INTEGRACIJA DISTRIBUIRANIH PV SISTEMA U PAMETNIM SREDINAMA KORISTECI FOG COMPUTING ARHITEKTURU

INTEGRATION OF DISTRIBUTED PHOTOVOLTAIC SYSTEMS IN THE SMART ENVIRONMENT THROUGH FOG COMPUTING ARCHITECTURE

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U ovom radu je predstavljen koncept integracije distribuiranih PV sistema u pamentnim sredinama. Prikazani su detalji integracije, greske pri funkcionisanju PV sistema povezane sa smanjenom izlaznom snagom istih, kao i implementacija mikroservisa i specificnosti korišćene FOG arhitekture.

Ključne reči: *PV sistemi; pametna sredina; otkrivanje grešaka rada sistema; Fog Computing arhitektura*

This paper presents the concept of the integration of distributed photovoltaic systems in the smart environment. The details of the proposed integration and its operation faults related to the reduced power output of the photovoltaic system, design and implementation of services as well as architecture-related details are presented.

Key words: *Photovoltaic systems; smart environment; fault detection; Fog computing architecture*

1 Introduction

Due to the world, development where the living spaces requirements increases, the challenges and opportunities are to create such environment founded on a foresight understanding and pragmatism. Enormous and complex congregations of people in urban areas inevitably tend to become disordered places. Making an environment smart is emerging as a strategy to mitigate the problems generated by the urban population growth and rapid urbanization [1].

The concept is essentially aiming to develop a system for following up the activities electronically in the smart environment. The advantage of adopting such systems is the high level of integration and systems interoperability, which expanding the view of daily controlling. The goal is to provide the initial necessary guidelines to improve operations and maintenance, reduce the cost of operation, provide enhanced energy management capabilities and provide scalability and freedom for future. A smart city relies, among others, on a collection of smart computing technologies applied to critical infrastructure components and services [2]. Distributed generation of clean and cost effective energy can provide an adequate tool to deal with energy reliability and to successfully implement the principals of the renewable energy [3].

2 System architecture

The distributed PV systems with its sensors of interest represent single sensor node. This concept of sensor nodes along with its services is usefully implemented in fog computing architecture providing increased performance, energy efficiency, reduced latency, quicker response time, scalability, and better localized accuracy for different applications in energy network [4]. The solution enables efficient way of real-time monitoring and provides crucial information for further integration in smart environments.

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On the other hand, the fog computing architecture concept is based on the tiered architecture [5]. It enables the modularity and efficient upgrade of the implemented overall systems. The particular node functionalities vary based on its role and position in N-tiered fog architecture. The nodes at the edge of the network infrastructure located at Tier 1, collect or provide the data for/from connected end devices at tier 0. Following the complexities of the network itself, the nodes at the higher tier (Tier 2) are focused on data filtering, edge analytics, and support for time-critical processing/services. The nodes closer to the network core are capable for extensive processing and communication, supporting higher-level analytics [4-6]. The layer scheme of the system based on Fog computing architecture is presented in figure 1. The deployment view of particular indoor sensor node system based on the fog computing architecture concept is shown in figure 2.

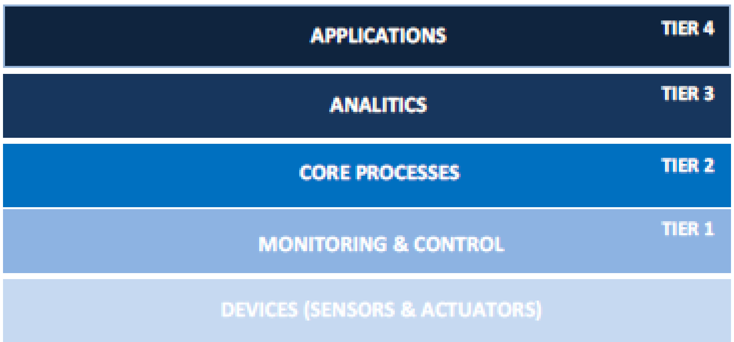

Figure 1. Layer scheme of the system based on Fog computing architecture

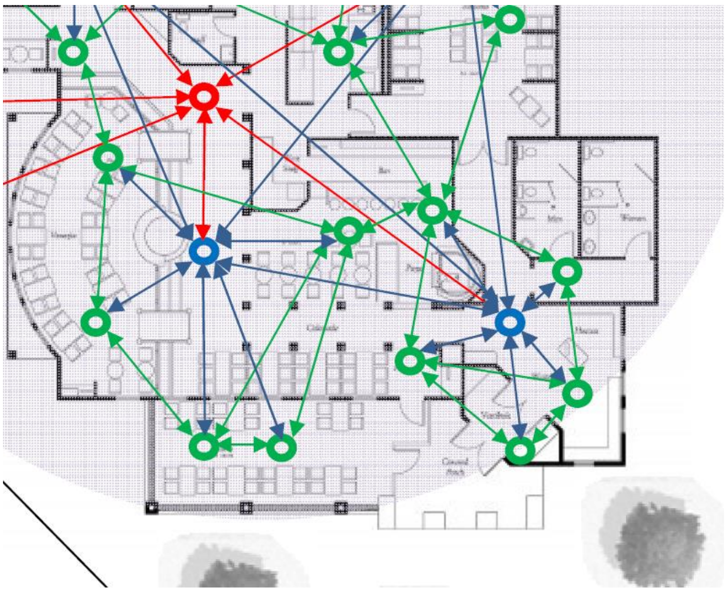

Figure 2. Deployment view of sensor nodes based on the fog computing architecture concept

3 Implementation and results

The introduced concept is focused on the several aspects regarding the integration of sensing nodes in distributed application based on reference fog architecture. The goal is to localize the processing of measured data and to lower the pressure on the data transfer at the higher tiers of the fog architecture by integrating the application at the edge of the architecture [4]. The solution enables efficient way of real-time process monitoring and provides crucial information for further determination and prediction services [7,8].

The bottom level of the fog node application service layer is reserved for the fog connector service (FCS). The FCS is used as an interface to different front-end devices. On the device side, the local service management layer (LSM) is providing the interface to the corresponding fog node. Device-to-node pathways are given as a collection of end-to-end data communications. The individual communication context is managed through the service agent as a dedicated system level component

[5]. The service agent operation is positioned at the top of the data link layer supporting legacy point-to-point communication technologies. From the application point of view, service agents are given in the form of configurable micro services as a part of fog connector operation. The operation of service agent might be either time-triggered or event-based, supporting the request-response and publish-subscribe message exchange pattern with end-device [5].

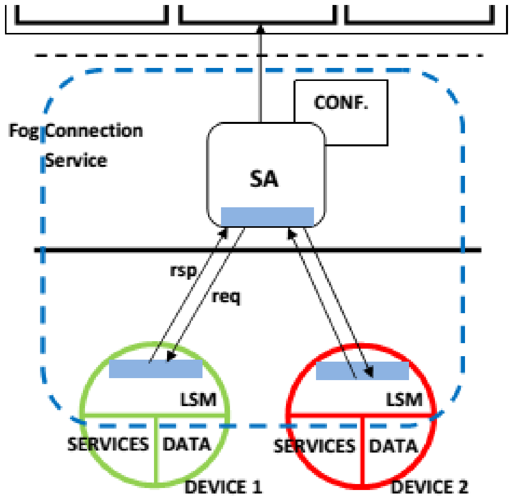

Fig. 3. Fog node architecture for multi channel sensing applications

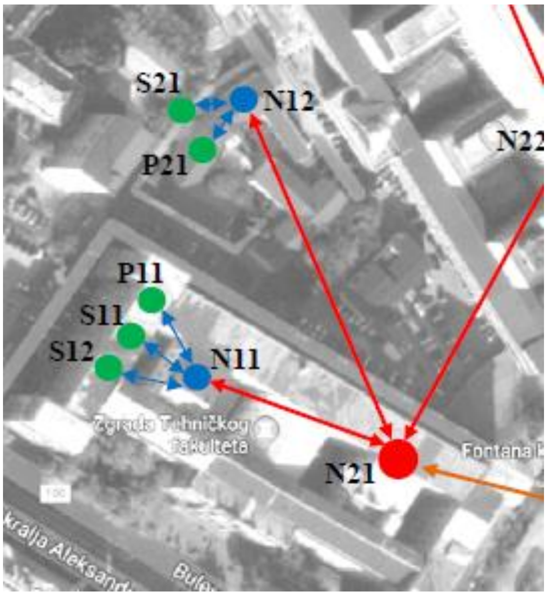

Figure 4. Deployment view of the integrated sensor nodes

The deployment scenario presenting the tiered fog architecture in the local area is given on the Figure 4. The area includes several University buildings and research facilities located in separate buildings. PV panel 1 together with other end devices (set of sensors S1), are connected to the fog node N11 located at the RES lab at the Technical Faculty building. They are integrated into the fog architecture through building area node N11 residing at tier 1. Similarly, the PV panel 2 and environmental sensors are located at the ICEF research lab and they are connected to the building area node N12. Higher-level services are supported through the technical faculty infrastructure node N21. Further integration toward core services is supported through local area nods N3X. The set of sensors S1 is used for temperature, humidity, PM and other environmental and air quality measurements.

4 Conclusion

The presented solution enables efficient way of integrating distributed PV systems in smart environments. Depending of its use, the integration might vary in complexity and systems interoperability. The utilized fog computing infrastructure enables the further integration of locally generated information and knowledge, and provides basis for further system upgrades. The onsite results have shown that the presented approach is adequate for real-time or near real-time constrained application. The further system integration would consist of the detailed smart environment map with different groups of sensors.

5 Acknowledgement

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