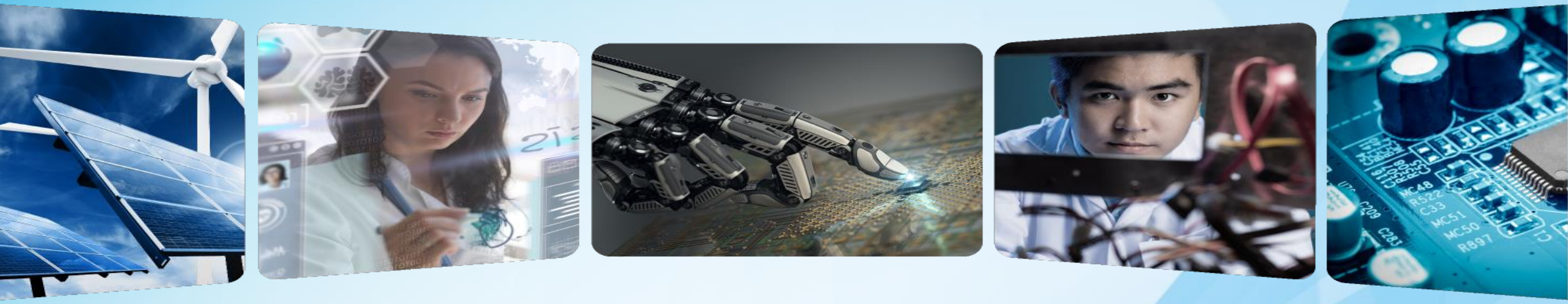

Remote Monitoring at Distribution Network of Dynamically Constrained Working Areas

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IEEE Smart Cities

SIDROCO Smart5Grid

Demonstration of **5G** solutions for **SMART** energy **GRID**s of the future

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Outline

- Background
  - NetApps
  - Expected benefits
- Motivation
- Problem statement
- NetApps in Smart5Grid
- Validation and Verification Framework
- Conclusion

Motivation

Smart5Grid exploits the robustness and flexibility enabled by the 5th generation (5G) mobile network technology to contribute an open and adaptable platform for reliable testing, validation, and operation of **Network Applications (NetApps),** addressing the challenges of the Renewable Energy Sources (RES).

- **Smart5Grid** aims to support current energy sector and future smart grid stakeholders through the adaptation of 5G networks and the support of the respective NetApps that will be developed and validated on real power grid facilities.
- **Smart5Grid** intends to provide a more secure, flexible, efficient, scalable and real-time communication framework for modern smart grids.

Aim: Improvement of working conditions

- Methodology of the Smart5Grid project, which will enable remote inspections in high-risk areas and real-time execution by supporting various distribution network applications and providing accurate results and information on the operational condition of power grid assets via augmented reality.
- If maintenance work is undertaken, real-time control will be enabled to support working procedures remotely and automatically, without putting employees in potentially harmful conditions.

Motivation

- Energy sector is transformed creating new supply and demand concerns.
- The energy infrastructure must be upgraded and digitalized
- Smart grids will promote resource-efficient economic growth and global and local pollution reduction by boosting Renewable Energy Sources (RES)
- New types of energy demand in building, transport, and industry are transforming energy consumption patterns.
- **Smart integration of electricity** with ultimate uses will reduce greenhouse gas emissions and energy demand, delivering similar services with less energy and resources.

- Smart5Grid platform aims to **support the energy transition** by providing the needed digital layer for communication infrastructure's availability whenever needed.
- Power systems incorporate interrelated and geographically dispersed components, and retrieve their assets to produce higher functionalities.

Problem statement

- Virtual network functions (VNFs) – High flexibility.
- VNFs can be linked across domains to develop NetApps suited to diverse needs of tenants.
- **Smart5Grid** presents an open 5G platform for managing power grid resources by leveraging unique NetApps and VNFs built for the energy industry.
- The opensource NetApps will be created and tested on the Smart5Grid experimental facilities to meet the needs and development of modern power grids.

- 3rd party developers, engineers, and small medium enterprises (SMEs) will be allowed to utilize the Smart5Grid platform, fostering openness
- Existing power grids will benefit from **Smart5Grid NetApps** because the project will improve communication, monitoring, operational, and maintenance conditions for the network tenants (DSO, TSO)

Motivation

- DSOs charge substantial operational costs
- Dedicated people are frequently exposed to **hazardous working conditions**,
- For **employee safety**, intentional power outages are scheduled during inspection and maintenance operations, reducing the capacity and availability of the distribution network regularly.
- As it is critical for DSOs to obtain an **efficient and short duration inspection and maintenance procedures** from central offices in order to support risk prevention and assist field operators through the provision of advanced information and data, inspection and maintenance, and procedures of delimited working areas at the distribution level must be performed remotely without compromising quality.

Smart5Grid solution

- Build **vertical applications**
- Separating the NetApp's functionality into decoupled VNFs facilitates the reuse of software functions.
- **Smart5Grid suggested that NetApp is a native cloud application.**
- **It is composed of VNFs utilizing OS container technology.**
- A Smart5Grid NetApp has the required components to provide a service as a software application for the energy vertical.
- NetApp takes advantage of cloud/edge infrastructure by dividing components whenever possible.
- In the case of a NetApp with two components, **the function** that requires low latency input or responses could be placed at the edge of the computing infrastructure, while the **other function**, which may be resource-intensive should be placed in a cloud data center where resources are not constrained.
- Each NetApp structure is correctly defined in a **NetApp descriptor**, which includes information about its services, configuration, and performance requirements

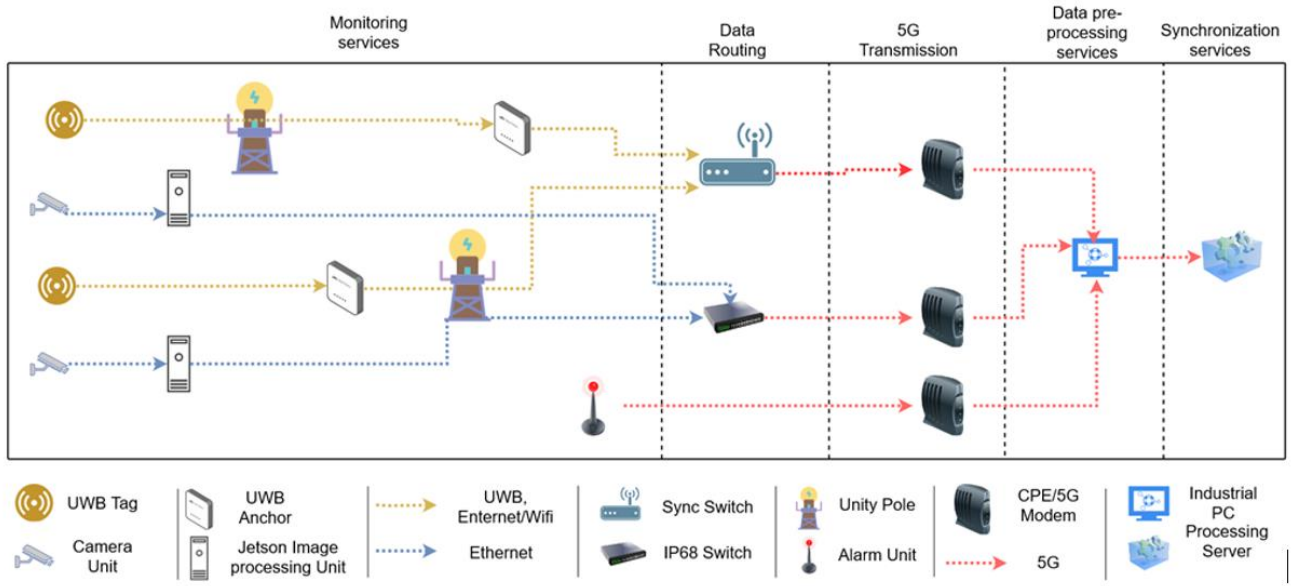
Expected Benefits

- **Economic:** To save expenses by enhancing worker safety. If there is an accident at the primary substation, the network could fail, affecting many customers.
- **Social:** To reduce workplace accidents and enhance workplace safety.
- **Business:** As part of the UC, the company's workforce management systems will incorporate a new bespoke digital system to enhance the safety of primary substation workers.

NetApp Concept in Smart5Grid

- The **developed NetApp will**
  - generate a detailed **volumetric model** of the setup of the electric grid resources where the work will be performed,
  - Instantly define the **working areas** and the **authorized personnel**,
  - **allow real-time communication** of big data generated from the existing permanent and manual sensors and cameras within the working area,
  - allow real-time **remote control** of the work and identify the movement.
- The current infrastructure employs two safety systems: a camera software with integrated image recognition that provides a overview of the workers physically located in the substation and a UWB (Ultra-Wideband) that provides basic location information via tags and anchors.

NetApp Concept in Smart5Grid: Use case-based Smart5grid Architecture

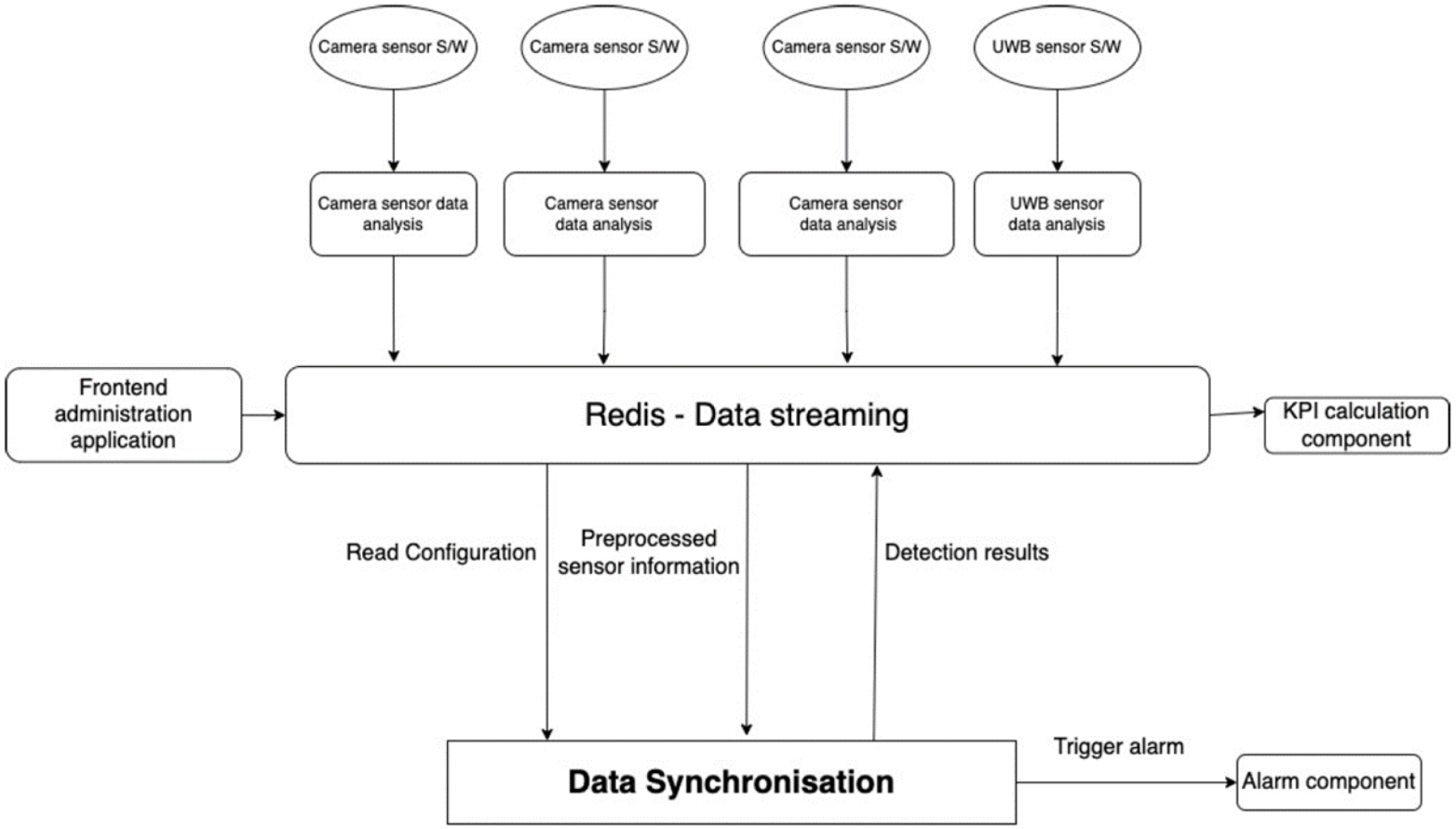


1) The **camera sensor** software receives the image from the camera and incorporates a neural network that can identify the worker and tool presence within site.

2) **UWB sensor software** collects data from deployed wearable sensors. As workers move across space, their actions are detected by sensors and transmitted to the Synchronisation NetApp.

3) The **Synchronisation NetApp** receives and combines the information from the primary components, assess and validate it, and, if necessary, activate the alarm system.

NetApp UC architecture at a high level



NetApp Development Phases

1) The **technology stack:** For the proposed solution, Python was chosen as the primary programming language for the more significant part of the code base. Redis for the data streaming component for its simplicity, reliability and speed. For the front-end administrative application, Django [12].

2) Every software component has to be containerized. Docker was utilized for the containerization.

3) For the deployment of the NetApp to the demonstration pilot site, cluster management software was required. Kubernetes was selected.

4) Kubernetes deployment manager software. For this purpose, the first choice was Helm.

Experimental design and Testing scenarios

This UC addresses two scenarios:

1. The worker enters the primary substation and stays within the prescribed area without triggering an alarm;
2. The worker crosses the safety area and activates the alarm. Figure 5 depicts a sequence diagram encompassing both instances.

Validation and verification framework for NetApps

The **Smart5Grid Validation and Verification Cycle (VV Cycle**) will include several components that will aid in developing, validating, and verifying NetApp workflows that can be implemented on the Smart5Grid platform.

Smart5Grid will embrace the DevOps paradigm for providing access to the Smart5Grid open platform, enabling faster and continuous software delivery, less complexity to manage, and faster resolution of possible vulnerabilities and problems, resulting in NetApps that are more reliable and take less time to produce.

Conclusion

- Main objective: Outline the Smart5Grid NetApp idea followed by the UC on ”Remote Inspection of Automatically Delimited Working Areas at Distribution Level”, including the platform architecture, its components, and their interconnections.
- Smart5Grid will enable an environment where cloud-native NetApps may actualize the integration between the energy vertical and 5G networks, emphasising installations that employ edge infrastructure.
- This work emphasized the need to reduce the difficulties vertical application developers have while working with 5G networks by shielding them from the intricacies of the most recent generation of telecommunications networks.
- Regarding the services supported by the described UC, the subdivision must be accomplished in real time, and the data processing and warning signal must be transmitted as quickly as possible.

Thank you!

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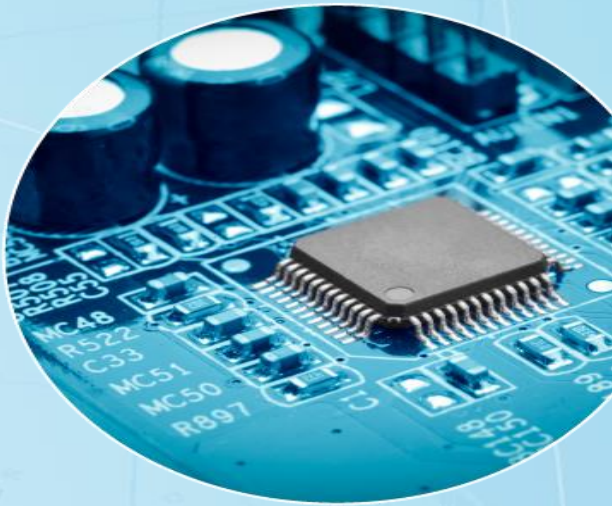

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