244

# Top 10 Obstacles for Cloud Computing

Communications of the ACM, Vol. 53 No. 4, Pages 50-58

1. **Business Continuity and Service Availability**
2. Data Lock-In
3. **Data Confidentiality/Auditability**
4. Data Transfer Bottlenecks
5. **Performance Unpredictability**
6. **Scalable Storage**
7. Bugs in Large-Scale Distributed Systems
8. **Scaling Quickly**
9. Reputation Fate Sharing
10. Software Licensing

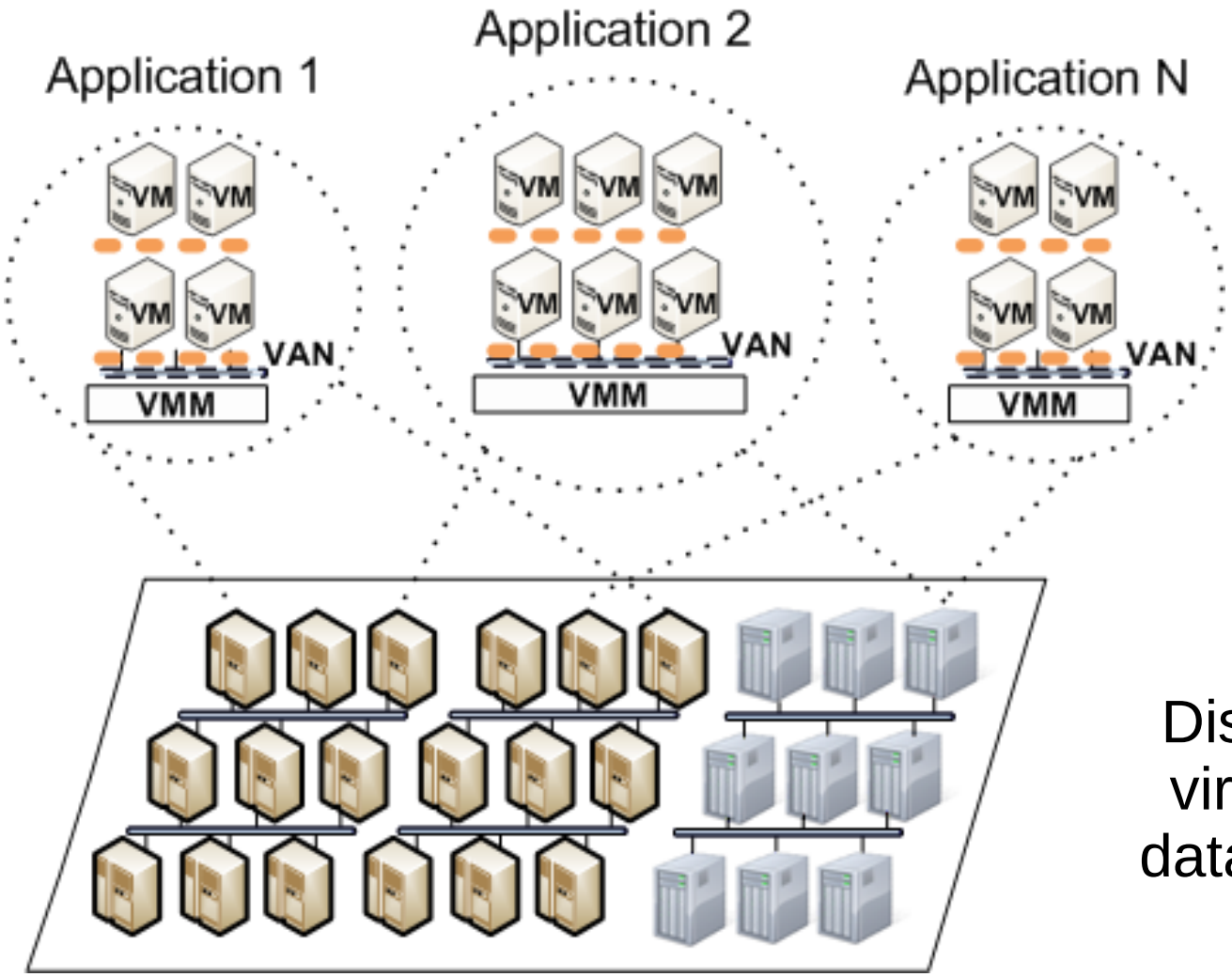
# Most Recent Large Amazon's Outage

"Amazon's Trouble Raises Cloud Computing Doubts." by Steve Lohr

The New York Times, April 22, 2011.

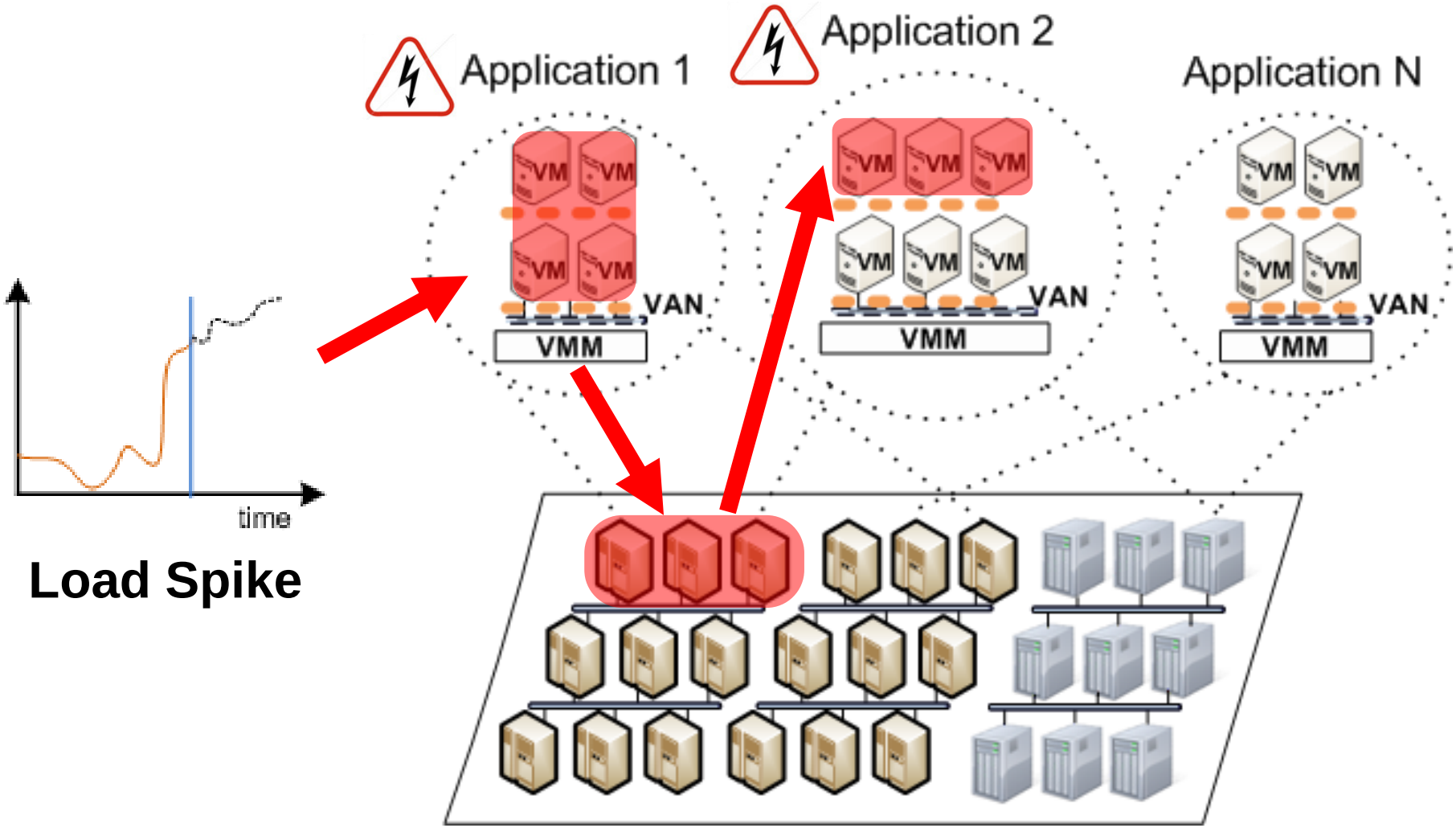
*"the computing equivalent of an airplane crash - a major episode with widespread damage"*

# Cloud Computing Infrastructures

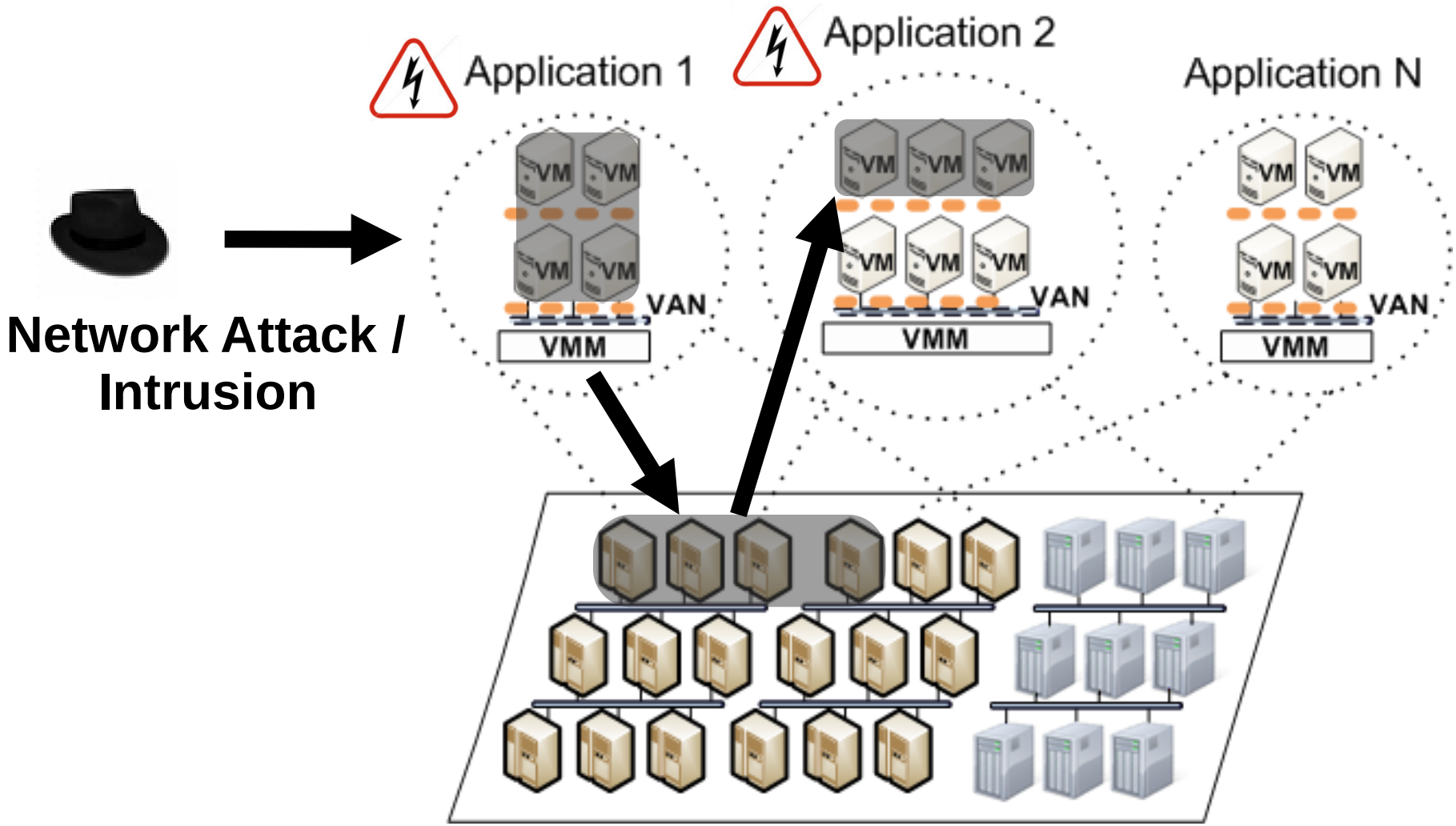



Distributed virtualized data centers

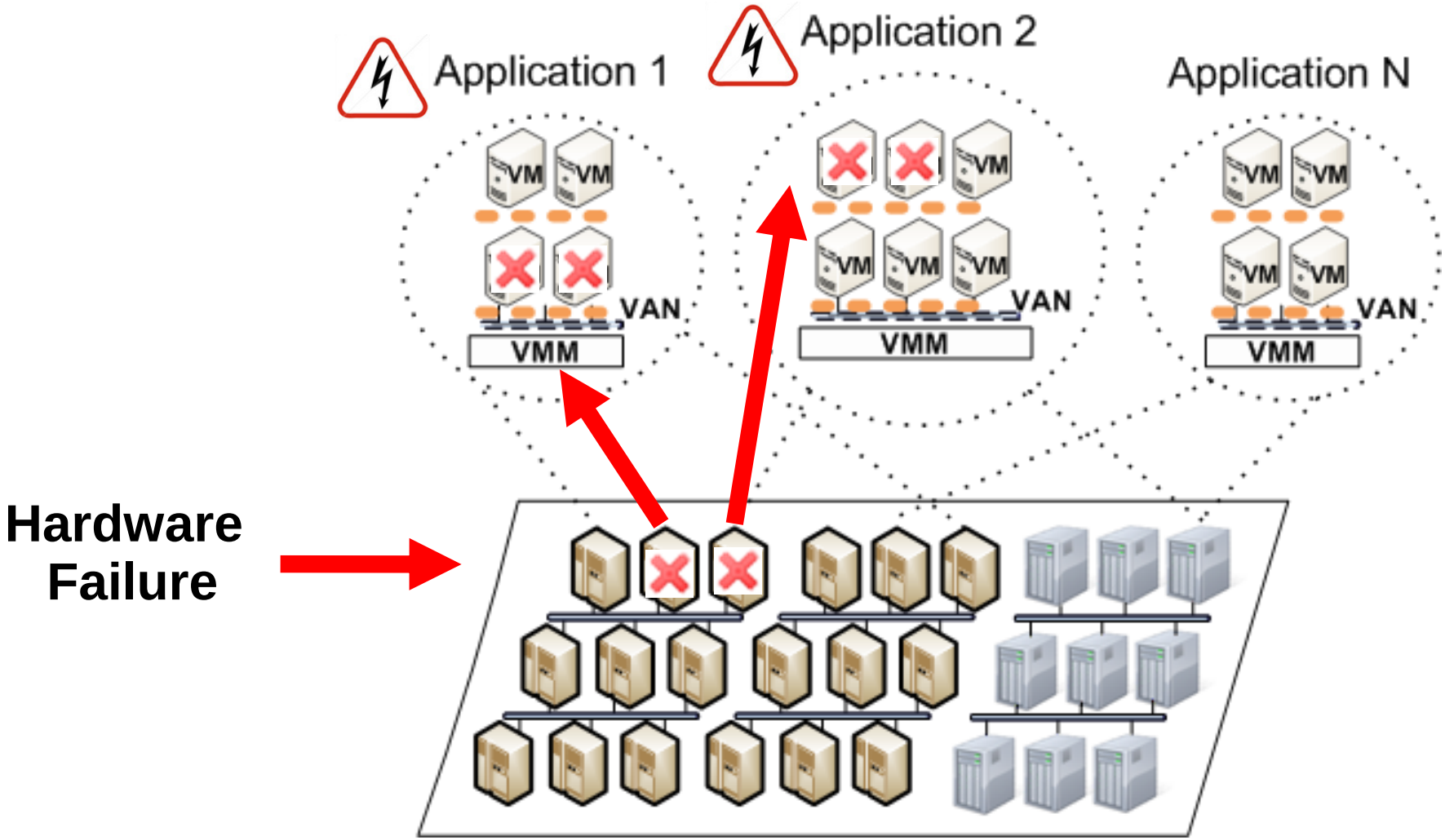
# Challenges (1)



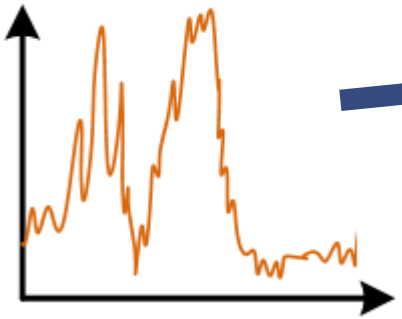
# Challenges (2)



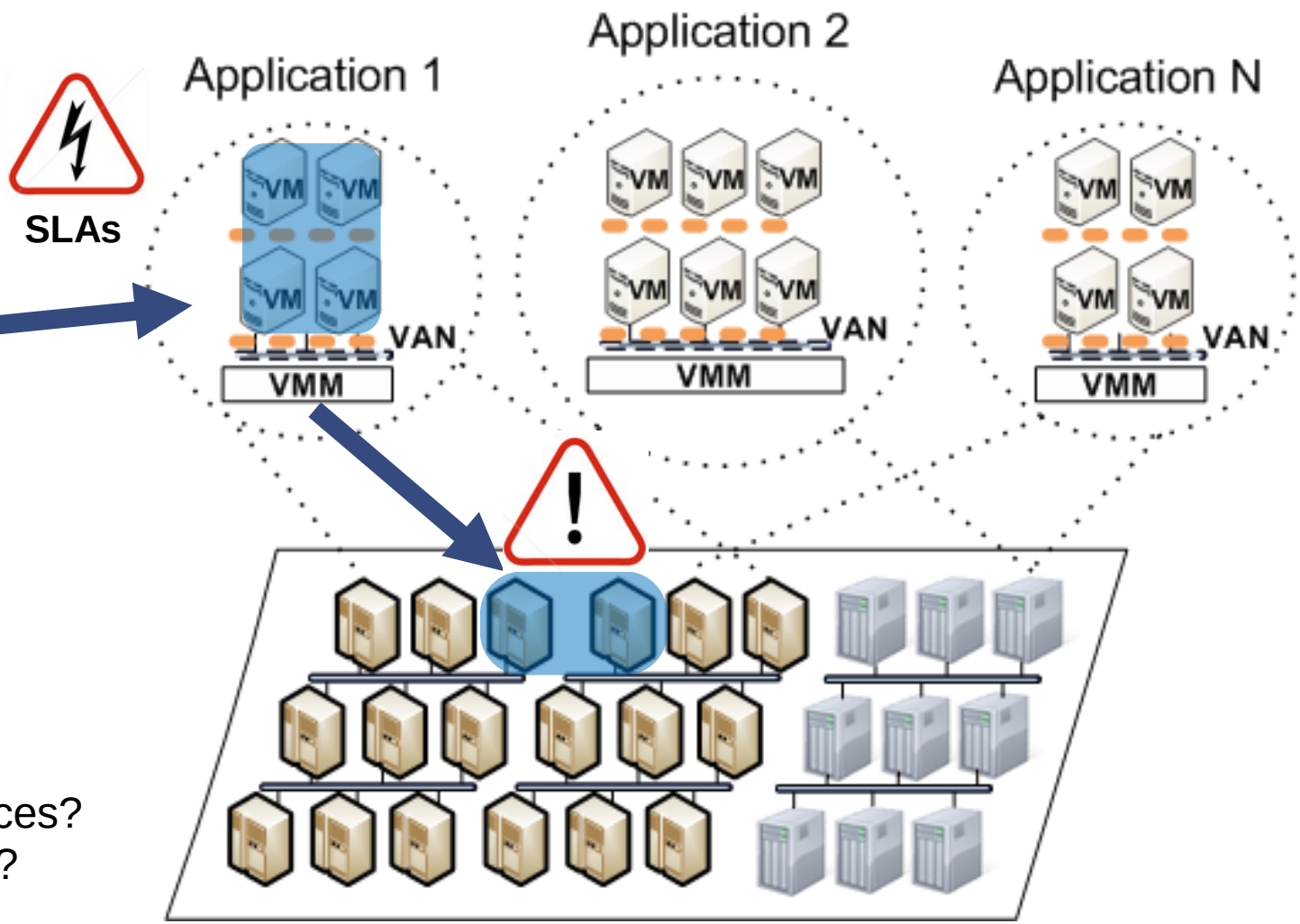
# Challenges (3)



# Challenges (4)



**Load Fluctuations**




Expand/shrink resources?

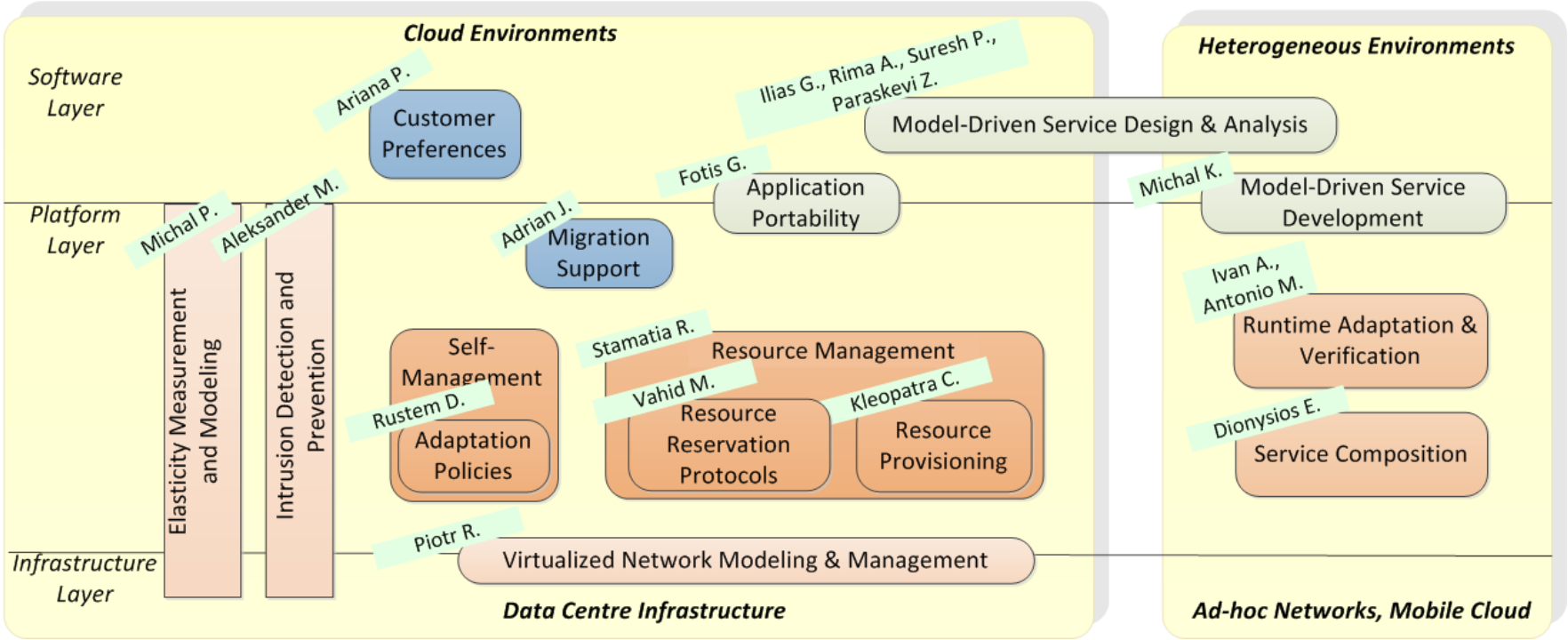
- At what granularity?
- How quickly?
- Reserve for how long?

# Research Challenges: Summary

- Increased system complexity and dynamics
- Lack of direct control over underlying hardware
- New threats and vulnerabilities due to resource sharing
- Separation of service providers and infrastructure providers

- Inability to provide QoS and dependability guarantees
- Lack of trust

# RELATE Research Map



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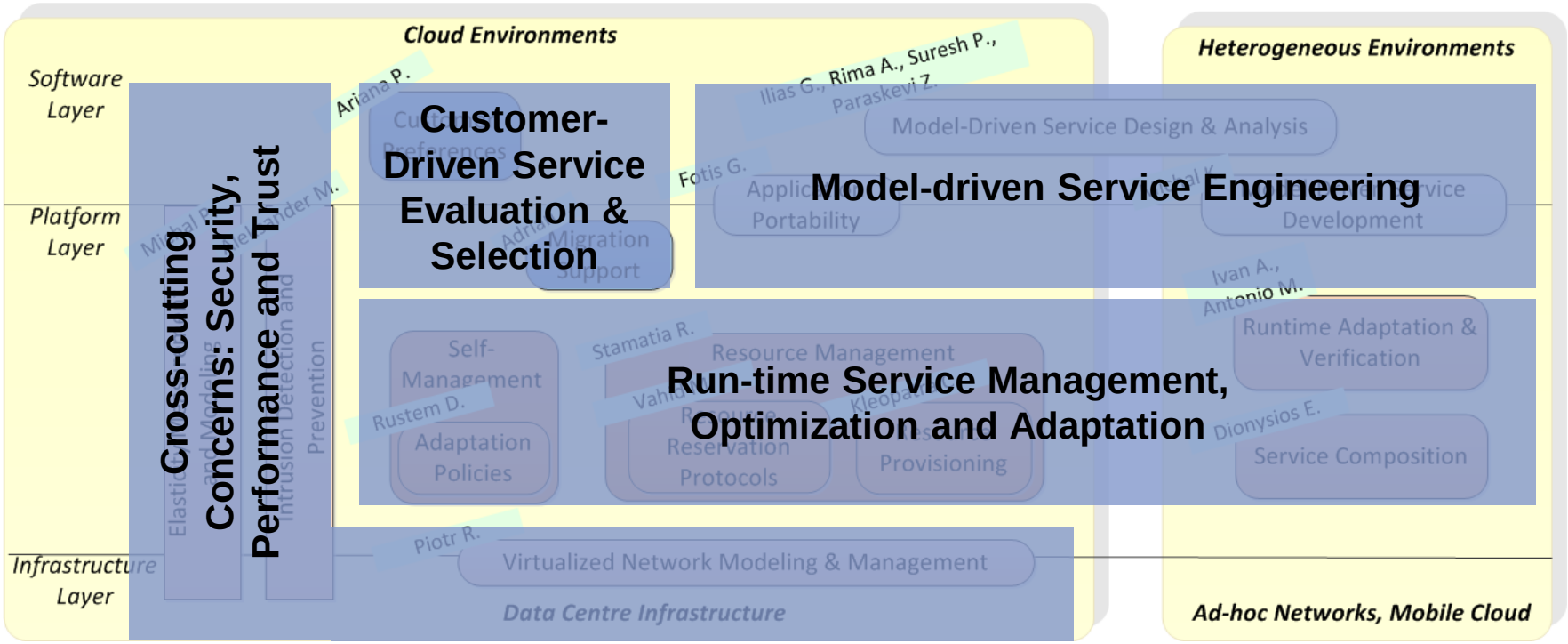

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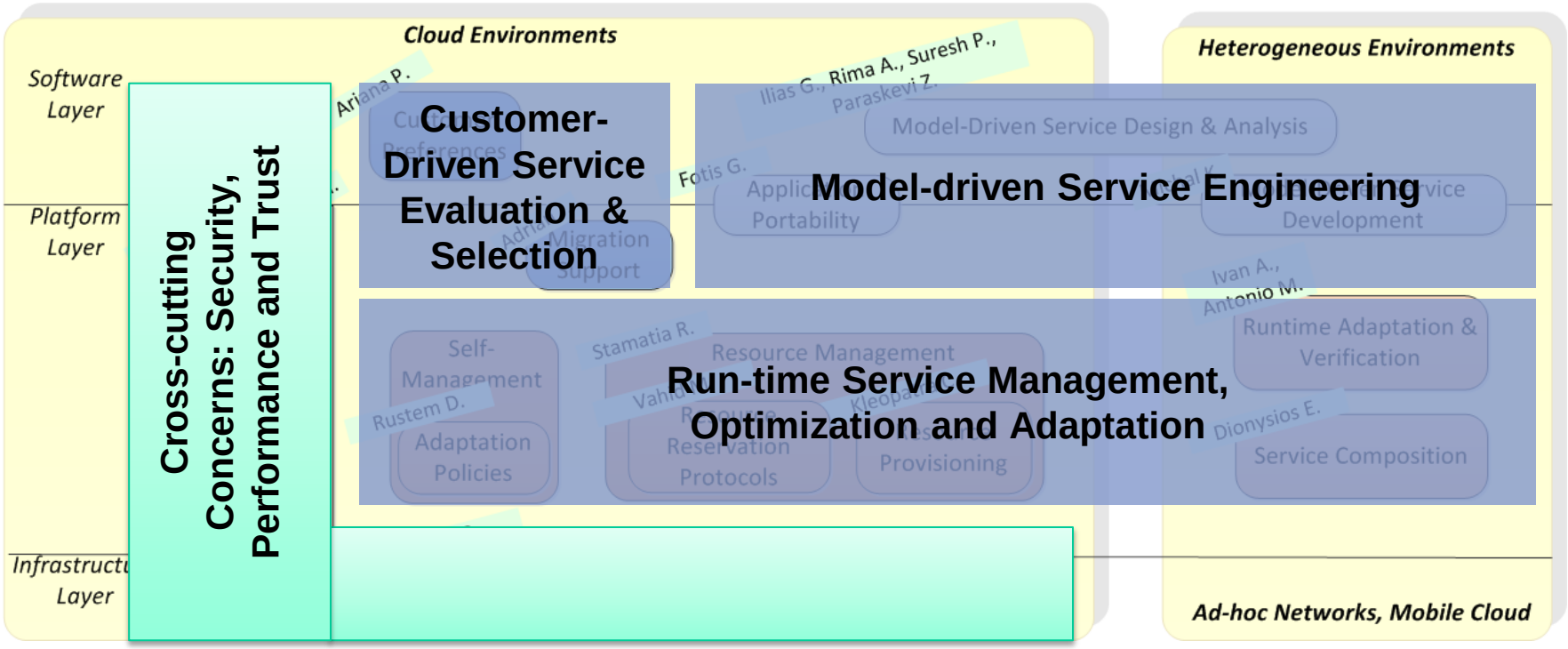
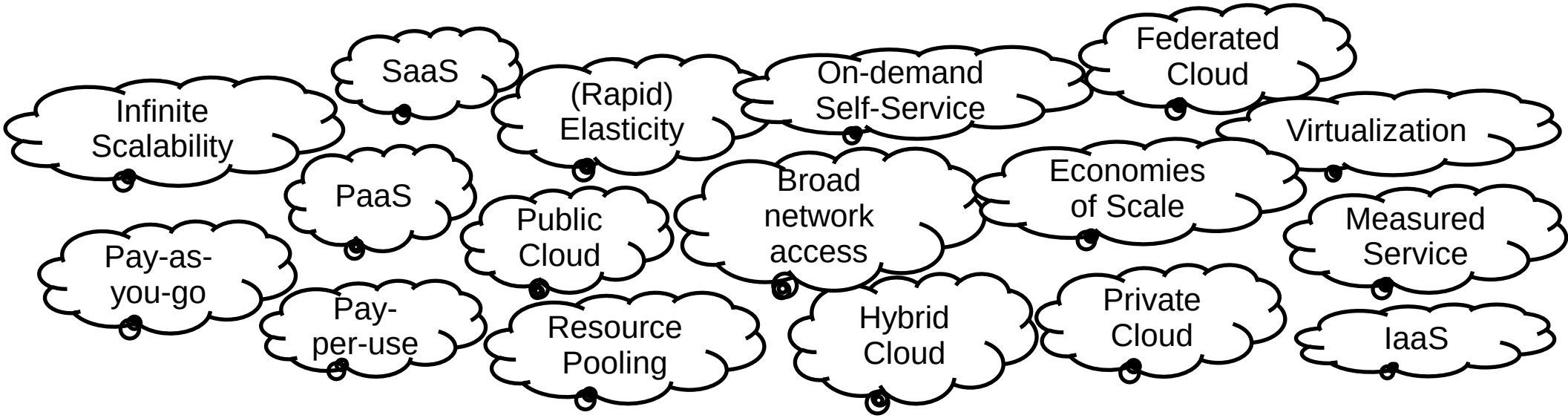


# A Cloudy Research Area

*"We have redefined cloud computing to include everything that we already do."*
*Larry Ellison, Oracle, 2009.*




- Inconsistent and overloaded use of terminology
- Lack of comparability of service offerings
  - Quality-of-Service / dependability / SLAs
  - Pricing models (pay-per-use?)
- Lack of standard metrics / measurement approaches

# SPEC Research Group (RG)

*The Research Group of the*
*Standard Performance Evaluation Corporation*

## Mission Statement

- Provide a **platform for** collaborative research efforts in the area of quantitative system evaluation and analysis
- Provide metrics, tools and benchmarks for evaluating early prototypes and research results as well as full-blown implementations
- Foster interactions and collaborations btw. industry and academia

Find more information on: *http://research.spec.org*

# Members (April 2013)

# Cloud Usage Patterns

Textual and visual formalism for describing cloud usage scenarios

Value chains, value chains with mediators, hybrid service provisioning, …

A. Milenkoski, A. Iosup, S. Kounev, K. Sachs, P. Rygielski, J. Ding, W. Cirne, F. Rosenberg. Cloud Usage Patterns: A Formalism for Description of Cloud Usage Scenarios, Technical Report SPEC-RG-2013-2001, SPEC Research Group, April, 2013. (To appear)

SPEC RG Cloud Working Group
http://research.spec.org/working-groups

# Cloud Usage Patterns

Potential and actual cloud users:
Specification of service requirements

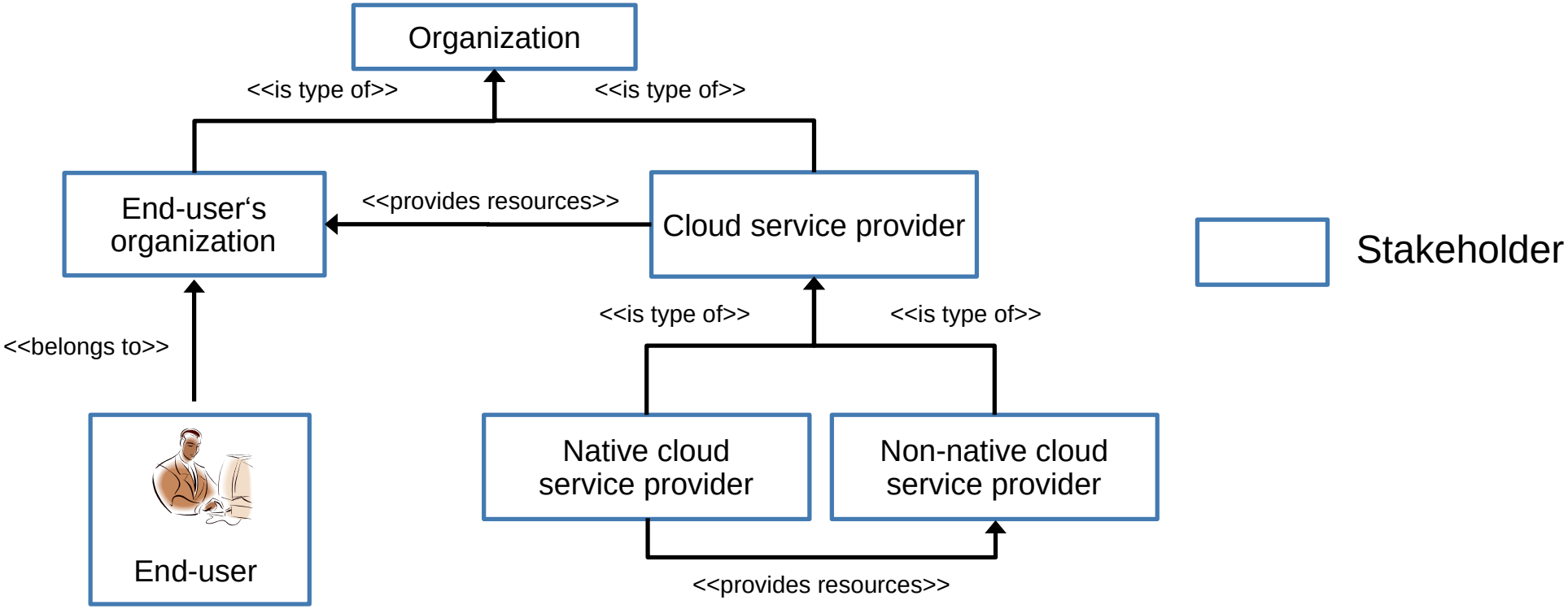
Cloud system designers:
Identification of frequently used cloud service patterns

Researchers and consultants:
Classification and comparison of cloud usage scenarios

And many more …

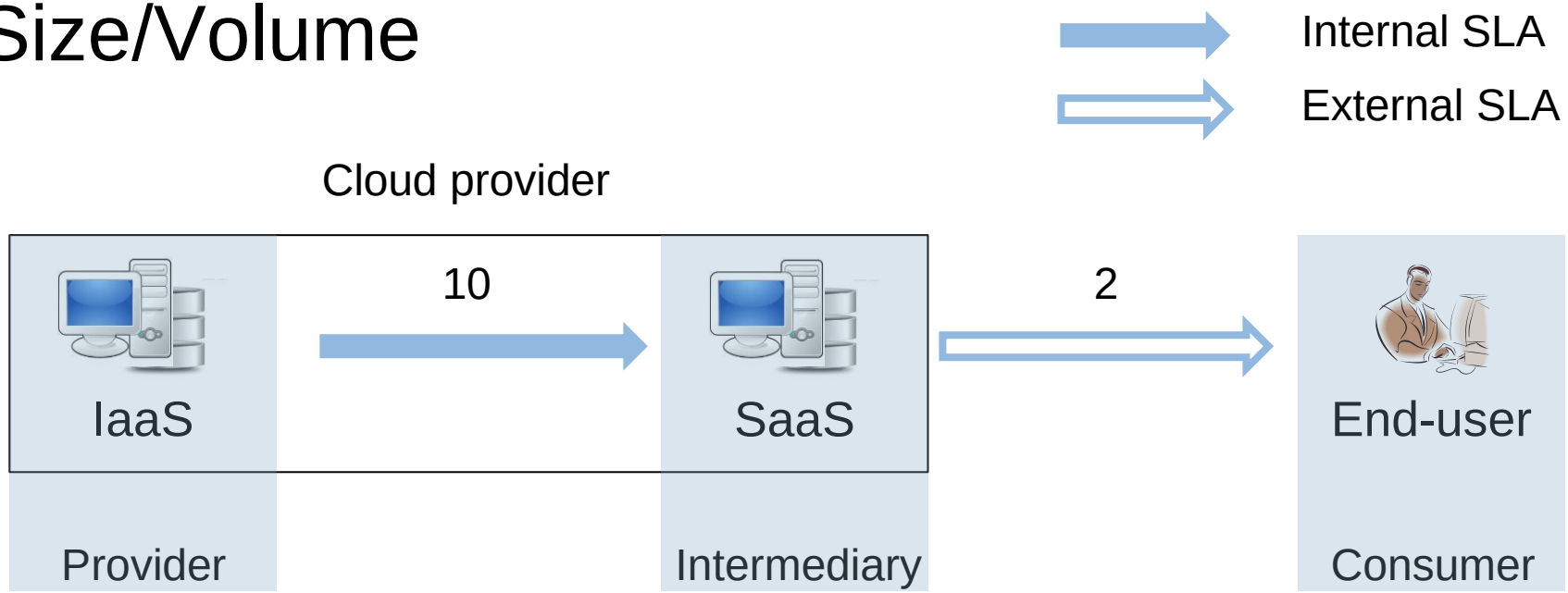
# Cloud Usage Patterns: Dimensions

- Abstraction levels
  - Hardware resources » IaaS » PaaS » SaaS
- Stakeholders

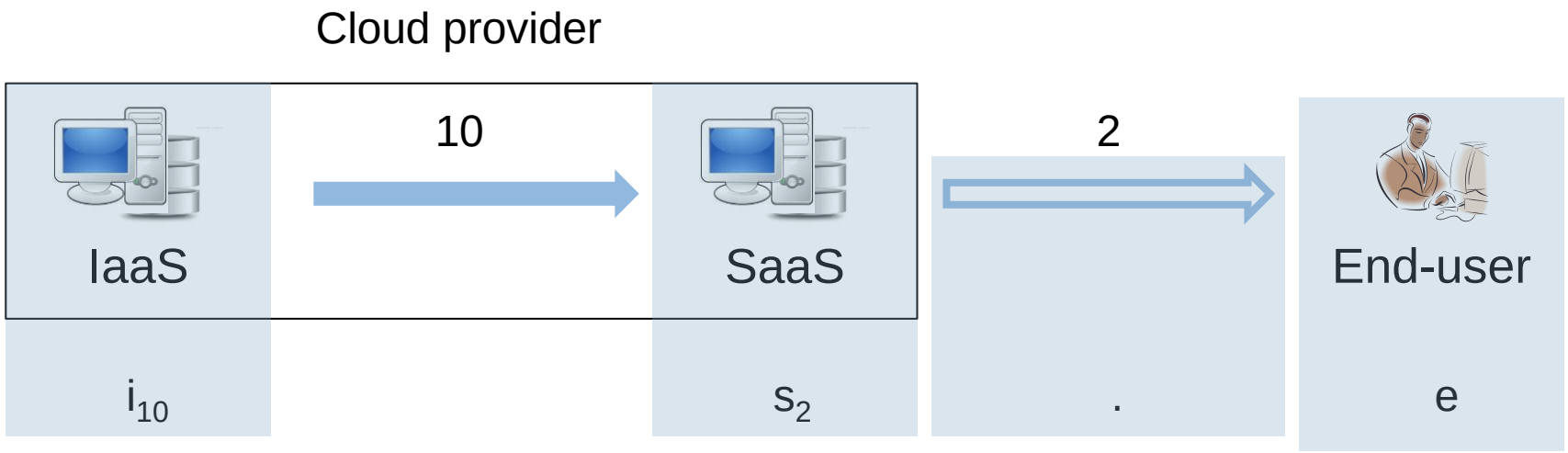


# Cloud Usage Patterns: Dimensions (cont.)

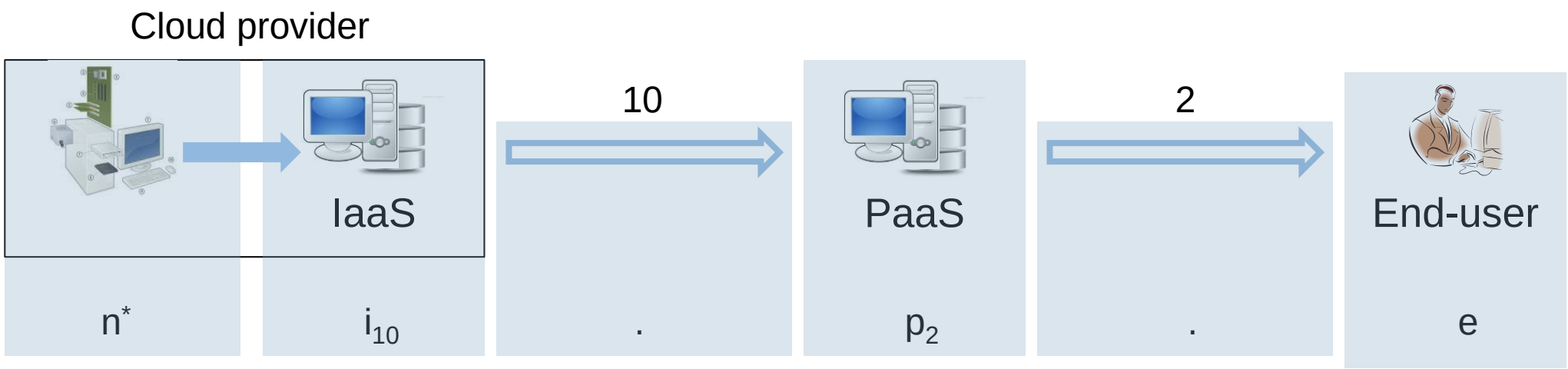
- Roles
  - Provider, consumer, intermediary
- Server Level Agreements (SLAs)
  - Internal, external
- Size/Volume



# Textual Cloud Usage Patterns: Value Chains



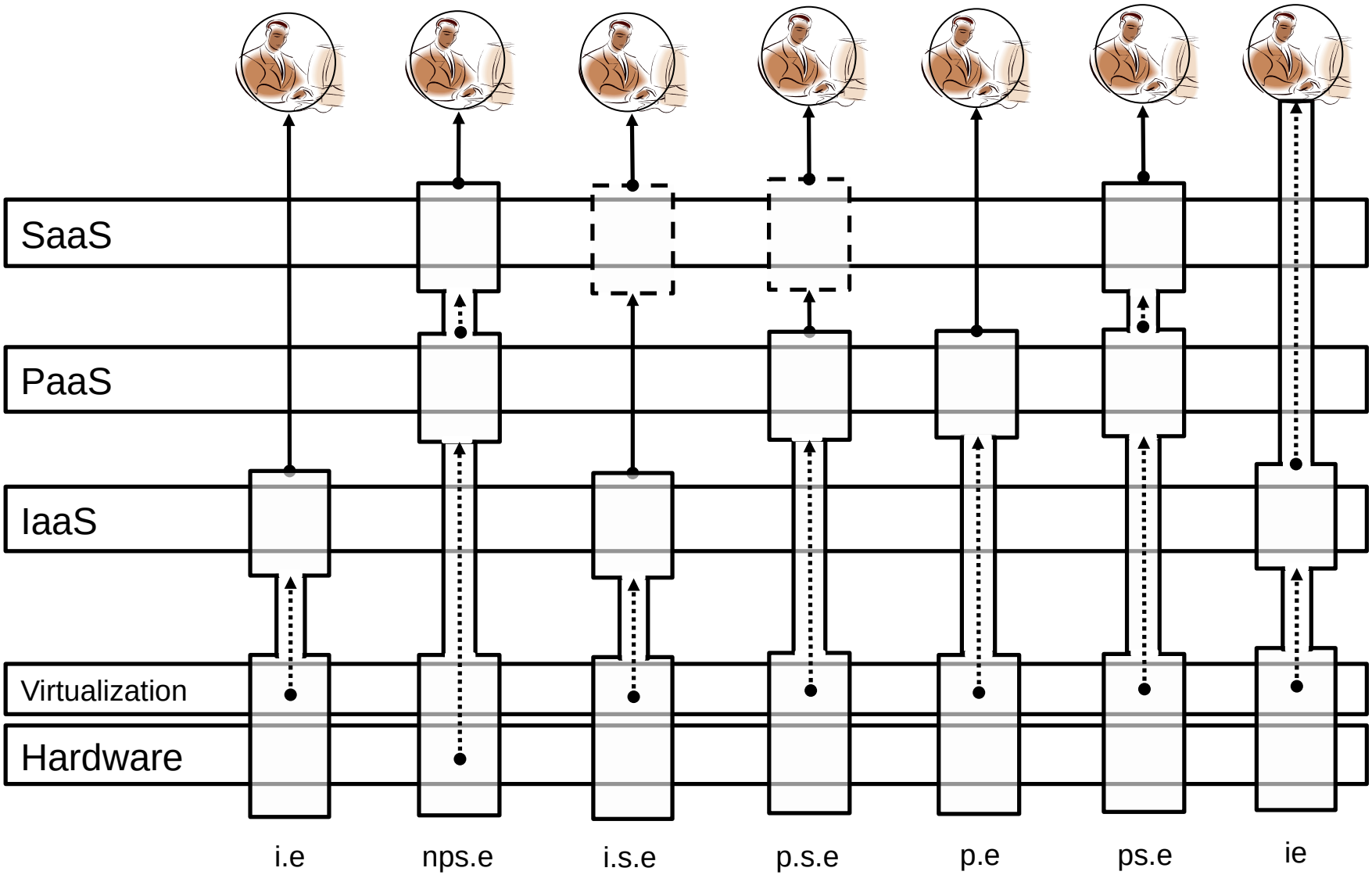

$\mathbf{i_{10}.s_2.e}$




$\mathbf{ni_{10}.p_2.e}$

* Hardware resources (no virtualization)

# Visual Cloud Usage Patterns: Value Chains



# Cloud Usage Patterns in Practice: Value Chains

**Amazon Web Services**

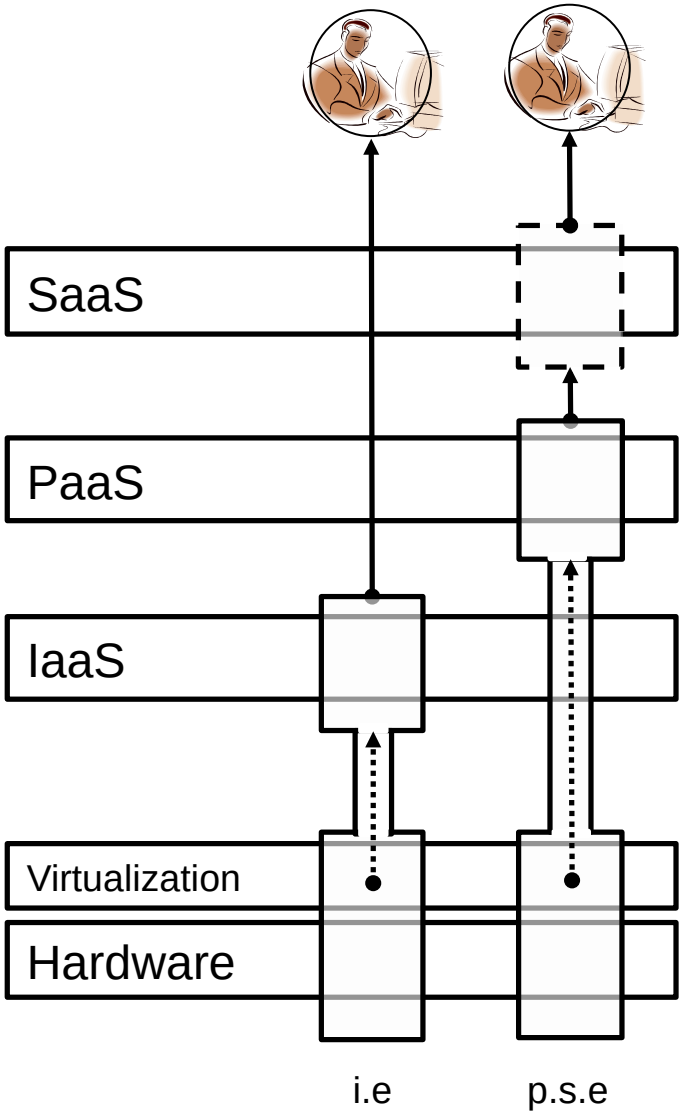
Infrastructure resources ⟩ End-user

Textual cloud usage pattern: **i.e**

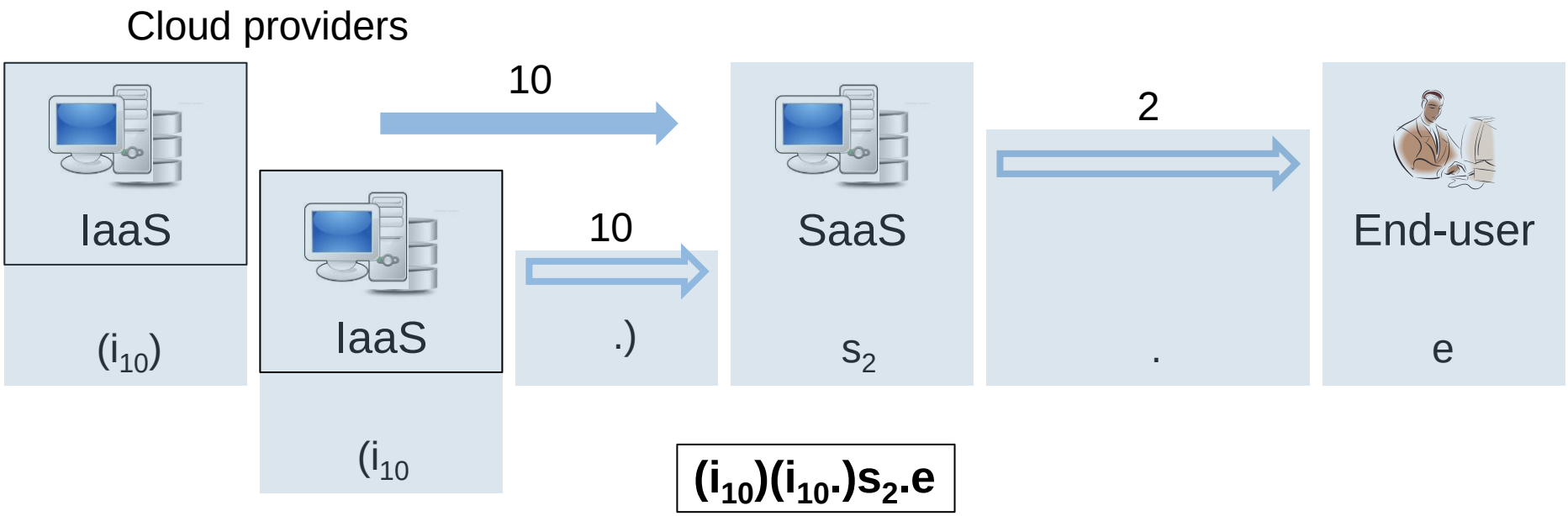
**EZAsset**

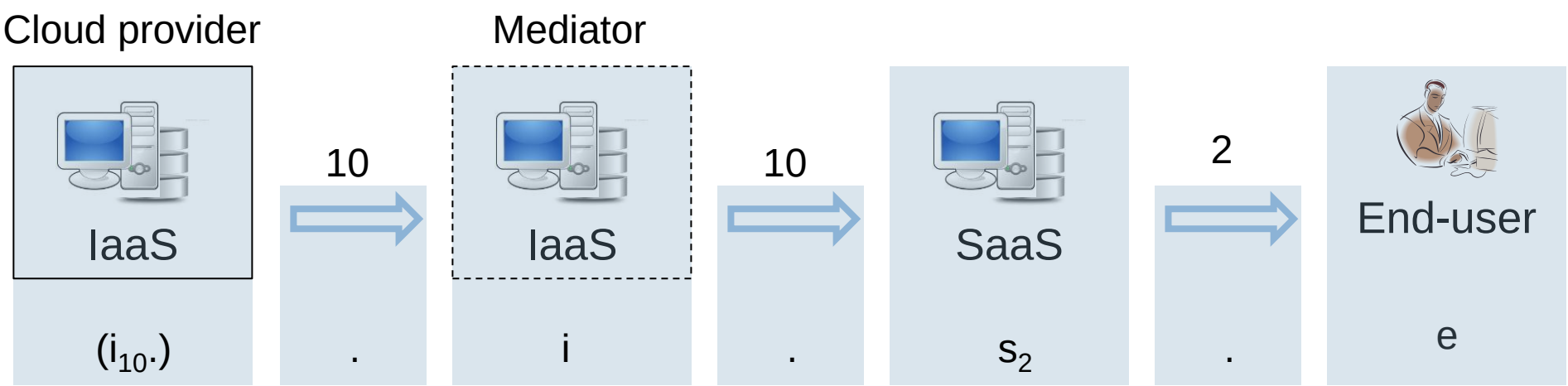
Google Engine APIs ⟩ Application ⟩ End-user

Textual cloud usage pattern: **p.s.e**



# Textual Cloud Usage Patterns: Hybrid Service Provisioning and Value Chains with Mediators



# Cloud Usage Patterns in Practice: Hybrid Service Provisioning and Value Chain with Mediators

**Zynga**

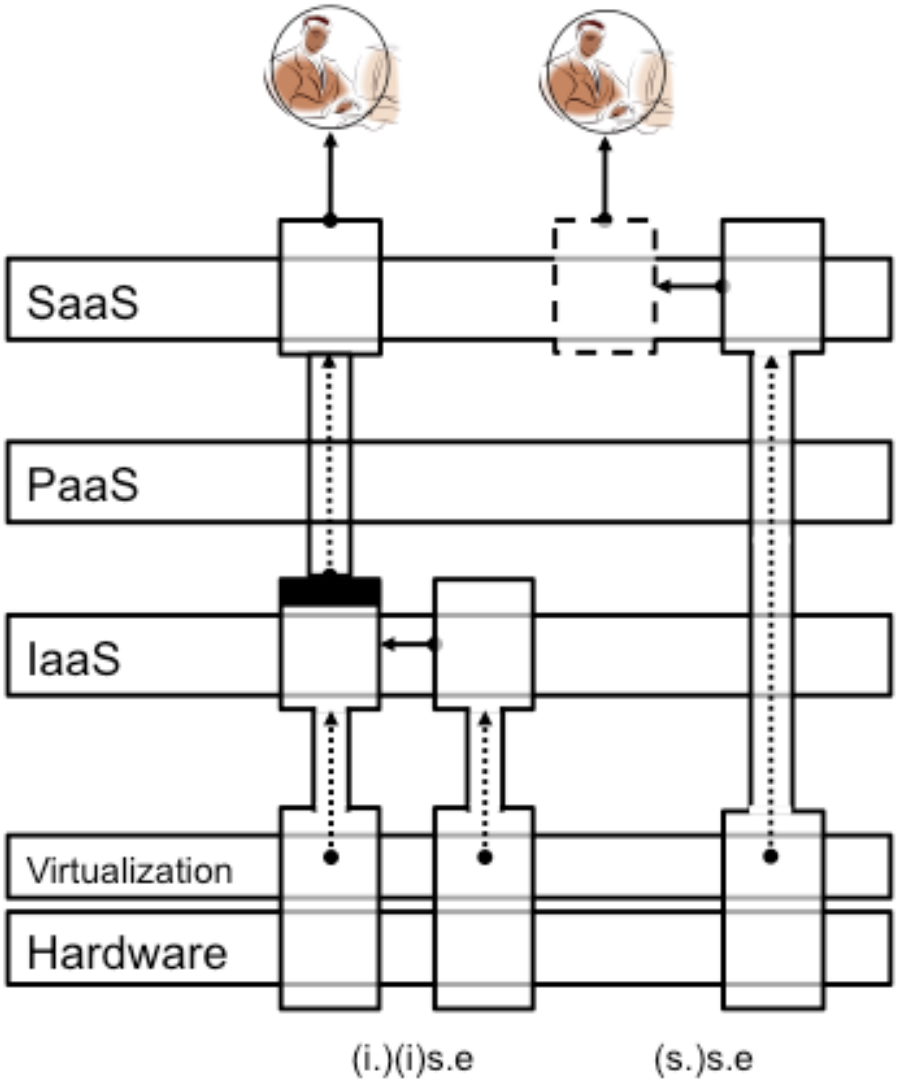
Infrastructure resources (Zynga + Amazon) ⇒ Application ⇒ End-user

Textual cloud usage pattern: (**i.)(i)s.e**

**Dito**

Google Apps software ⇒ Reseller ⇒ End-user

Textual cloud usage pattern: (**s.)s.e**



# Elasticity

- **ODCA, Compute Infrastructure-as-a-Service:**

  *”[...] defines elasticity as the configurability and expandability of the solution[...] Centrally, it is the ability to scale up and scale down capacity based on subscriber workload.”*

- **NIST Definition of Cloud Computing**

  *”Rapid elasticity: Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand.”*

- **IBM, Thoughts on Cloud, Edwin Schouten:**

  *”Elasticity is basically a ’rename’ of scalability [...]” and ”removes any manual labor needed to increase or reduce capacity.”*

- **Rich Wolski, CTO, Eucalyptus:**

  *”Elasticity measures the ability of the cloud to map a single user request to different resources.”*

- **Reuven Cohen:**

  *Elasticity is ”the quantifiable ability to manage, measure, predict and adaptive responsiveness of an application based on real time demands placed on an infrastructure using a combination of local and remote computing resources.”*

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# Elasticity

*N. Herbst, S. Kounev, and R. Reussner. Elasticity: What it is, and What it Not. In Proceedings of the 10th International Conference on Autonomic Computing (ICAC 2013), San Jose, CA, USA, June 24-28, 2013.*

**Generic definition of elasticity:**

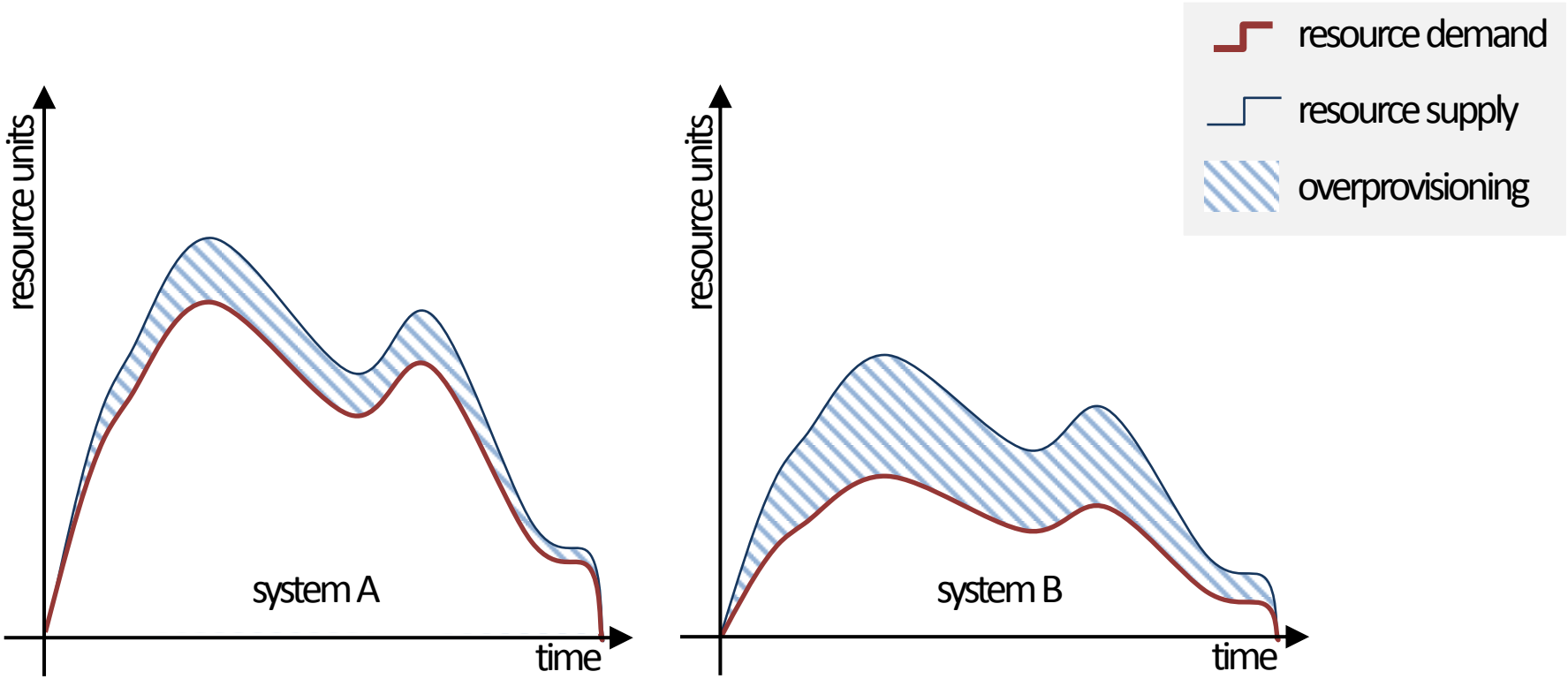
*The degree to which a system is able to adapt to workload changes*

*by provisioning and deprovisioning resources in an autonomic manner,*

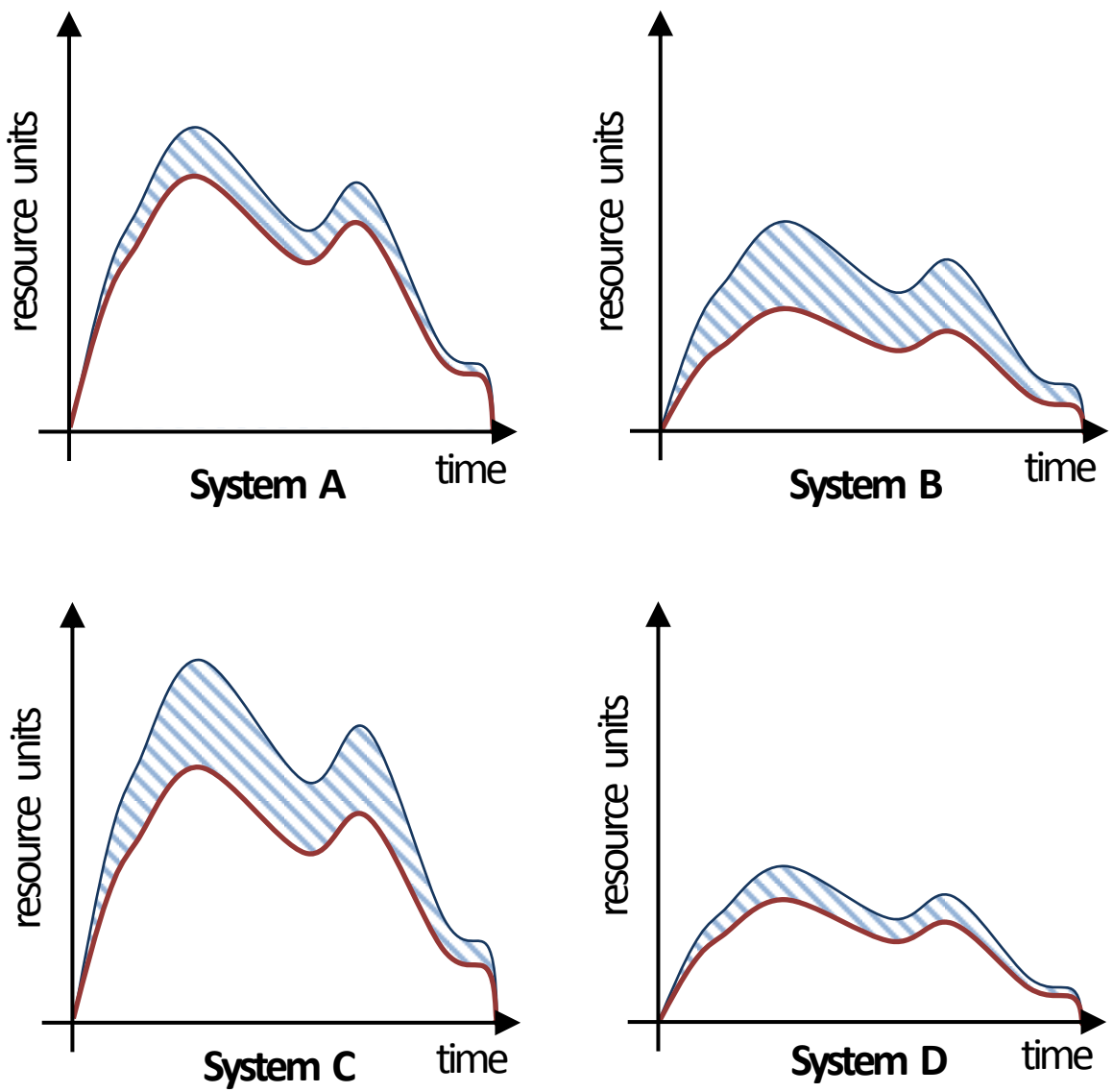
*such that at each point in time the available resources match the current demand as closely as possible.*

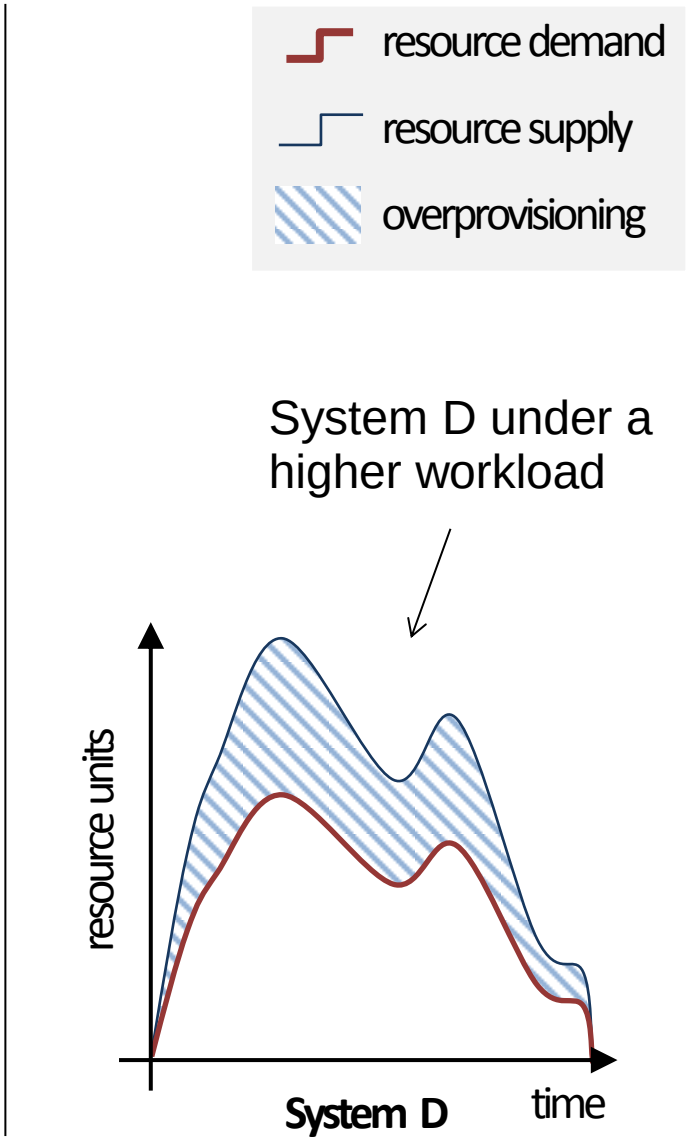
# Elasticity

Two systems executing the *same* workload. Which one is better?



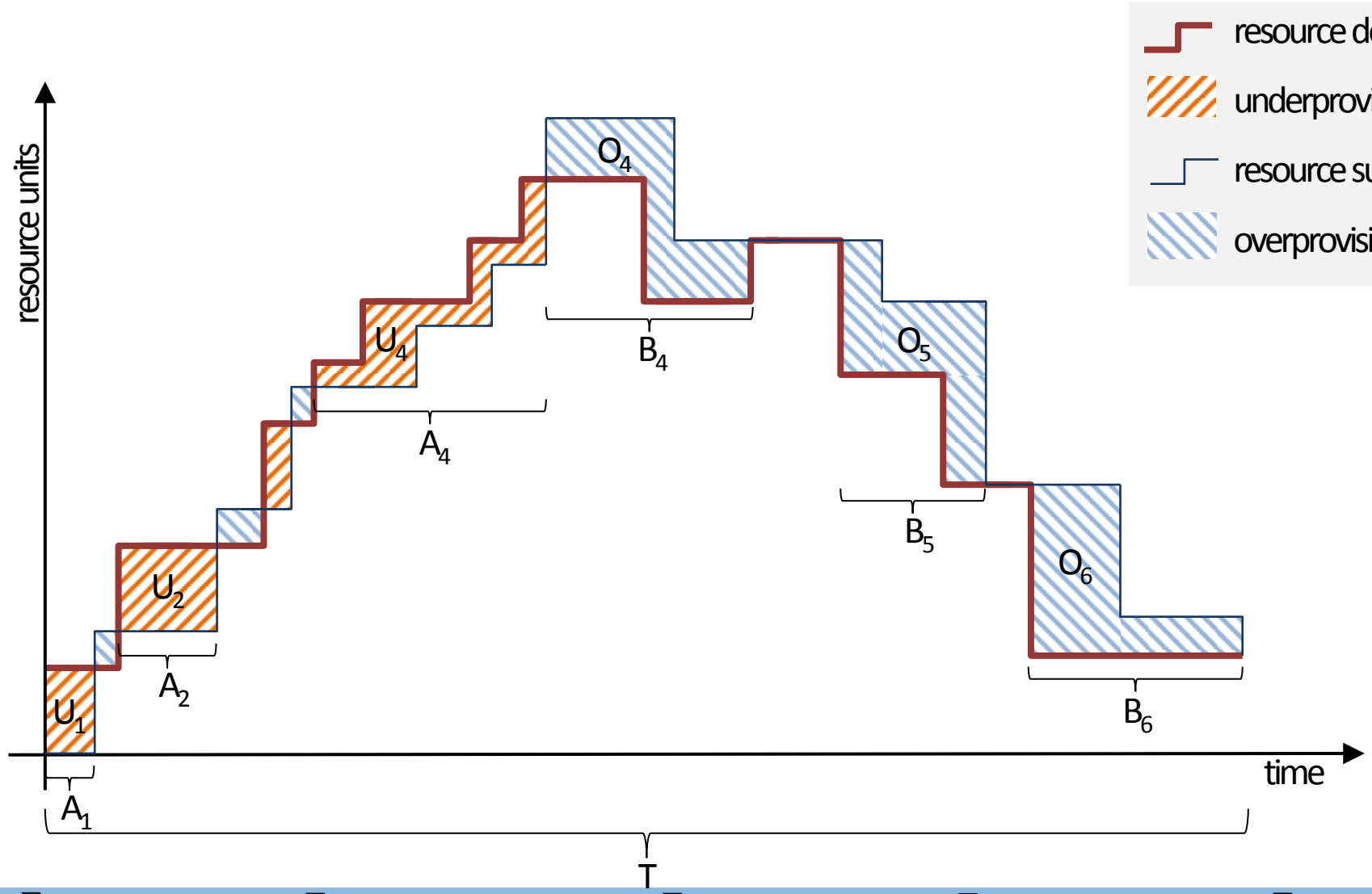
# Elasticity


resource units
time
System A
System B
System C
System D


resource demand
resource supply
overprovisioning
System D under a higher workload
resource units
time
System D

# Elasticity

Speed vs. precision of scaling up vs. down.



- Workloads
  - Representative benign workloads: scalable & heterogeneous
  - Malicious workloads: representative attack profiles
- Metrics
  - Considering on-demand resource provisioning to an IDS

- References

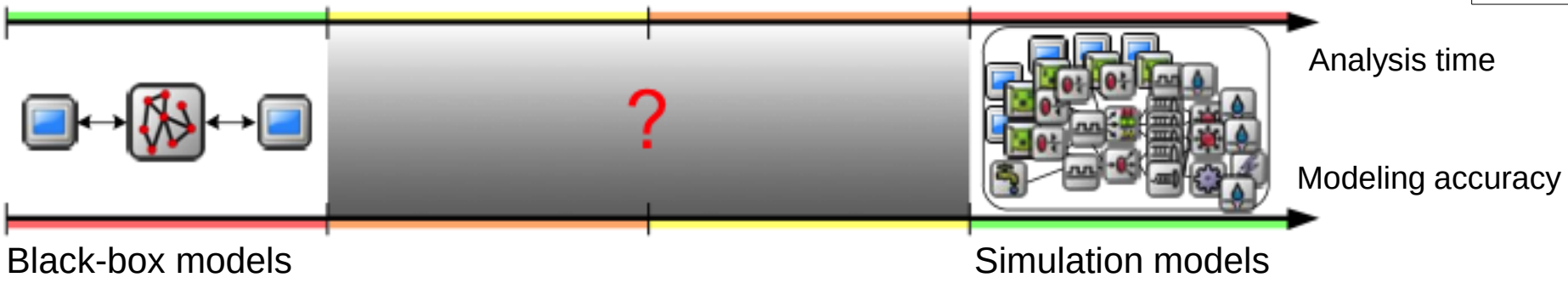
SPEC Research Group IDS Benchmarking Working Group:

http://research.spec.org/working-groups/ids-benchmarking-working-group.html

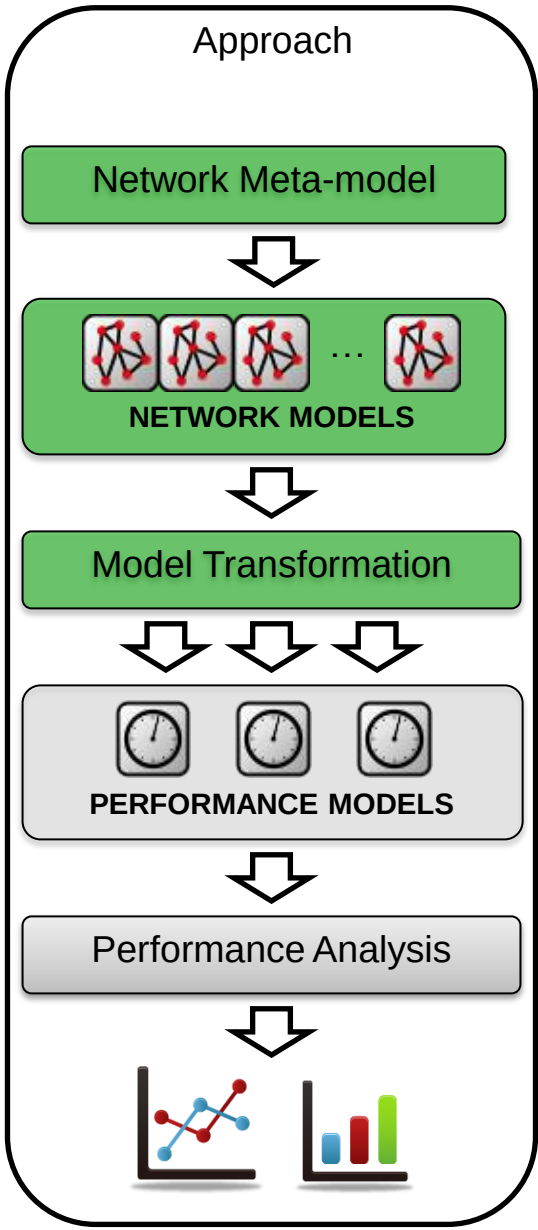
*Aleksandar Milenkoski and Samuel Kounev. Towards Benchmarking Intrusion Detection Systems for Virtualized Cloud Environments (Extended Abstract). IEEE ICITST 2012, London, United Kingdom, December 10-12, 2012, pages 562-563.*

*Aleksandar Milenkoski, Alberto Avritzer, Samuel Kounev, Nuno Antunes, and Marco Vieira. On Benchmarking Intrusion Detection Systems for Virtualized (Cloud) Environments. SPEC Research Group, Technical Report SPEC-RG-2013-002, v. 1.0, May, 2013. (to appear)*

- **Problem**
  - Increasing volume of inner data center network traffic
  - Bandwidth overprovisioning leads to inefficeincy
  - Existing models too coarse or too detailed
  - Existing models are bound to particular technologies
- **Goal**
  - Performance analysis of Cloud data center networks during run-time



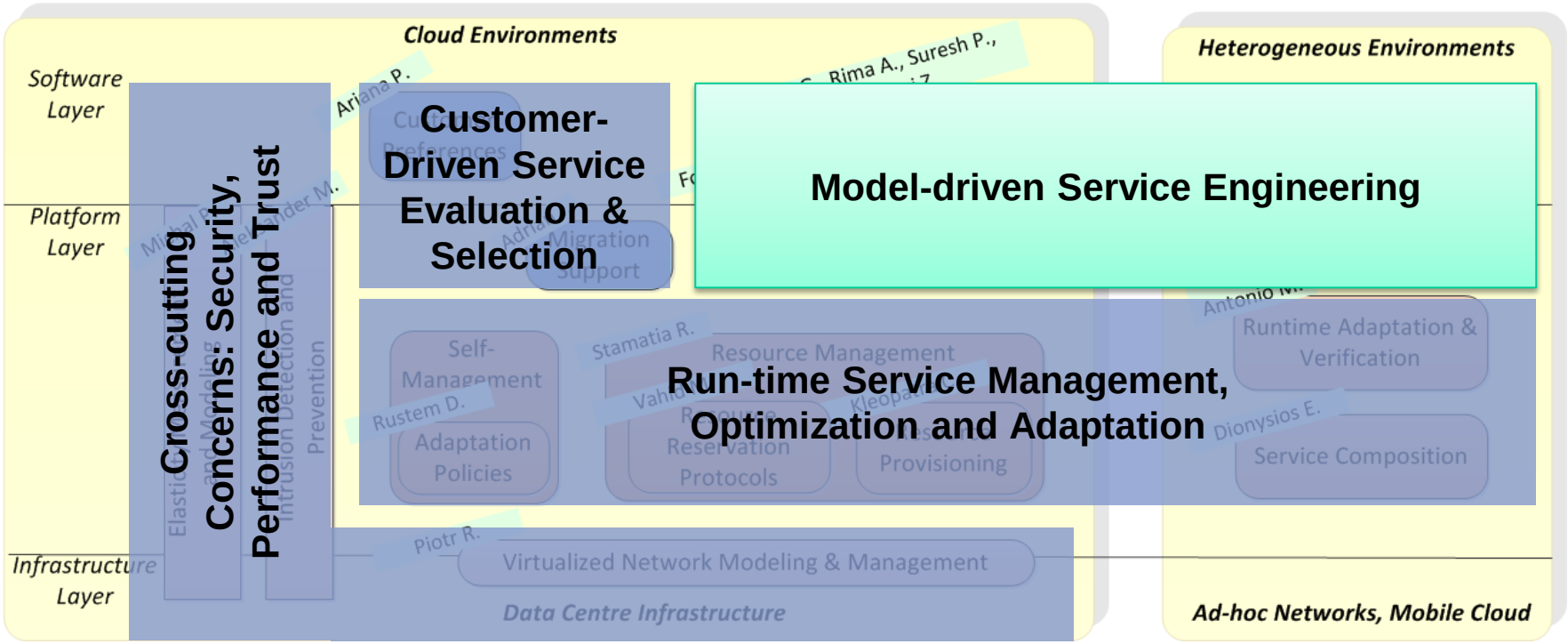
- **Approach**
  - Build meta-model of network infrastructures
  - Develop transformations into predictive models
  - Use the models for performance analysis
- **Novelty**
  - Generic and technology independent model
  - Virtualization in networks
  - Run-time relevant aspects
  - Cloud specific features
  - Flexibility in modeling level of details



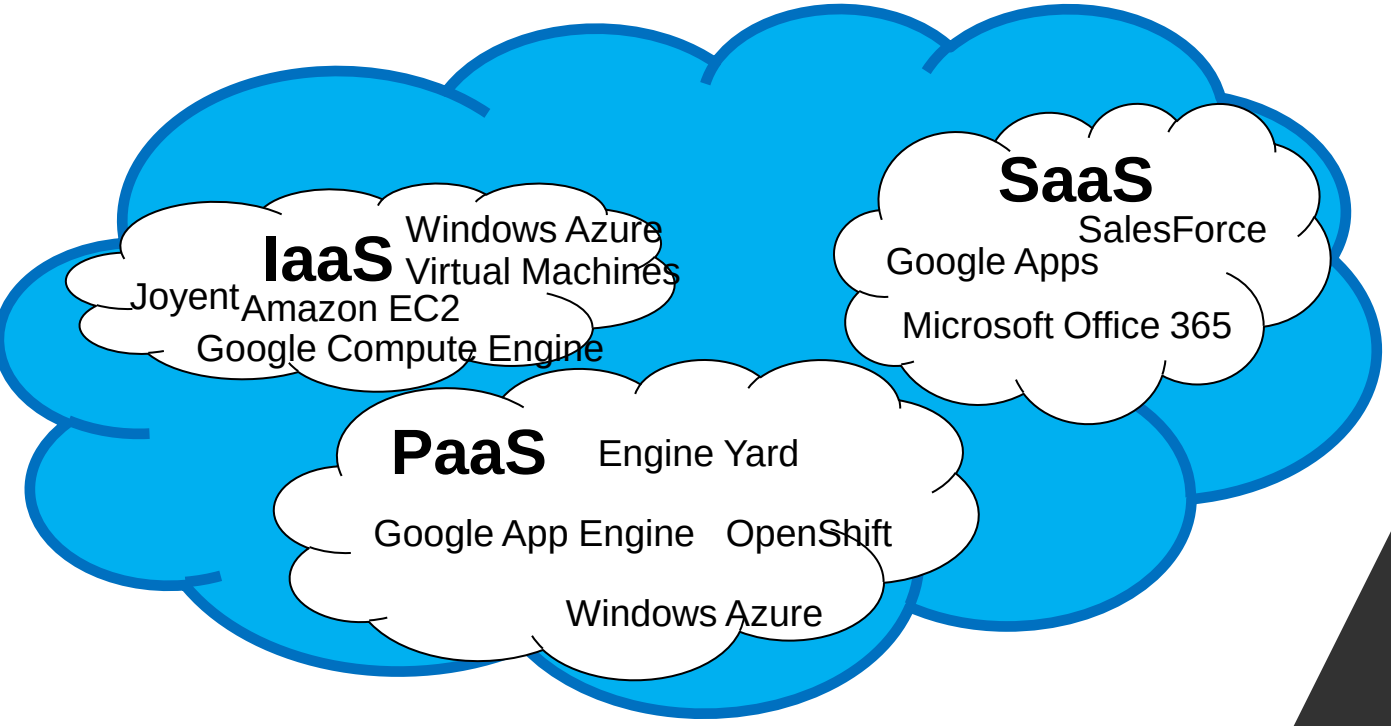
- **Results so far**
  - Descartes Network Infrastructures (DNI) Meta-model
  - Automatic transformation to OMNeT++ simulator
  - Case study: Cambridge traffic monitoring system
- **References**

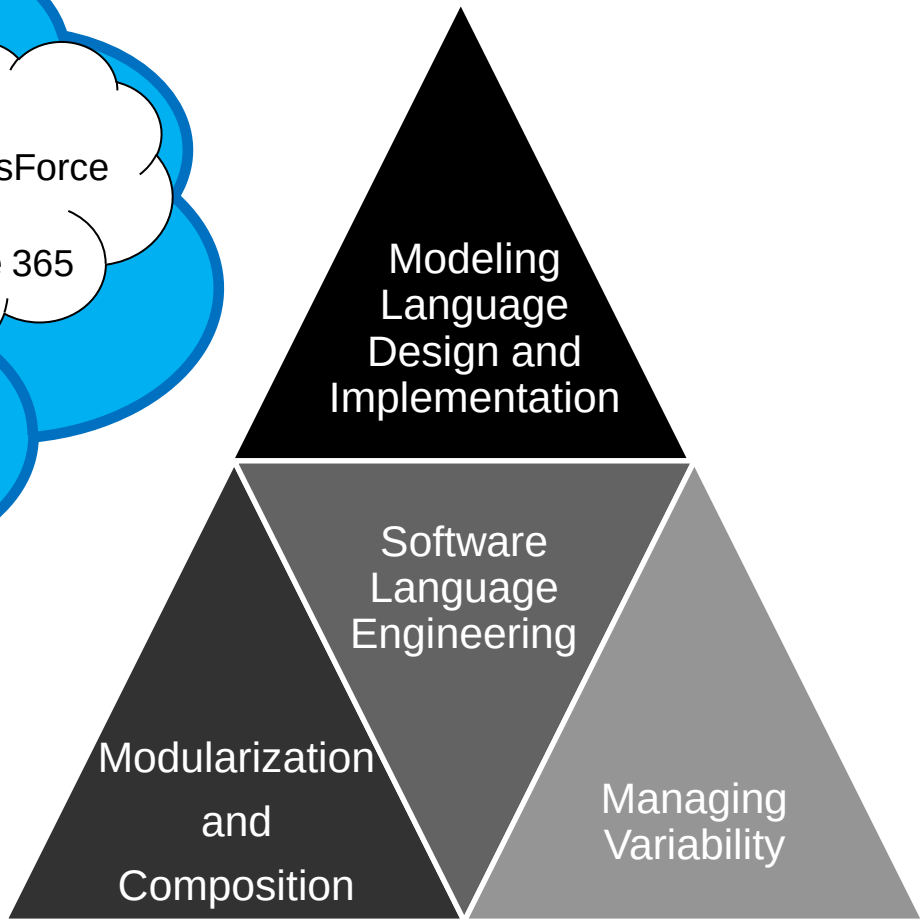

  - **Survey of Network virtualization approaches**: Piotr Rygielski and Samuel Kounev. *Network Virtualization for QoS-Aware Resource Management in Cloud Data Centers: A Survey*. PIK - Praxis der Informationsverarbeitung und Kommunikation, 36(1):55-64, February 2013, de Gruyter
  - **Presentation of the meta-model**: Piotr Rygielski, Steffen Zschaler, and Samuel Kounev. *A Meta-Model for Performance Modeling of Dynamic Virtualized Network Infrastructures*. In Proceedings of the 4th ACM/SPEC International Conference on Performance Engineering (ICPE'13), Prague, Czech Republic, **April 21-24, 2013**. Work-In-Progress Paper

# RELATE Research Map



# Suresh Pillay (suresh.pillay@irisa.fr): Managing Variability in Modelling Languages




**Problem:** To exploit the various options available from the different providers, would require a specific model for each provider, thus there is a loss of portability and minimum re-use.

Use variability modeling to manage variability and re-use commonalities

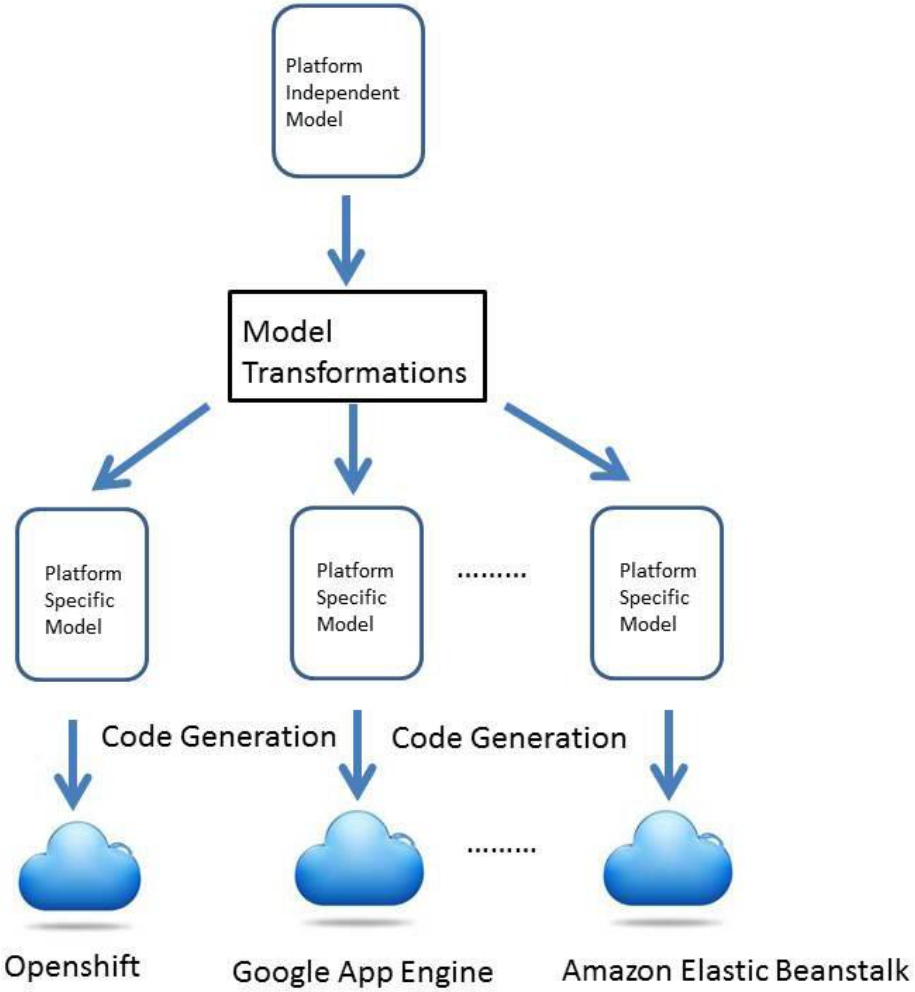
# Suresh Pillay (suresh.pillay@irisa.fr): Managing Variability in Modelling Languages

- Goals
  - Specify a language family by modelling the common constructs and he differences
  - Automatically derive a modelling environment (including model editor, interpreter and compiler) for any language of the family

- Current activities
  - Extension of the Kermeta language workbench for designing well-typed language units
  - Extension of CVL to deal with language units in Kermeta, and multi-dimensional variability
  - Definition of composition operators for language units

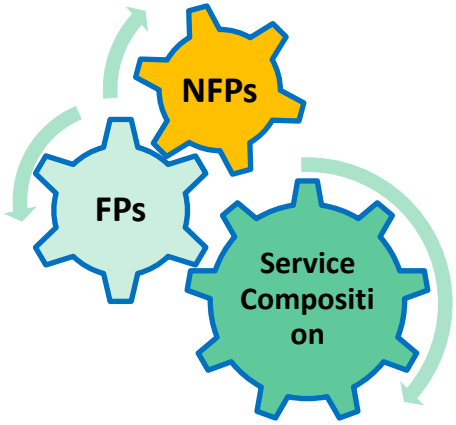
# Fotis Gonidis (fgonidis@seerc.org):
## Formal modeling for cross-platform development and deployment of cloud applications

- Motivation: Lack of portability across cloud platforms
- Various conflict points
  - Cloud databases
  - File storage
  - Platform specific services
  - Message queue service
  - Programming languages/frameworks
  - File storage service
  - .....




F. Gonidis, I. Paraskakis, D Kourtesis,“ Addressing the Challenge of Application Portability in Cloud Platforms", In 7th South East European Doctoral Student Conference (DSC 2012), pp.565-576,Thessaloniki, Greece, September 2012.

- Provenance Awareness
  - The ability to answer provenance questions by recording provenance data during service execution
  - Questions about *how they have processed and produced data* (*the **provenance** of the data*).




- Example Provenance Questions
  - Why the travel planner booked a bike instead of a car?
  - What was the reason for booking a high cost flight?
  - Which bank managed the authentication of the credit card number?
  - Were all the hotel services available during the hotel reservation?

# Provenance awareness types of services and service composition

- Goals
  - Provenance-awareness as explicit NFP in composite service specifications
  - Analyse services to see whether they meet provenance-related requirements

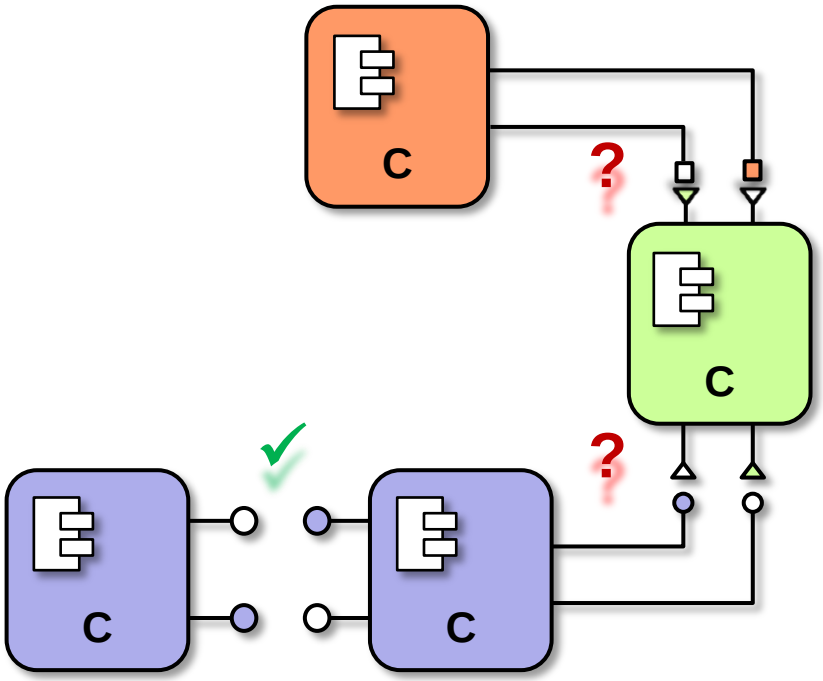
    P. Zerva, S. Zschaler, and S. Miles, "Towards Provenance Aware Design of Service Compositions: A Methodology for Analysing the Provenance Awareness in Service Designs''. In 10th IEEE International Conference on Services Computing (SCC 2013)"

  - Identify and categorize the provenance questions that need be answered

    P. Zerva, S. Zschaler, and S. Miles, "Towards Design Support for Provenance Awareness: A Classification of Provenance Questions'' In International Workshop on Managing and Querying Provenance Data at Scale (BIGProv'13), Genova, Italy

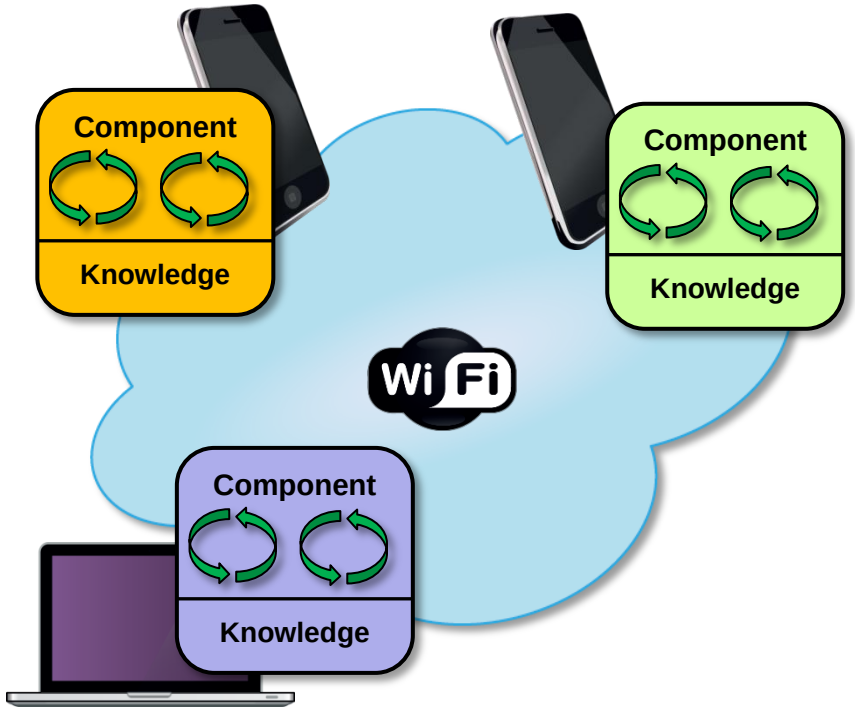
  - Propose a number of provenance question type patterns
  - Analyse impact of on other properties (e.g., performance, storage)

# Supporting heterogeneous service-oriented systems


- Context: Open ad-hoc clouds (both heterogeneous and dynamic)
- Motivation: Currently available solutions (component-based and agent-based) do not deal with heterogeneity very well.
- Goals: Overcome the problems related to the heterogeneity

## Components




## Ensembles

1. Coordinator

Should they communicate?

Member

2. If so, then transfer data

Coordinator

Member

- Components and Ensembles as first class constructs
- A component is composed of Knowledge and Processes
- An ensemble consists a membership condition and knowledge exchange prescription
- Existing realization in Java - jDEECo

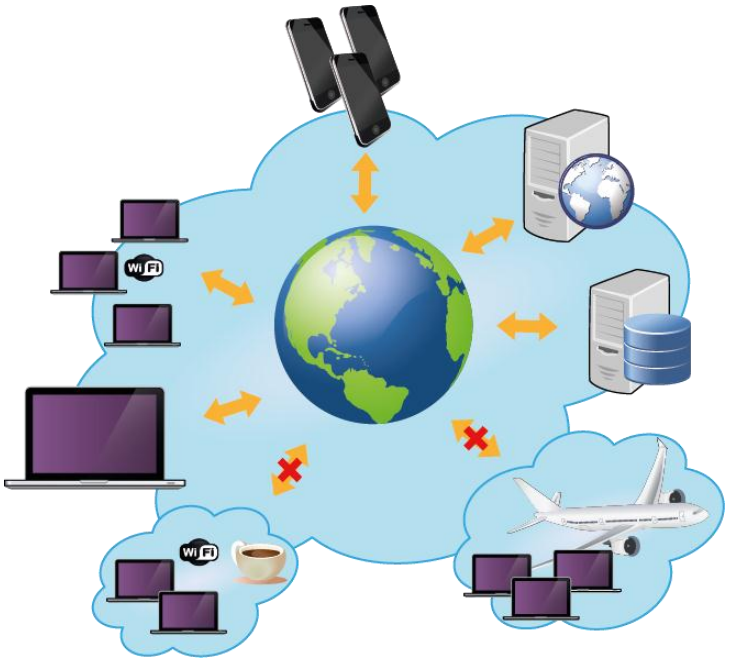
- Keznikl J., Bureš T., Plášil F., Kit M.: "Towards Dependable Emergent Ensembles of Components: The DEECo Component Model", Proceedings of WICSA/ECSA 2012, Helsinki, Finland, pp. 249-252, IEEE CS, ISBN 978-0-7695-4827-2, DOI 10.1109/WICSA-ECSA.212.39, August 2012

- Bureš T., Gerostathopoulos I., Hnětynka P., Keznikl J., Kit M., Plášil F.: "Autonomous components in dynamic environments", Awareness Magazine (official magazine for the Awareness: Self-Awareness in Autonomic Systems Future and Emerging Technologies Proactive Initiative, funded by the European Commission under FP7), 2012

- Bureš T., Gerostathopoulos I., Hnětynka P., Keznikl J., Kit M., Plášil F.: "DEECo – an Ensemble-Based Component System" CBSE 2013


**jDEECo:**

**https://github.com/d3scomp/jDEECo.git**




## domain analysis

- **Nodes in ad-hoc, dynamic networks**
- Inherently distributed
- Recurring/dynamic changes in the environment

## the problem

Classic requirement-driven design approaches (use-case, goal-oriented) incapable to deal with

- dynamic, emerging behavior
- dynamic software architecture

## Key idea

- Design systems comprised of *autonomous software components*
- Use DEECo component model
- Capture the *operational normalcy* of the system

## Approach

- Model system requirements in terms of **invariants** (~ system goals) over stakeholders knowledge

## Expected contribution

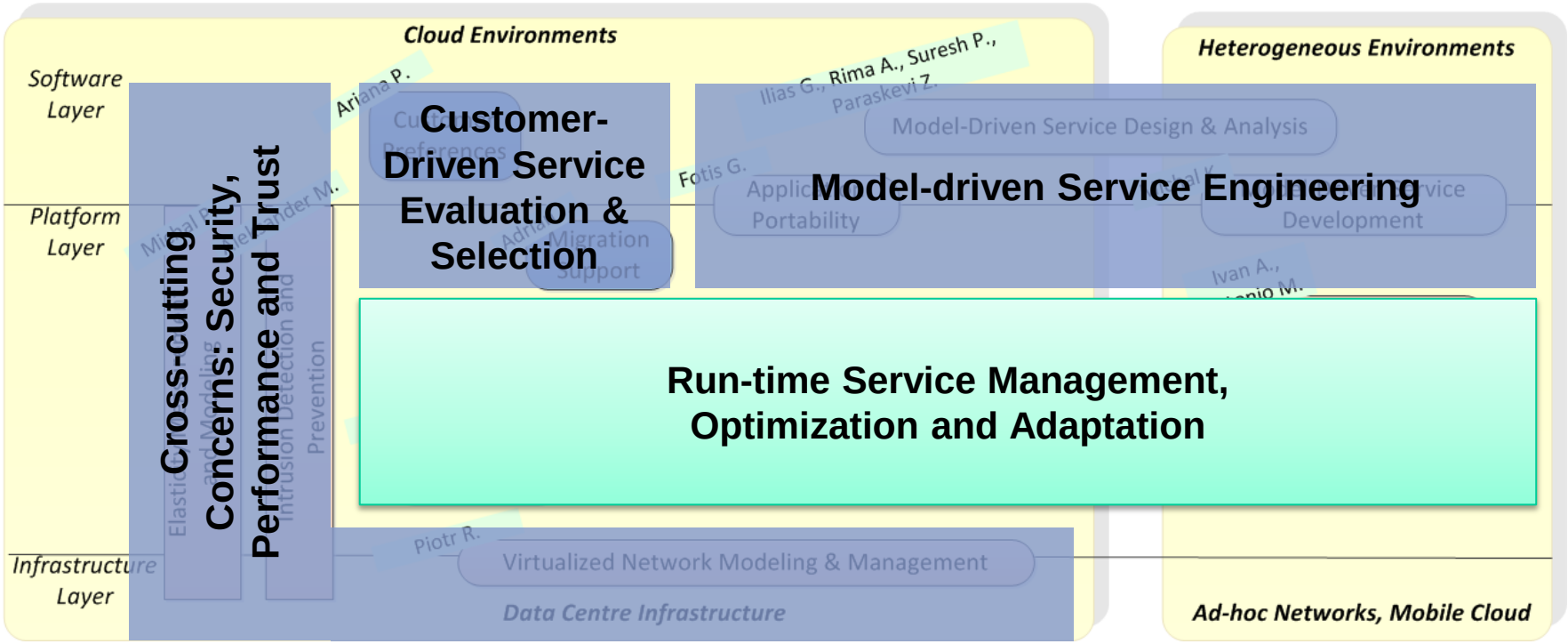
- Bridge the gap btw. requirements, design and implementation
- Provide guidance to system design based on scientific evidence

I. Gerostathopoulos, T. Bures, and P. Hnetynka, “Position Paper: Towards a Requirements-Driven Design of Ensemble-Based Component Systems”, In HotTopiCS 2013.

T. Bures, I. Gerostathopoulos, P. Hnetynka, J. Keznikl, M. Kit, and F. Plasil, “DEECo – an Ensemble-Based Component System,” In *CBSE 2013*.

J. Keznikl, T. Bures, F. Plasil, I. Gerostathopoulos, P. Hnetynka, and N. Hoch, “Design of Ensemble-Based Component Systems by Invariant Refinement,” In *CBSE 2013*.

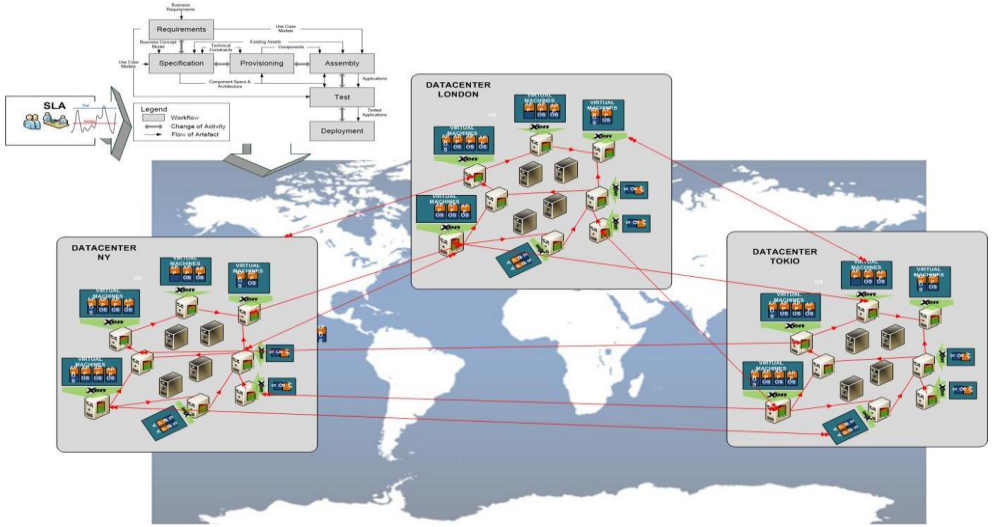
# RELATE Research Map



# Kleopatra Chatziprimou (kleopatra.chatziprimou@kcl.ac.uk)

## Optimal control techniques for automated resource reconfigurations in IaaS environments

- Service runtime constraints
- Cloud is highly dynamic
  - Workload fluctuations
  - Energy price fluctuations
  - Market conditions variations




- **Goal** Optimal online infrastructure reconfigurations
  - Formalization of IaaS resource landscape
  - Automated search for good configuration candidates in the IaaS space
  - Trade-off decisions: performance vs. energy cost, cost of adaptation vs. benefit
  - Online adaptation: Runtime constraints, Limited iterations to calculate solutions
- **Approach**
  - Model driven design, Evolutionary computation, Quality attributes predictions
- References: Chatziprimou K., Lano K., Zschaler S., “Towards a Meta-model of the Cloud Computing Resource Landscape”, MODELSWARD 2013

Distributed service-based systems

Resource heterogeneity, Intermittent connectivity, Fluctuating QoS

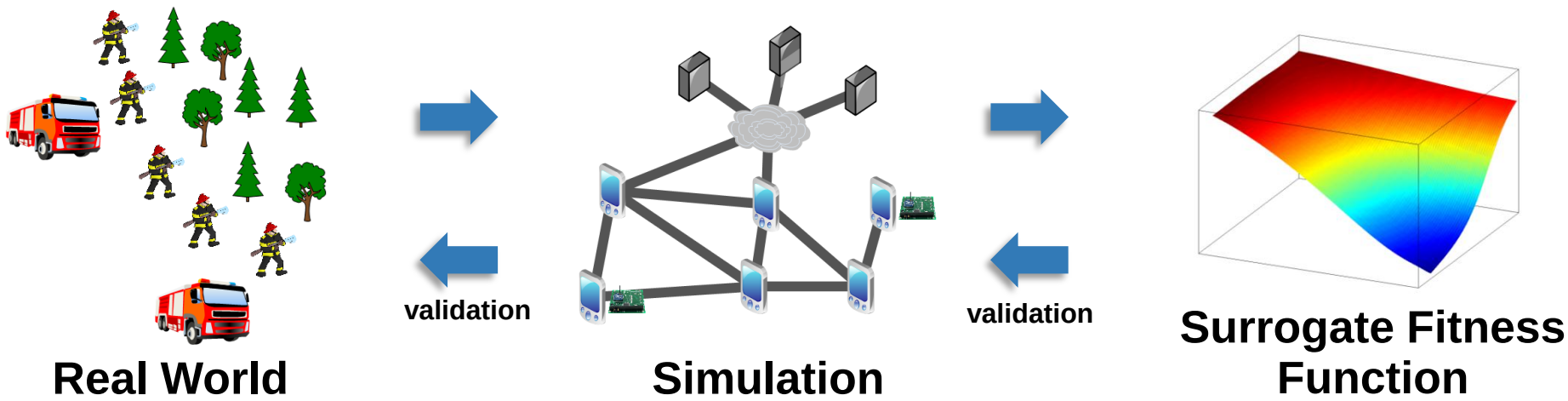
Run-time QoS-aware service composition: Quality trade-offs (latency, availability)

A flexible formulation of composition configurations: multiple degrees of freedom[2]

Efficient exploration of optimal composite applications

Search-based approach[3], , Surrogate objective function models

**Validation**: Simulation, real-world scenario, Fire-fighter decision support system[1]

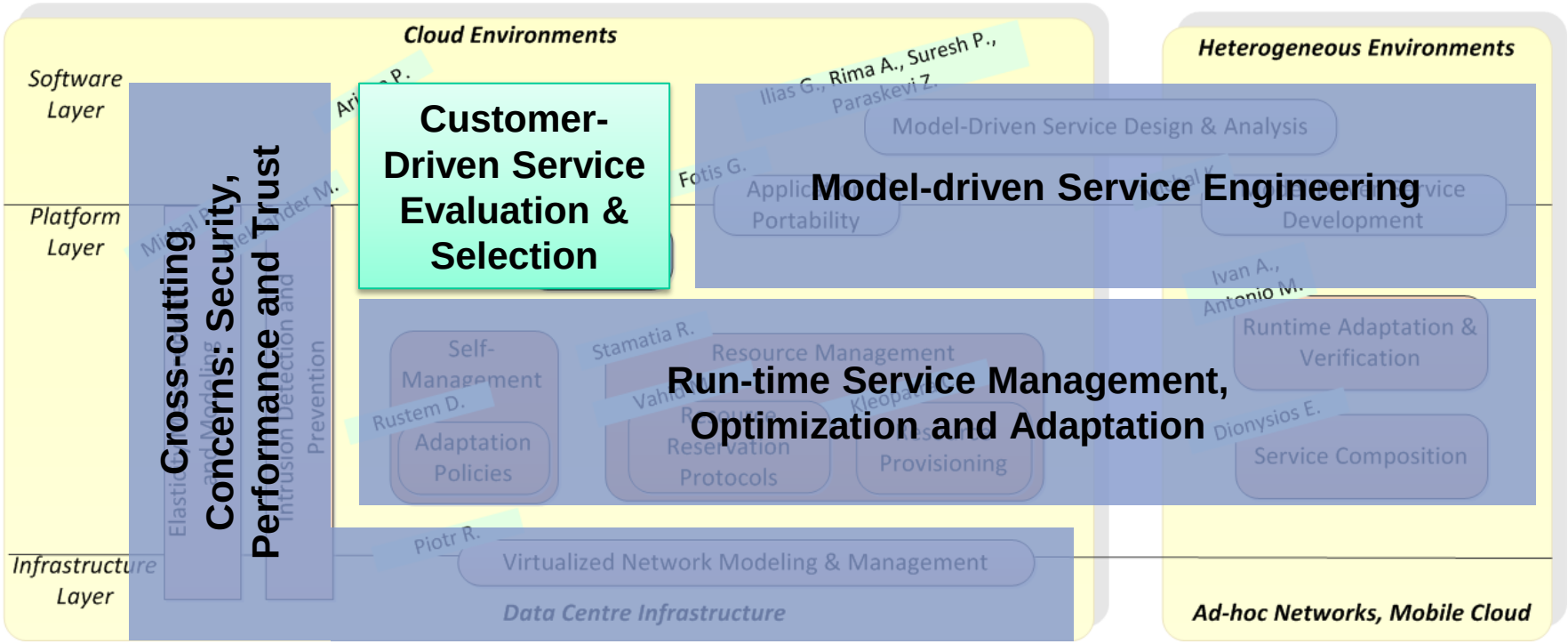


1. Efstathiou D., McBurney P., Plouzeau N. and Zschaler S. Improving the Quality of Distributed Composite Service Applications. **Published** in the 2nd Imperial College Computing Student Workshop September 27-28, 2012, London, United Kingdom.

2. Efstathiou D., McBurney P., Zschaler S. and Bourcier J. Enabling High-Quality Service Composition in Distributed Service-Oriented Environments. **Submitted** in the 5th USENIX Workshop on Hot Topics in Cloud Computing (HotCloud 2013), 2013.

3. Efstathiou D., McBurney P., Zschaler S, Bourcier J. Exploring Trade-off Composite Applications in Highly Heterogeneous and Dynamic Service-Based Systems. **To be submitted in** 5th Symposium on Search-Based Software Engineering (SSBSE 2013), St. Petersburg, 2013.

# RELATE Research Map



## Motivation

- Need to understand adoption & selection of SaaS solutions
- Tools that could assist customers in selecting cloud services
- SLA design policies & cloud standards

## Qualitative Studies

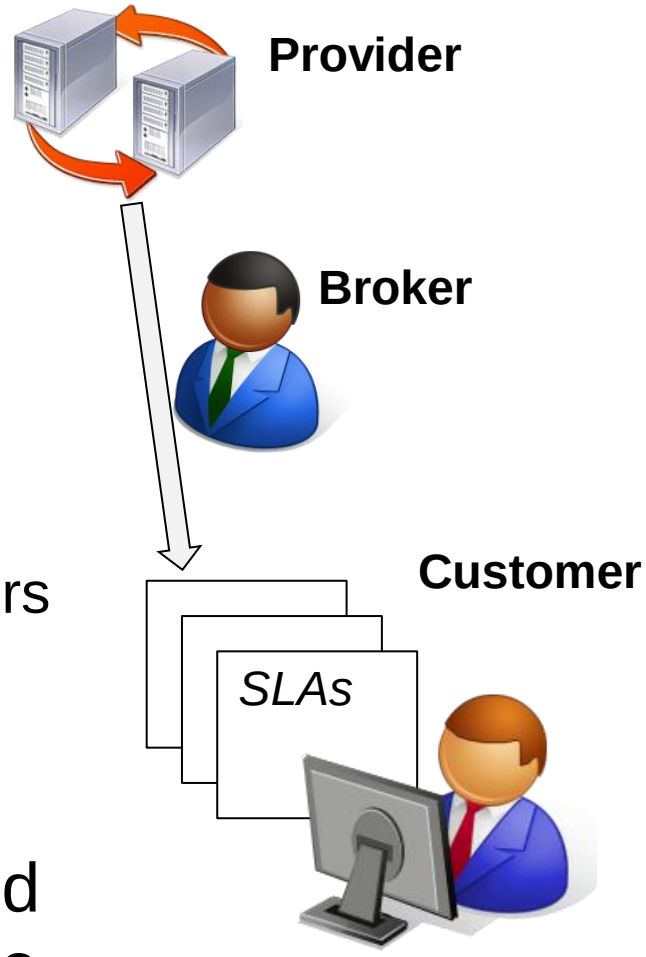
- Semi-structured interviews with vendors and clients
- Adoption, selection and migration/integration are processes that interfere with each other and impact the decision making

## Framework of the adoption-selection-migration process

Polyviou A., Pouloudi. SaaS selection criteria from vendor's and client's perspective. ICIS'13 (under preparation)

Stamatia Rizou, Ariana Polyviou. Towards value-based resource provisioning in the Cloud. In 4th IEEE CloudCom'12

- Cloud provider‘s perspective
  - Increase revenue
  - Manage their resource pool efficiently
- Customer‘s perspective
  - Satisfy their requirements and needs
- Intermediate roles e.g. cloud brokers
  - Assist relationship btw. customers and providers
  - Increase competition among providers




→ Challenge: Assist users in evaluating cloud services and selecting the most appropriate

Need for *continuous service optimization* process from the cloud broker‘s perspective

Rizou S., Verginadis Y., Mentzas G. Continuous Service Optimization as Cloud Brokerage Service. In *3rd International Conference on Cloud Computing and Services Science, May 8-10, Aachen, Germany,* 2013.

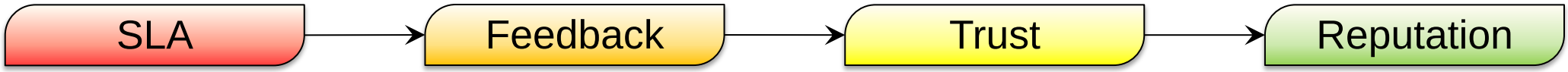
Need for *service ranking* that handles both precise and imprecise metrics

Patiniotakis I., Verginadis Y., Rizou S., Mentzas G. Managing Imprecise Criteria in Cloud Service Ranking with a Fuzzy Multi-Criteria Decision Making Method. To be submitted in ESOCC 2013.

# Kahina Hamadache (khamadache@singularlogic.eu)
## Trust and reputation mechanisms for cloud services

- Goal
  - Improvement and simplification of trust and reputation management
  - Faster adoption of the Cloud (more reliable and efficient T&R mechanisms)

- Approach
  - Development of standards and ontologies for Cloud SLA
  - Designing feedbacks, trust and reputation mechanisms based on Cloud SLA



# Further Projects

- Ilias Gerostathopoulos (iliasg@d3s.mff.cuni.cz)
  - Model-driven development of scalable service-oriented systems
- Rima Al Ali (alali@d3s.mff.cuni.cz)
  - Formal specification of services
- Rustem Dautov (rdautov[at]seerc.org)
  - A self-adaptation framework to address evolution and change in service-based cloud environments
- Adrián Juan Verdejo (adrian.juan[at]cas.de)
  - Assisted migration of enterprise applications to the cloud
- Inti Gonzalez Herrera
  - Resource Reservation in Containers for Applications

# Further Projects (cont.)

- Dr. Jose María Alvarez Rodríguez (jmalvarez@seerc.org)
  - Quality Management in Service-based Systems and Cloud Applications
- Ivan Dario Paez Anaya (Ivan.Paez_Anaya@irisa.fr)
  - A Proactive Adaptation Approach for Pervasive Distributed Systems
- Seyed Vahid Mohammadi (vahid.mohammadi@cas.de)
  - Algorithms and protocols for coordinated capacity planning in IaaS environments
- Dr. Bholanathsingh Surajbali (b.surajbali@cas.de)
  - Adaptive business models for PaaS solutions

# Thank You!

**http://www.relate-itn.eu/**

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**Trans-European Research Training Network on Engineering and Provisioning of Service-Based Cloud Applications**