Event-Driven IoT-Based Structural Health Monitoring of Public Buildings in Seismic Urban Areas: The Campi Flegrei Use Case

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***Abstract*—This paper presents an event-driven IoT-based Structural Health Monitoring (SHM) framework for public buildings in seismic urban areas. The system uses distributed MEMS accelerometers to monitor structural vibrations and correlate seismic events with the response of monitored buildings. Cloud-based analytics extract structural metrics, enabling post-event assessment through synthetic indicators and alert levels. The framework has been validated in a real deployment in the Campi Flegrei bradyseismic area, demonstrating the feasibility of scalable SHM solutions for urban resilience applications.**

***Index Terms*—Structural Health Monitoring, Smart Buildings, IoT, Seismic Monitoring, Event-Driven SHM, Structural Assessment, Urban Resilience**

I. Introduction

Urban areas exposed to seismic and bradyseismic phenomena require rapid and reliable assessment methodologies for the safety of public buildings. Traditional post-earthquake inspections are mainly based on visual surveys, resulting in delayed evaluations.

Structural Health Monitoring (SHM) enables the assessment of building behavior through distributed sensor networks [2]. Variations in vibration characteristics, modal frequencies, and spectral energy distributions can provide useful indicators of possible structural changes after seismic events [1]. Unlike earthquake detection systems, which are already provided by institutional seismic infrastructures such as INGV, the proposed framework focuses on evaluating the structural response of monitored buildings after certified seismic events. The main contributions are:

- An event-driven SHM workflow integrating institutional seismic event feeds;
- A scalable IoT monitoring architecture for public buildings;
- Structural assessment metrics and operational monitoring services for public buildings;
- Validation in the Campi Flegrei seismic area.

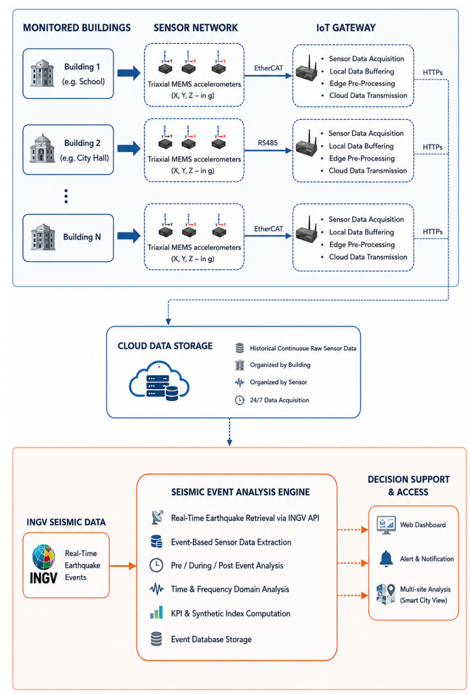

Fig. 1. Architecture of the proposed event-driven SHM framework

II. System Architecture

The proposed framework is based on a distributed network of tri-axial MEMS accelerometers installed in public buildings [3]. Sensors continuously acquire raw acceleration data along the three spatial axes at 100 Hz. The acquired data are transmitted to a cloud infrastructure where event-driven analyses are performed [4]. Event data are retrieved from institutional seismic feeds and correlated with monitored buildings according to temporal and geographical criteria. For each seismic event, the system extracts the structural response within a selected time window and computes structural metrics describing the vibration characteristics of the building.

The framework also provides a web-based dashboard supporting:

- Geospatial visualization of seismic events;
- Aggregation of monitored buildings;
- Building-level risk classification;
- Building condition assessment.

III. Event-Driven Structural Assessment

The proposed workflow evaluates building response after seismic events. For each correlated event, structural indicators are computed in both time and frequency domains.

A. Time-Domain Indicators

Time-domain analysis includes:

- Peak acceleration along X, Y, and Z axes;
- Resultant peak acceleration;
- Threshold deviation analysis;
- Alert-level estimation.

These indicators provide a synthetic representation of the structural response intensity during seismic excitation.

B. Frequency-Domain Indicators

Frequency-domain analysis includes:

- Modal frequency estimation;
- Modal Dominance Ratio (MDR);
- High Frequency Ratio (HFR);
- Spectral energy distribution.

Monitoring modal-frequency variations enables the identification of possible changes in the modal response of the structure.

C. Pre/Post-Event Analysis

The framework also compares pre-event and post-event structural conditions.

The computed indicators include:

- RMS variation;
- Spectral centroid variation;
- Peak-frequency variation;
- Bandwidth variation;
- Arias intensity variation;
- Structural Variation Index.

These metrics provide synthetic KPIs describing possible structural changes following seismic events.

A traffic-light alert logic classifies the structural condition into green, yellow, or red levels to support technical operators.

IV. Experimental Validation

The proposed framework has been deployed in public buildings located in the Campi Flegrei area, a region characterized by significant seismic and bradyseismic activity.

The experimental activity confirmed the capability of the framework to identify vibration patterns associated with seismic events and to provide building-level assessments through the proposed indicators and alert logic.

The deployment confirms the feasibility of scalable event-driven SHM solutions for public-building monitoring in seismic urban environments.

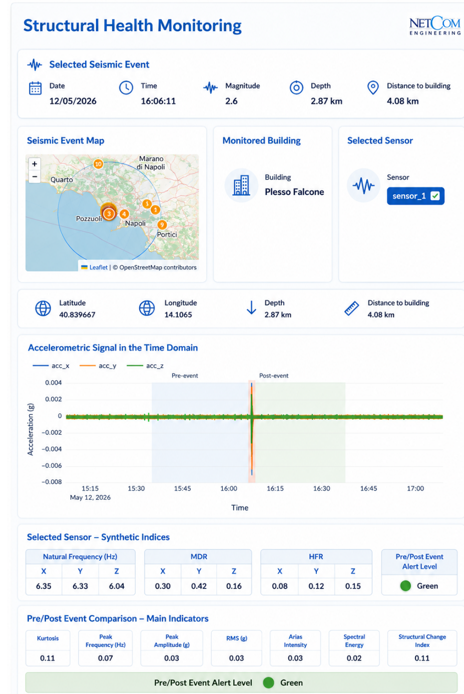

Fig. 2. Dashboard for seismic event correlation and building-level assessment

V. Conclusion

This paper presented an event-driven IoT-based SHM framework for monitoring public buildings in seismic urban areas.

The proposed approach integrates structural sensing, cloud-based analytics, modal descriptors, and smart-city alert and assessment services into a scalable monitoring infrastructure.

Future work will focus on AI-ready predictive maintenance services and anomaly detection models based on accumulated monitoring data from distributed urban infrastructures.

References

[1] F. Magalhães, A. Cunha, and E. Caetano, "Vibration based structural health monitoring of an arch bridge: From automated OMA to damage detection," *Mechanical Systems and Signal Processing*, vol. 28, pp. 212–228, 2012.

[2] C. R. Farrar and K. Worden, "An introduction to structural health monitoring," *Philosophical Transactions of the Royal Society A*, vol. 365, no. 1851, pp. 303–315, 2007.

[3] A. Cardoni, A. Flora, and G. Gesualdo, "Structural health monitoring of buildings in seismic areas using MEMS sensors," *Sensors*, vol. 21, no. 4, pp. 1–19, 2021.

[4] M. Abdel-Basset, G. Manogaran, and M. Mohamed, "Internet of Things in smart cities: A survey," *Journal of Network and Computer Applications*, vol. 108, pp. 1–15, 2018.