

Survey of Component-Based Software Engineering (CBSE) within IoT Development

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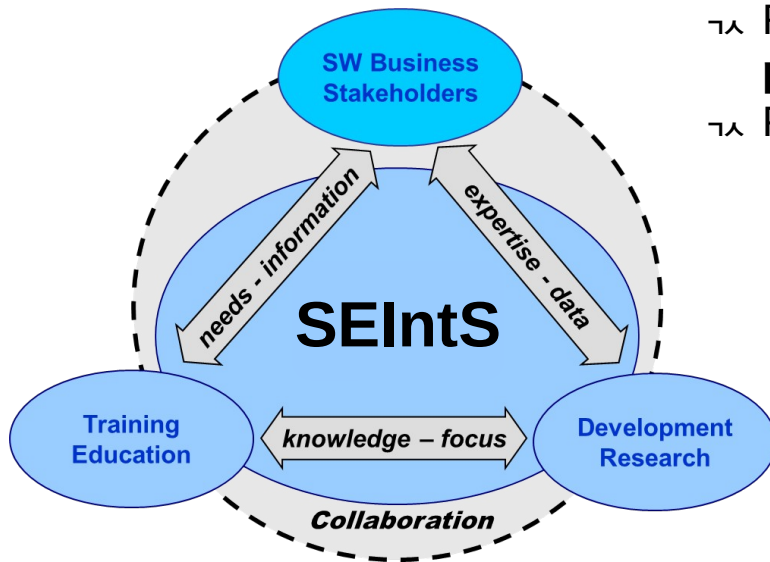


Professor
emeritus
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- ↗ Research staff: **15 persons**
- ↗ Project volume: **1 M€**



- Global software engineering
- Software business
- Software engineering management
- **Software and application architectures**
- Web services and user interface techniques
- **Mobile and web applications**
- Smart systems and intelligent spaces
- **Sensors and sensor networks**
- **Embedded systems and IoT**
- Green ICT



Our paper – CBSE in IoT

- Motivation
 - We are software developers, who like to build IoT prototype devices
 - CBSE method focuses on the design and development of computer-based systems with the use of reusable software components.
 - Has CBSE been used in IoT research?
- Goal:
 - Focus on software
 - Study the use of the software components.
 - Discover if CBSE characteristics are present in IoT prototype research.

Example – A typical IoT paper

”Towards the utilization of cost-effective off-the-shelf devices for achieving energy savings in existing buildings”

- Intro and Background
- Architecture – Hardware
- Software and architecture
- Test setup

• Results

• Discussion and conclusion

Abstract

The optimization of energy usage, the prevention of energy losses and the use of smart devices in the building sector are many fields of research. Research shows that the most effective way to reduce energy consumption in buildings is to improve the energy efficiency of the building envelope. This means that the energy consumption of buildings can be reduced by using smart devices and energy-efficient building components. The aim of this paper is to investigate the possibilities of using off-the-shelf devices for achieving energy savings in existing buildings. The paper presents the results of a study conducted in a residential building. The study focuses on the use of smart devices for controlling the heating system. The results show that the use of smart devices can lead to energy savings of up to 10% in the heating system. The paper also discusses the challenges of using off-the-shelf devices in existing buildings and the need for further research in this area.

1. INTRODUCTION

Energy is a key resource in modern societies. The use of energy in buildings is increasing rapidly, and this is leading to a growing demand for energy-efficient buildings. The use of smart devices in buildings can help to reduce energy consumption and improve the energy efficiency of buildings. This paper presents the results of a study conducted in a residential building. The study focuses on the use of smart devices for controlling the heating system. The results show that the use of smart devices can lead to energy savings of up to 10% in the heating system. The paper also discusses the challenges of using off-the-shelf devices in existing buildings and the need for further research in this area.

2. BACKGROUND

The use of smart devices in buildings is a rapidly growing field of research. Smart devices can be used to control the heating system, the lighting system, and the air conditioning system. The use of smart devices can lead to energy savings and improved energy efficiency. This paper focuses on the use of smart devices for controlling the heating system. The results show that the use of smart devices can lead to energy savings of up to 10% in the heating system. The paper also discusses the challenges of using off-the-shelf devices in existing buildings and the need for further research in this area.

3. TEST SETUP

The test setup for the study was a residential building with a heating system. The study focused on the use of smart devices for controlling the heating system. The results show that the use of smart devices can lead to energy savings of up to 10% in the heating system. The paper also discusses the challenges of using off-the-shelf devices in existing buildings and the need for further research in this area.



4. RESULTS

Parameter	Value
Temperature (°C)	21.2
Humidity (%)	65.1
Light (lux)	120.5

The results of the study show that the use of smart devices can lead to energy savings of up to 10% in the heating system. The paper also discusses the challenges of using off-the-shelf devices in existing buildings and the need for further research in this area.

5. CONCLUSION

The use of smart devices in buildings can lead to energy savings and improved energy efficiency. This paper presents the results of a study conducted in a residential building. The study focuses on the use of smart devices for controlling the heating system. The results show that the use of smart devices can lead to energy savings of up to 10% in the heating system. The paper also discusses the challenges of using off-the-shelf devices in existing buildings and the need for further research in this area.

REFERENCES

[1] J. Kang, "Energy-efficient buildings: A review," *Energy*, vol. 100, pp. 1-15, 2016.

[2] M. Saari, "Towards the utilization of cost-effective off-the-shelf devices for achieving energy savings in existing buildings," *IEEE Internet of Things Journal*, vol. 6, pp. 1-10, 2019.

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TABLE I

Parameter	Value
Temperature (°C)	21.2
Humidity (%)	65.1
Light (lux)	120.5

The table shows the results of the study for different parameters. The temperature was 21.2°C, the humidity was 65.1%, and the light intensity was 120.5 lux. The results show that the use of smart devices can lead to energy savings of up to 10% in the heating system. The paper also discusses the challenges of using off-the-shelf devices in existing buildings and the need for further research in this area.

TABLE II

Parameter	Value
Temperature (°C)	21.2
Humidity (%)	65.1
Light (lux)	120.5

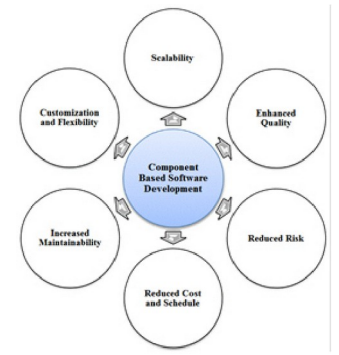
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TABLE III

Parameter	Value
Temperature (°C)	21.2
Humidity (%)	65.1
Light (lux)	120.5

The table shows the results of the study for different parameters. The temperature was 21.2°C, the humidity was 65.1%, and the light intensity was 120.5 lux. The results show that the use of smart devices can lead to energy savings of up to 10% in the heating system. The paper also discusses the challenges of using off-the-shelf devices in existing buildings and the need for further research in this area.

CBSE characteristics



Component-based software engineering (CBSE) emerged in the late 1990 (Ian Sommerville, “Software engineering 10.Ed”, 2016)

- Composable
 - External access to methods and attributes by using publicly defined interface
- Deployable
 - To able to operate as a stand-alone entity on a component platform.
- Documented
 - Documented so that potential users can decide whether or not the components meet their needs.
 - Component interfaces should be specified.
- Independent
 - Can be used standalone
- Standardized
 - Standard component model, which may define component interfaces, component metadata, documentation, composition, and deployment.

Research method - Literature survey

We used Systematic mapping study (K. Petersen et al, 2015)

1) We selected two combinations of search terms:

1) The combination of "IoT", "component based", and "Arduino"

2) The combination of "IoT", "component based", and "Raspberry Pi".

2) We excluded studies published before 2020. Most of these are technical studies and were partly discussed before in our earlier studies.

3) The studies were reviewed and if there was no mention of the software that was developed, tested or used, the study was excluded from the research.

4) The remaining studies were read, and based on the content of each study, it was decided whether or not to include it in the mapping study.

Findings

- Initially 60 studies were included in our survey.
 - After previous steps: 26 included, and 34 studies were left out(No CBSE characteristics)
 - Composable: 16
 - Deployable: 15
 - Documented: 11
 - Independent: 16
 - Standardized: 15
-
- Overall CBSE usage was low
 - Mentioning ready-to-use software components as MySQL-database add the paper in these.
 - More detailed examples in research paper





Conclusions

- The aim of this study was to evaluate the current state of the art in the use of component based software development in the IoT world.
- Study also shows the lack of component based software development in IoT related prototype development.
- The survey also shows that the developed and self-made software components are omitted when presenting the structure of IoT applications.
- It can be said that in order for studies to be reproducible, the software side should be described in more detail.

Future research:

- This collection of studies has potential for more comprehensive analysis.
- How to describe software aspects in IoT research publications?

Thank you!
Questions?

