A system-based framework for optimal sensor placement in smart grids

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INTRODUCTION AND PROBLEM STATEMENT

Optimal sensor placement increases a power system's **ability** to make inferences about its critical processes. Power system operators deploy sensors for operation and event-based use cases such as outage detection, recognition, asset monitoring, and fault diagnosis. Most optimal sensor placement techniques focus on the **technical** factors but fail to regard the **business** and **socio-environmental** factors. This work presents a holistic framework that addresses sensor placement as a **system-based** challenge.

SYSTEM-BASED FRAMEWORK FOR OPTIMAL SENSOR PLACEMENT

Traditionally, optimal sensor placement (OSP) techniques have mostly focused on the technical perspective. In Fig.1, we propose that OSP should be approached from a holistic view that considers three different perspectives in the design of a system-based framework for optimal sensor placement:

- ❑ **Technical perspective**
- ❑ **Business perspective**
- ❑ **Societal perspective (socio-environmental)**

An optimization problem (J) featuring the three perspectives seeks to **maximize the merits** associated with each perspective while **minimizing their shortcomings**.

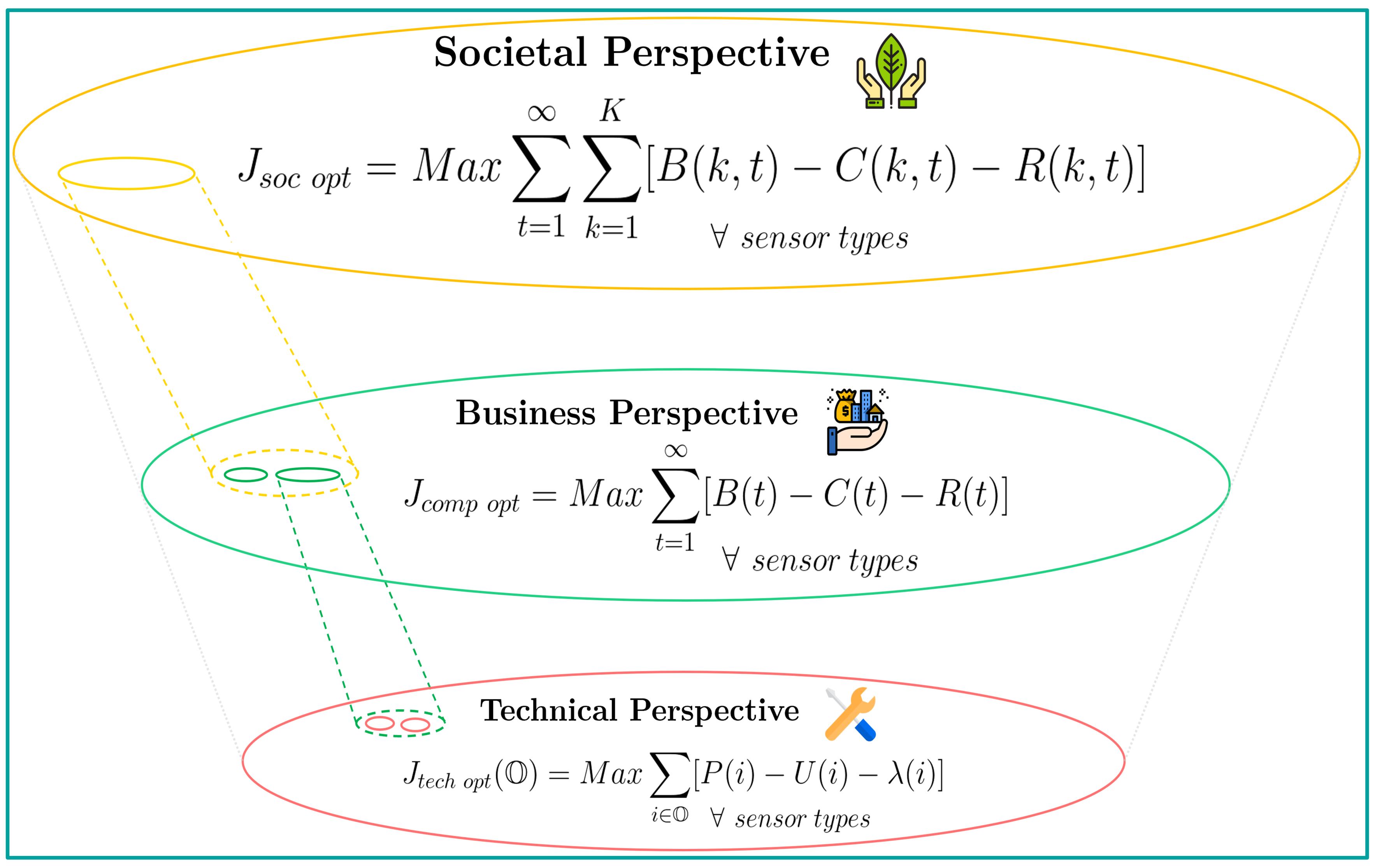
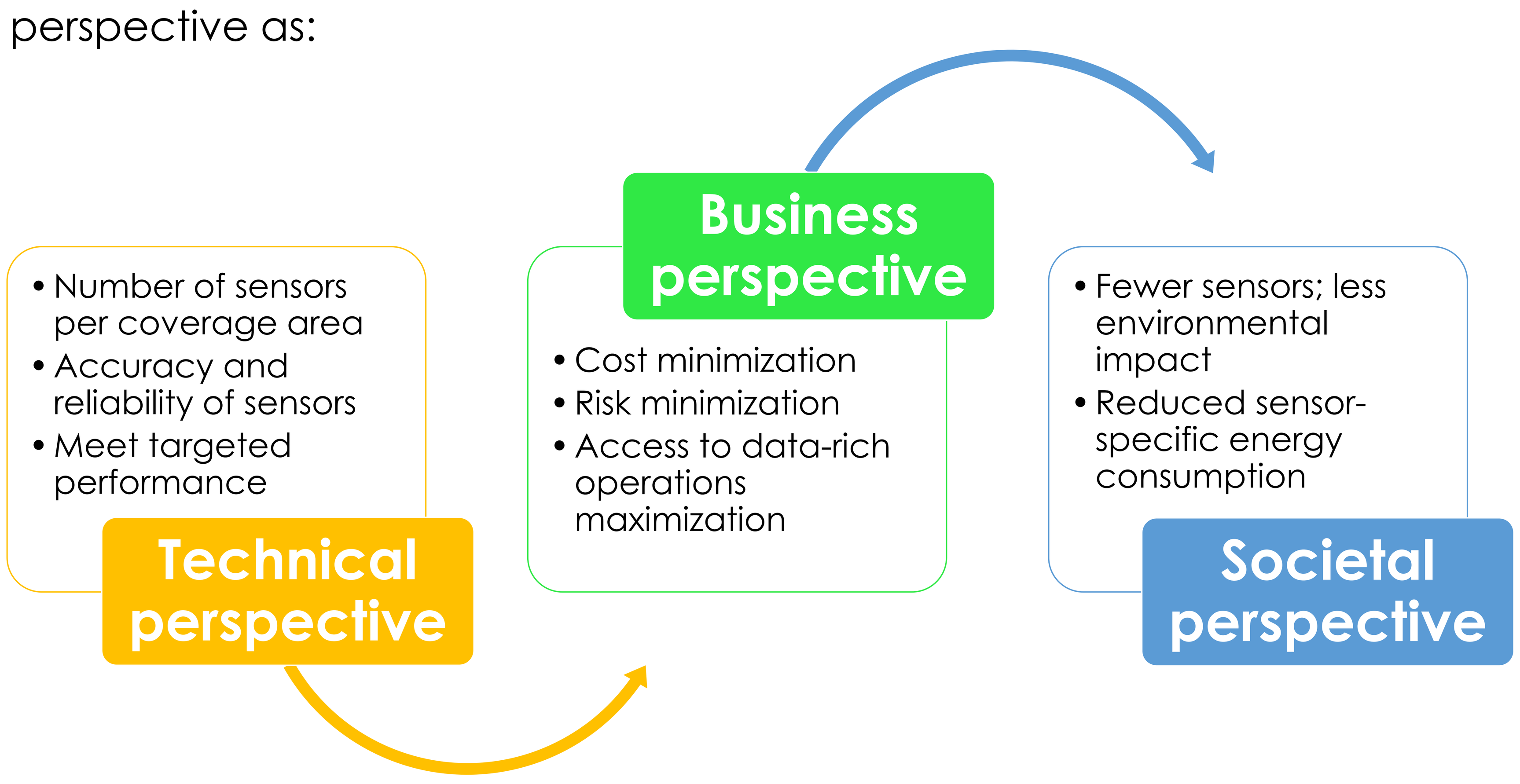


Fig.1 Optimal sensor placement from a system's life cycle perspective highlighting technical, business, and societal perspectives using a bottom-up approach.

We summarize the key features of focus used in feasibility studies for each perspective as:



SYSTEM PERSPECTIVE IN THE SENSOR PLACEMENT WORKFLOW

A **use-case-dependent** operational workflow is defined as illustrated in Fig.2 to denote the key phases considered for the system-based optimal sensor placement framework.

Stage 1: Use case definition
Stage 2: Data collection
Stage 3: Placement design
Stage 4: Implementation
Stage 5: Validation
Stage 6: Operation

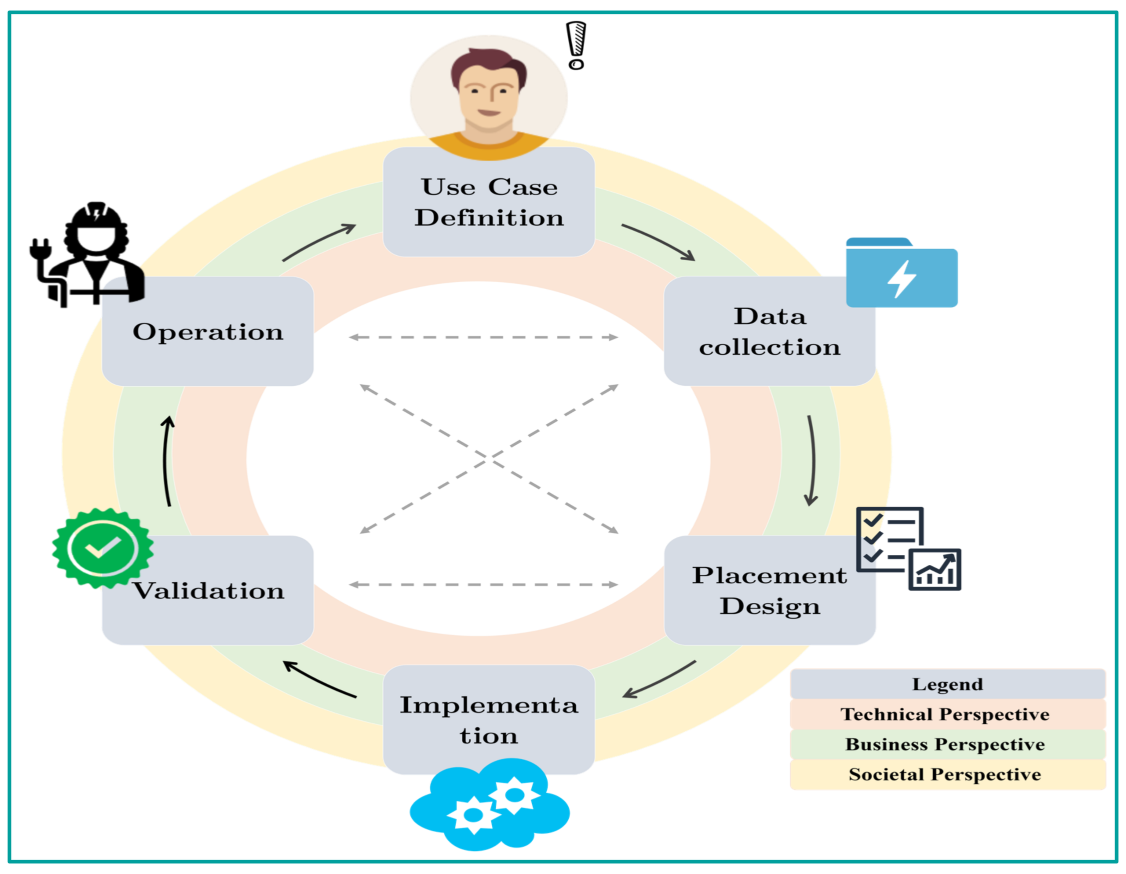


Fig.2 Phases of the system perspective operational workflow for optimal sensor placement

PROACTIVE MAINTENANCE AS AN INDUSTRIAL APPLICATION SCENARIO

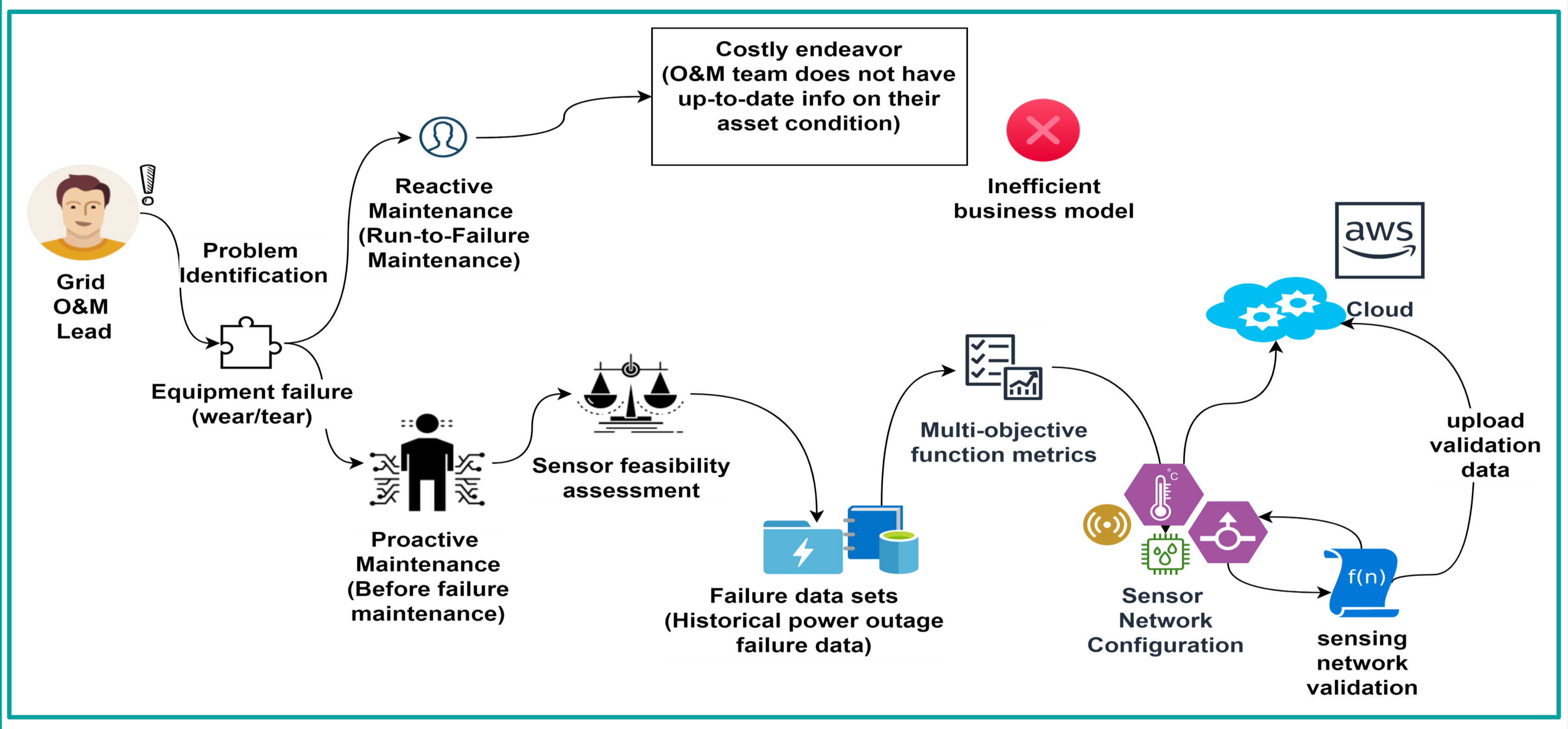


Fig.3 A system-based framework for optimal sensor placement in a proactive maintenance use case

Fig.3 maps the system-based operational workflow for sensor placement on a proactive maintenance application scenario. The Operations and Maintenance (O&M) personnel identifies "equipment failure" as the use case. The application scenario relies on the operational workflow in Fig.2 to run a holistic optimal sensor deployment plan for proactive maintenance.

FUTURE WORK AND RECOMMENDATIONS

- ❑ Real options theory to assess the economic value of delayed adoption of IoT in the event of technological uncertainty.
- ❑ Life cycle analysis to model optimal sensor placement around IoT sustainability.
- ❑ Develop comprehensive test cases in collaboration with grid planners, DSOs, and TSOs.

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