CLOUD ECOSYSTEMS SUPPORT FOR INTERNET OF THINGS AND DEVOPS USING PATTERNS

Madiha H. Syed and Eduardo B. Fernandez
College of Electrical Engineering and Computer Science
Florida Atlantic University, Boca Raton, FL, USA
msyed2014@fau.edu

Outline

- Introduction
- Motivation
- Cloud Ecosystem
- Models of ecosystem components
  - Software Container
  - Fog Computing
- Internet of Things
- DevOps
- Conclusion
Introduction

- Cloud computing offers demand-based computing service. Levels of service: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).
- A cloud is not a single system, it comprises a multitude of systems, components, services, and applications.
- Clouds usually do not work in isolation but interact with other clouds and with a variety of associated and interdependent systems.
- Associated systems are a growing set, where new types of products appear and provide some useful functions for some types of users.

Ecosystems

- Ecosystems were initially defined from a biological perspective: systems formed by the interaction of a community of organisms with their physical environment.
- The term was later applied to software systems: “a collection of software systems, which are developed and co-evolve in the same environment”
- An Ecosystem is the expansion of a software product line architecture to include systems outside the product which interact with the product.
- Developing ecosystems for complex systems helps service providers as well as consumers.
- Cloud computing is an excellent example of such complex interconnected systems.
Cloud Ecosystem

- A cloud, its associated systems, providers, consumers, brokers, software, and infrastructure are all related and make up the cloud ecosystem.
- The complexity of the cloud ecosystem is also increasing as new functions or technologies become available.
- Growth in dimension and diversity of this ecosystem is contributing to the evolution of intelligent and interactive environments like IoT.
- All this can be of tremendous value but we need to properly handle this complexity in order to better utilize the full potential of the system.
- Several companies are developing ecosystems around their products, e.g. Cisco, Apple, and Microsoft.

Motivation

- Lack of reference architectures or other abstract models inhibit the wider adoption of software ecosystems and deny the possibility of exploiting their full potential.
- This need motivates our work:
  - Architectural models based on patterns are a powerful representation when building or using cloud ecosystems and similar complex systems.
- After a careful search we have not found similar models.
Contribution

- We first describe the ecosystem in the form of a pattern diagram and then describe its components as patterns and reference architectures using UML models.
- Some of the components of this system have been already modeled as patterns but some are missing.
- We add to the cloud ecosystem newly identified components, described as patterns.
- We will discuss new types of systems, like IoT, which are driving the changes in cloud ecosystems.
- We also discuss how this evolution is changing the way we handle software development and deployment.
- We do not claim completeness, an ecosystem is open-ended and our model is a first step in their architectural representation.

Patterns and Reference Architectures

- A **Pattern** is a solution to a recurrent problem in a specific context.
- Patterns can be used to design and analyze complex systems, to capture design decisions, and to evaluate new or existing systems.
- They encapsulate the experience and knowledge of designers, provide a larger unit of reuse, and a communication vocabulary for designers.
- Usually, a template with predefined sections is used to describe patterns.
  - **POSA** (*Pattern-oriented software architecture*) template.
- A **Reference Architecture (RA)** is a generic and abstract software architecture that applies to a particular domain and does not contain implementation details.
- It specifies the components of the system, their individual functionalities and their mutual interaction.
- An RA can be considered as a compound pattern and its components described as patterns.
Pattern Diagram of Cloud Ecosystem

Models of Ecosystem Components

- Software Container
- Fog Computing
Software Container

- **Intent:**
  A Software Container provides an execution environment for applications sharing a host OS, binaries, and libraries with other containers with strong isolation between them.

- Containers are lightweight, portable, extensible, reliable, and secure.

- Docker is a popular example of software containers.

![Diagram of two containers sharing one OS vs a virtual machine](image)

Class Diagram for Software Container

![Class Diagram](image)
Fog Computing

- **Intent**
  Fog Computing is a virtualized platform that stands between cloud computing systems and Internet devices, providing to these computation, storage, and networking services and allowing a cloud to control and communicate with these devices.

- Fog can offer low latency, location awareness, efficient use of bandwidth and storage services.

- Cisco provides fog computing platforms

---

Class diagram of the Fog Computing pattern
Internet of Things

- The IoT has found its application in various domains.
  - Examples include smart traffic control, smart grid, wireless sensor networks, precision agriculture, intelligent buildings, health care, industrial automation, oil and gas, etc.
- The IoT has brought about an explosive proliferation of endpoints.
  - According to an estimate, nearly 50 billion heterogeneous devices will be connected to the internet by 2020.
  - Storage and processing costs are declining and the devices are getting smaller and less expensive.
- Increased intelligence of these devices
- Huge amounts of data
  - 90% of the world’s data was created in the last 2 years, and it is increasing exponentially.
- We need to manage the large number of devices and process the data produced by them.

Internet of Things

- IoT applications require low latency, mobility support, location awareness and support for geo-distribution.
- Popularity of IoT has made the limitations of clouds more apparent, We need new solutions.
- Fog computing offers one of such solutions.
  - It complements rather than replaces the cloud.
- Cisco fog computing solutions, Amazon Web Services (AWS) Amazon IoT cloud service, IBM IoT solutions for analytics.
- Numerous papers discuss these IoT applications in connection to fog computing. Ours is the first pattern for fog computing.
- Containers are also providing more lightweight, portable virtualization solutions that will offer support for IoT applications.
DevOps

- A conceptual framework which can be considered as a type of Agile Software Development.
- DevOps stands for “development” and “operations”
- Cloud-Computing-enabled orchestration of services enables development and operation teams to use code for automatically managing infrastructure. Automating the process of software delivery and infrastructure changes enables frequent iterations.
- Many major cloud service providers, like IBM and Amazon, are providing DevOps solutions as part of their platforms.
- Software containers are part of cloud ecosystems and are supporting DevOps teams for the isolation of services. They make application distribution much easier by providing lightweight, isolated execution environments for applications. A few patterns have been identified and described for software orchestration on clouds.
- IoT applications require the integration of development, IT operations and quality assurance which can be achieved by practicing DevOps.

Conclusion

- The cloud has long reached that stage where a large number of interconnected components exist while new ones are being added.
- We need to provide a holistic and unified view of the system to its users, developers, and researchers.
- Cloud ecosystems are still new and we are beginning to define them. This holistic, unified treatment is fundamental to handle the complexity of cloud-based systems.
- Such an ecosystem can help us control heterogeneity, provide a holistic security view, as well as take care of quality and compliance issues.
- Detailed cloud ecosystems will help both IoT system developers and DevOps practicing teams.
Conclusion

- New computing platforms (like fog computing), development practices and software frameworks (such as DevOps) are already popular. These advances are complementing and influencing each other as technologies mature.

- Most of the work related to cloud ecosystems presents very simplified models.

- The model presented here is just a step for achieving precise architectural representation of the cloud ecosystem. Many components still have to be defined as patterns, including security and threat patterns. New components will be added as cloud computing evolves.

- As future work, we are considering the mappings of the authorization models from clouds to fogs to devices.