Software architectures for AI: the case of autonomic microservices

Joint work with N. Bencomo (Aston University), A. Bucchiarone (FBK Trento), C. Guidi (ItalianaSoftware) and J. Spillner (Zurich University of Applied Sciences)
AI and distributed systems

- Originally, AI was used to build standalone AI applications (e.g., chess players)
- AI functionalities are more and more embedded into software applications and systems (smartphones, office applications, robots, …)
- Such systems are frequently distributed and heterogeneous
- Claim: there is a non trivial interplay between the AI techniques and the architecture of the distributed systems where they are used
Distributed systems architecture

- Distributed system architecture evolved over the years from simple client-server to more complex patterns

Evolution of Software Architectures

Monolithic → Service-oriented → Microservices
Microservices

- A software architectural style advocating the structuring of systems as the composition of small, loosely-coupled microservices
- Each microservice provides a restricted and coherent set of capabilities
- Microservices are deployed independently, frequently into containers (e.g., Docker) on the Cloud or on the edge
- Microservices can be independently scaled and updated
- Aim: maximizing flexibility and scalability
How to add AI capabilities to microservices?

• Microservices should adapt to changing environment and user requirements
• AI capabilities can help in this direction, minimizing human intervention
• We consider the autonomic computing (self-* ) approach
  − Suitable to monitor changes in the environment and adapt accordingly
The **MAPE-K** feedback control loop

- **Monitor**: acquires data from the system and its environment
- **Analyze**: refine and extract information from data
- **Plan**: decide which actions need to be taken to reach system goals
- **Execute**: takes the planned actions
- **Knowledge**: keeps track of the known information
Design decision: who is in charge?

- A main design decision for autonomic microservices: who is in charge of the MAPE phases and of K?

- Different possibilities:
  - The microservices
    - Each microservice or dedicated microservices
    - MAPE-K as a service?
  - The infrastructure
    - Containers, container managers (e.g., Kubernetes), the Cloud infrastructure
  - The IT personnel
  - A combination of the above
Some general tradeoffs

- If IT personnel is in charge: the system is not autonomic
- If the infrastructure is in charge: autonomic infrastructure managing dumb microservices
  - Vendor lock-in: moving the system to a different infrastructure causes loss of autonomic capabilities
- Microservices are in charge: not always easy
  - May not have access to all the information
  - Need for coordination
- Both infrastructure and microservices: need for an interface
  - If not standard can cause again vendor lock-in
Sample instance: monitoring

- Who is in the best position to get the data?
- The infrastructure for environmental data
  - E.g., allocated and used resources
- Microservices for internal data
  - E.g., which functionalities are more heavily used
- IT personnel has understanding of (changing) requirements
  - E.g., which functionalities and non-functional properties are more relevant at a given moment
- Having all the actors interact for monitoring may require complex coordination and interfaces
Future directions and challenges

- A paper on this topic is currently submitted to IEEE Software

- How the tradeoffs change in different application areas or in other architectural styles (e.g., serverless)?
- Which are suitable interface to share responsibility of phases among different actors?
- How to combine distribution and flexibility with timely and precise adaptations?
- How to provide autonomic capabilities in multicloud scenarios?
Finally

Thanks!

Questions?