



# Dynamic Adaptive System Composition Driven By Emergence in an IoT Based Environment: Architecture and Challenges

**Nils Wilken (University of Mannheim)**, Mohamed Toufik Ailane, Christian Bartelt,  
Fabian Burzlaff, Christoph Knieke, Sebastian Lawrenz, Andreas Rausch,  
Arthur Strasser

Contact: [wilken@es.uni-mannheim.de](mailto:wilken@es.uni-mannheim.de)

## Short Resume

From 2013 until 2018, I studied Business Informatics at the University of Mannheim and gained my Bachelor and Master degrees.

Since 2018 I am working as a scientific assistant at the Institute for Enterprise Systems (InES) at the University of Mannheim. I am currently in an early-advanced state towards a PhD in Computer Science. My main research interests are goal recognition, plan recognition, and artificial intelligence in general.

Some things I like doing in my free time are traveling, playing basketball, and cooking.



# The Institute for Enterprise Systems (InES)

Central institute at university establishing an interdisciplinary platform at the intersection of business and technology. Overall, 7 professors and 35 Phd students from computer science, business informatics and operations management in Mannheim and Karlsruhe involved at InES.

## Research Areas

Computer Science

Management of Enterprise Systems

Innovative Solutions

## Selected Projects

- **ARBAY:** Augmented-Reality platform for selling full of variety products (<https://arbay.projekt.de/de/>)
- **VanAssist:** Interactive and intelligent System for autonomous vans in parcel logistics (<https://www.vanassist.de/>)

## Selected Partners



## Outline of this talk

1. Motivation
2. Emergent Platforms
  - Architecture
  - Challenges
3. Conclusion and Future Work

# Motivation

## Motivation

- One major characteristic of IoT environments is a high level of dynamism:
  - Available services/devices change constantly at runtime
  - Context information in the environment might change frequently
  - User needs and requirements might change in response to changes of the environment
- This is a major challenge for software systems, as they have to be able to change their behavior to adapt to dynamic changes in their environments
- Currently, these challenges are already addressed by Dynamic Adaptive Systems and Self-adaptive Systems

## Example Use Case: Home Automation

When I come home, I want the alarm to be turned off and a comfortable temperature in the home.

### User Profile

- Address: L15, 1-6, Mannheim
- Likes a temperature of 23-25°C
- Usually works between 9am and 5 pm
- Emphasizes saving energy



### Add new automation rule

**IF** user location is within 5km of home location  
**THEN** set temperature of thermostat service to 24°C and turn off the alarm system.

### Home Automation System

Android GPS Service

MyThermostat Service

MyAlarmSystem Service

MySensorSystem Service

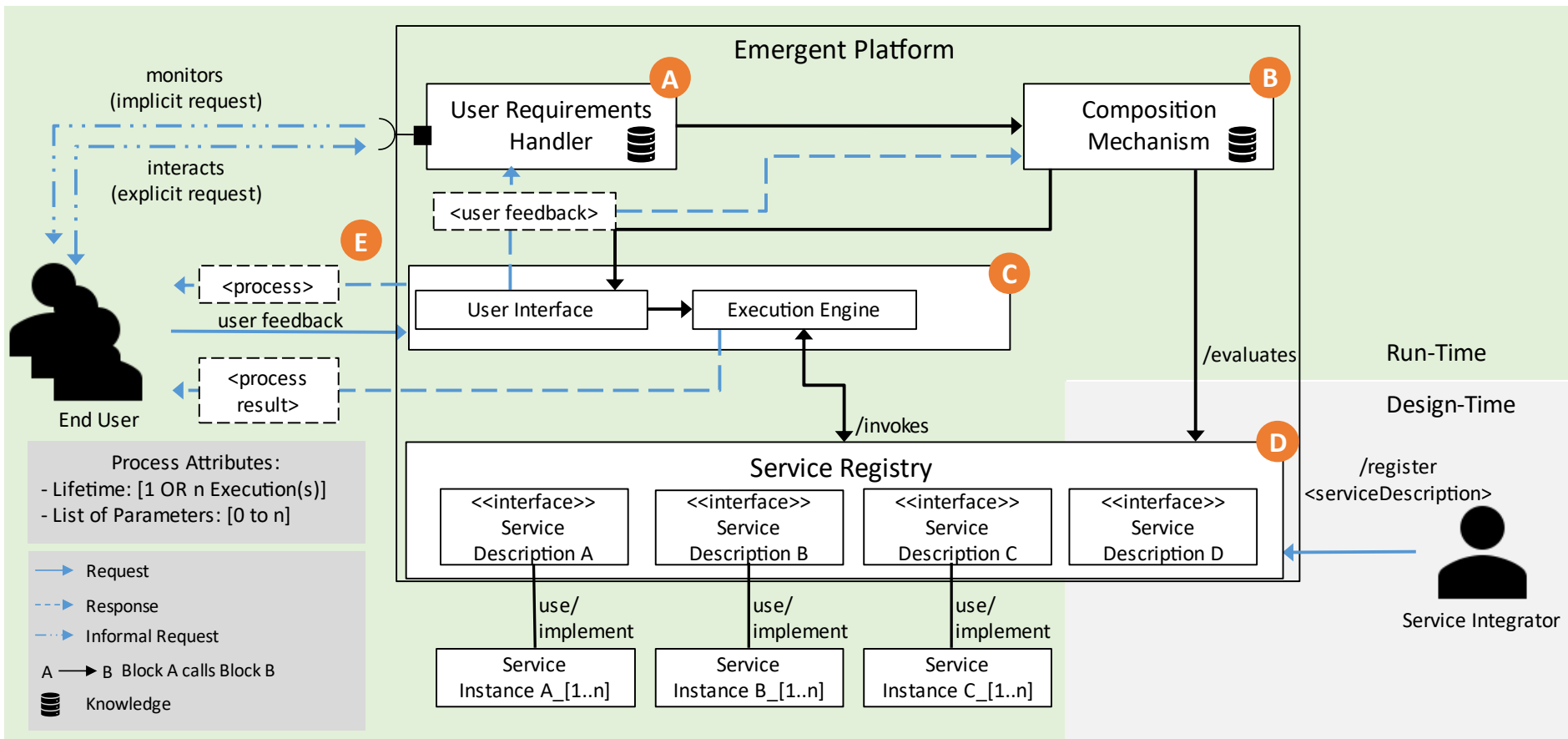
# ■ Emergent Platforms



## Emergent Software Platform: Definition

***„A software platform is called emergent if it automatically and dynamically composes available components in response to a trigger event. The resulting behaviour of the platform is not predefined at design time and not anticipated by the individual components.“***

# Emergent Platforms: Architecture

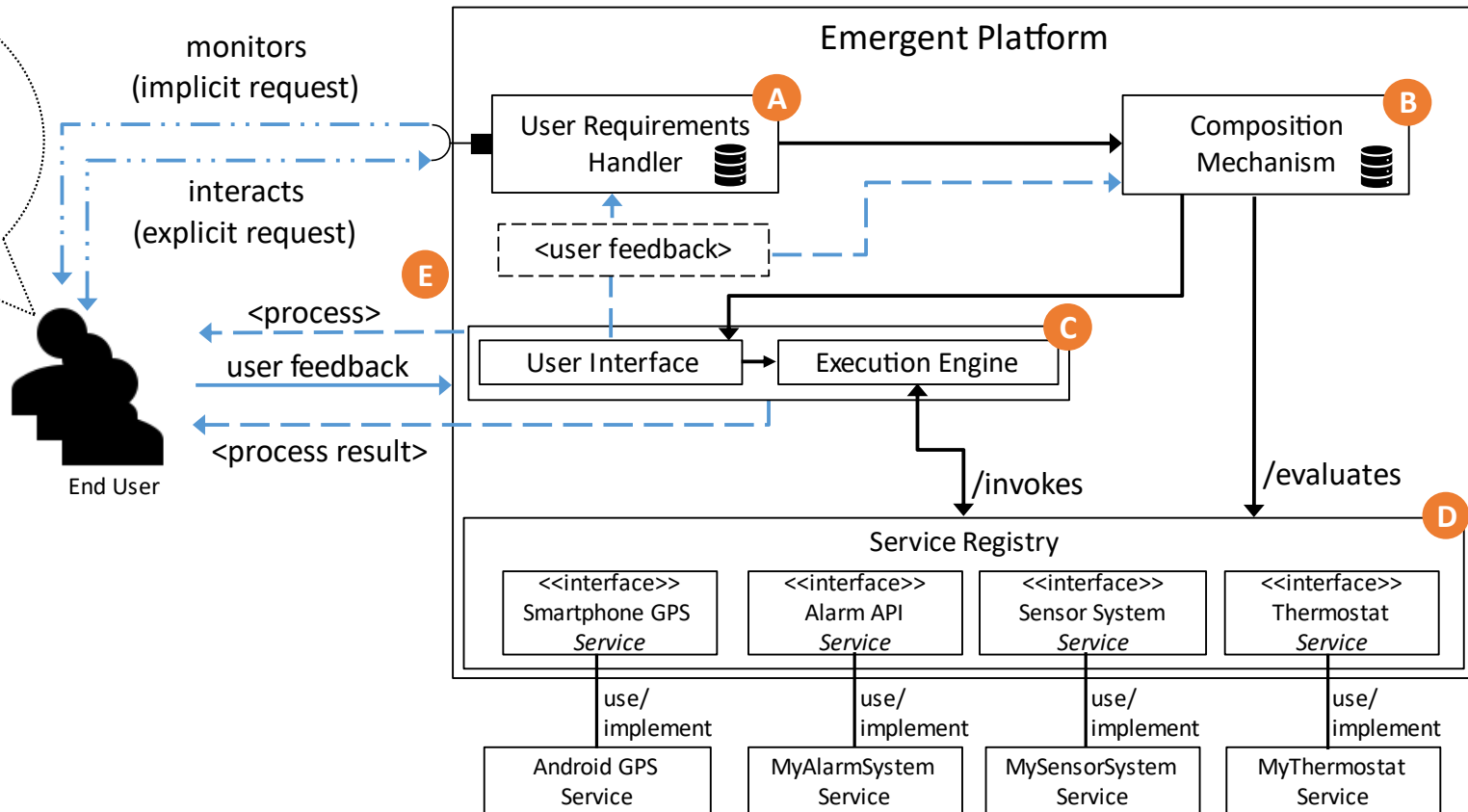


# Example Use Case: Home Automation

When I come home, I want the alarm to be turned off and a comfortable temperature in the home.

### User Profile

- Address: L15, 1-6, Mannheim
- Likes a temperature of 23-25°C
- Usually works between 9 and 5 pm
- Emphasizes saving energy



## Challenges

- **User Requirements Handling**
  - How can user requirements be elicited automatically from unstructured data?
  - How can user requirements be formalized?
- **Composition Mechanism**
  - How to compose?
  - How to evaluate a given composition?
- **Service Registry**
  - How are service components integrated?
  - How can semantic interoperability between service components be achieved automatically?

# ■ Conclusion and Future Work

## Conclusion and Future Work

- We have proposed a possible architecture for an envisioned Emergent Platform
- We have analyzed the challenges that have to be solved to successfully implement such a platform and proposed possible techniques to solve them
- As a next step we plan to evaluate the feasibility of the proposed architecture in practice through a prototypical implementation

■ **End – Thank you for your attention!**



# Backup



## Emergence: General Definition

“Emergence is defined as a property of a total system which cannot be derived from the simple summation of properties of its constituent subsystems. Emergent phenomena are characterized by (1) the interaction of mostly large numbers of individuals (2) without central control with the result of (3) a system behavior, which has not been ‘programmed’ explicitly to the individuals.” [1]

## Sources

- [1] Muller-Schloer, Christian. "Organic computing-on the feasibility of controlled emergence." International Conference on Hardware/Software Codesign and System Synthesis, 2004. CODES+ ISSS 2004.. IEEE, 2004.