

Paris Session 2022



End-to-end architectures for substation O&M

B5 PS3 Q3.01

What are the benefits of digital solutions like IoT-sensors, machine learning, artificial intelligence, drones, robots etc. for substation life cycle from planning to maintenance?

Which measures are necessary to increase the acceptance of intelligent IoT-based power equipment in substations?

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End-to-end architectures for substation O&M

Any specific IoT and AI application is part of an overall architecture

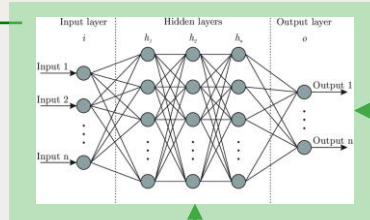
Decision-making



human-readable reports

2 AI-based centralized monitoring

- ✓ Easy to maintain
- ✓ Automatization of tasks
- ✗ Unique point of failure
- ✗ Not scalable
- ✗ Not completely secure

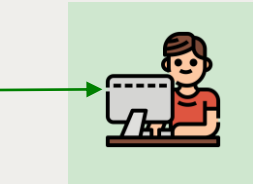


structured datasets



Remote servers

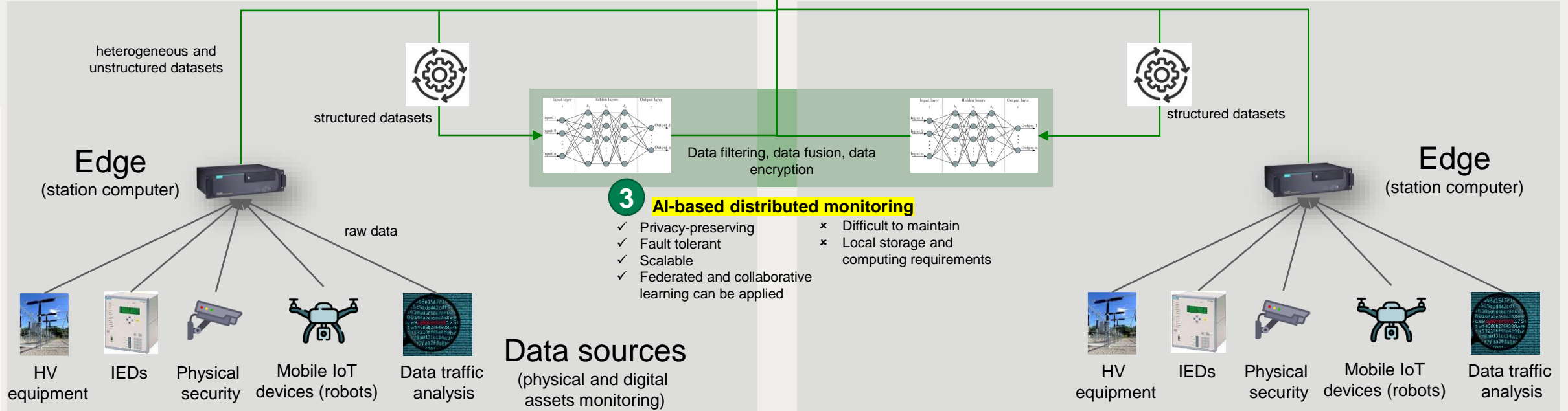
large, heterogeneous and unstructured datasets



Data preparation, data analysis, decision-making

1 Manual centralized monitoring

- ✓ Easy to implement
- ✗ Cumbersome and time-consuming
- ✗ Not scalable
- ✗ Not completely secure
- ✗ Error prone



3 AI-based distributed monitoring

- ✓ Privacy-preserving
- ✓ Fault tolerant
- ✓ Scalable
- ✓ Federated and collaborative learning can be applied
- ✗ Difficult to maintain
- ✗ Local storage and computing requirements

Group Discussion Meeting

End-to-end architectures for substation O&M

Future research directions

Benefits of digital solutions for substation O&M

- IoT (and robotics): data *collection*
- Artificial Intelligence: data *management* (filtering, organization, refinement, synchronization), *protection* (e.g., encryption), and *interpretation* (to facilitate decision making)

Still several measures are necessary to increase the acceptance of intelligent IoT-based power equipment in substations

<p>Multi-modality</p>	<p><i>The integration and correlation of different information sources opens up new perspectives in substation monitoring.</i> E.g.,</p> <ul style="list-style-type: none"> • thermography and isolator sensors for hot spot detection • RGB images and radar signals for substation physical security 	<p>Persistent monitoring</p>	<p><i>IoT-technologies provide continuous data flows.</i></p>
<p>Research directions</p>	<ul style="list-style-type: none"> • <u>Sensor-rich platforms</u> to minimize hardware installation and correlated O&M efforts. • <u>Data-fusion algorithms</u> to cope with source diversity (data synchronization, different dimensionality, different statistical distribution). 	<p>Research directions</p>	<ul style="list-style-type: none"> • <u>Automatic data ingestion modules</u> to cope with unreliable datasets and avoid extensive human data preparation. • <u>Task scheduling programs</u> to release intensive computation from resource constrained devices. • <u>Self-configuration and self-adaptation</u> strategies to cope with dynamic environmental conditions and changing requirements.
<p>«Pervasive O&M»</p>	<p><i>Ubiquitous sensing increases the substation digital assets; hence, it comes at the cost of a higher system complexity.</i></p>	<p>Privacy and security</p>	<p><i>Environmental sensors pose severe questions on possible privacy violations, while complex data flows are exposed to data breach and poisoning attacks.</i></p>
<p>Research directions</p>	<ul style="list-style-type: none"> • <u>Criteria and conditions</u> for the pre- and post-installation of substation pervasively sensing infrastructures. • Self-diagnosis, fault tolerance and <u>fault mitigation mechanisms</u> for large sensor networks (e.g., by leveraging on the advantages offered by multi-modality). 	<p>Research directions</p>	<ul style="list-style-type: none"> • Robust <u>privacy-preserving and secure systems</u>, where formal guarantee of privacy and security is needed with tight accuracy loss.

Group Discussion Meeting

Thank you for your attention!