GENESI: General requirements

End User Workshop

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Coordinator: Prof. Chiara Petrioli[†]

Department of Computer Science, University of Rome La Sapienza

Goal and metrics

- The goal of structural health monitoring is to check serviceability and operability of (static) structures and structural elements.
- The ***sampling rate*** (SMR) or ***sampling interval*** (SPI) depends on the least possible time span of an event on the structure which could be detected. In order to provide a sufficient degree of reliability sampling rate should by 10 times higher than the least necessary rate to detect an event.
  - Can imply contineous monitoring in some application domain
  - However smart solutions such as passive sensors triggering more accurate active sensors upon detection of an event can be considered

Relevant metrics

- The ***recording rate*** (RER) is independent from the sampling rate i.e. not every sample needs to be recorded. Data have to be recorded only if they bear new information or as a sign of life (e.g. once a day).
- The ***transmission rate*** (TMR) represents how often data transfer to the backend should occur. A periodical data transfer can send out all recent recorded data to the data visualisation server, or a summary of data (applying data fusion and filtering techniques) or can send data only when thresholds are exceeded (event-based or alarm-based communications).

Relevant metrics

- The ***reaction time or latency*** (LAT) is the least interval to recognize an event in the system. One single measurement might not be enough to give evidence of an event, but processing of multiple data and combination of data from heterogeneous sensors maybe needed.

Alarms

- The engineer or geologist defines relevant 'observation values' (e.g. displacement, inclination, pressure, …)
- Cooperative sensing: observation values may be captured by a single instrument or sensor (e.g. displacement "at a point"), a **group** of sensors (e.g. water levels of a whole area) or be calculated with a combination of sensors (e.g. total inclination of an inclinometer chain, displacements which are temperature compensated).
- The alarm can only be defined and triggered at a point of the system, where all values of the system are available and where the true values already are calculated
  - alarm is triggered either because of an **absolute value** of the observed data (e.g., a threshold has been exceeded or there are values observed outside a predefined range) or because of a **change of the observation value** within a (defined) time span;
  - **Different levels of alarm** can be defined: "yellow-Alert" (pre-alarm / low level alarm) und "Red-Alert" (Alarm / high level alarm).

Practical general requirements

- Housing: Robust for environmental conditions such as rain, dust, UV-radiation as well as high and low temperatures (approx. -30°C to +60°C).
- The circuit boards to which the sensors and device are connected in the field must have clamps which are in right size, that they also can be connected in rough field conditions (e.g. mud, very cold temperatures). A good lightning protection is necessary.
- Size is less critical: Often a housing with approx. 25 cm x 15 cm x 10 cm is a good choice. Currently envisioned size with nodes and interfaces with side in the order of a few centimeters should not create problems.

Communication primitives envisioned

- Broadcasting
- Multicasting
- Unicasting
- Anycasting

-To transmit 'interests' which express the mode on which a sensor node should operate, e.g. frequency of sampling/recording/reporting,…
-To set or change alarm thresholds and operational ranges expected for a given sensor
-To disseminate a request for information on a set of nodes ('alive' messages, request of link quality information,…)

- Wireless re-programming and updates of the QoS model
- Convergecasting (i. e., transmission of the observed values to the sink(s))
  - supporting periodic and event based data communication
  - sending periodic alive messages which are used to assess all system components are correctly working
- To put/get synchnronization

GENESI use cases *(preliminary set)*

- Tunnels
- Excavations
- Buildings
- Bridges and viaducts
- Dams
- Landslides and rock falls
- Heritage
- Landfills and waste management
- Mining/Quarries

Sensors

- Displacement meters
- temperature
- strain gauges
  - vibrating wire strain gauge
  - resistive strain gauge

QUESTION 1: WHAT ELSE?

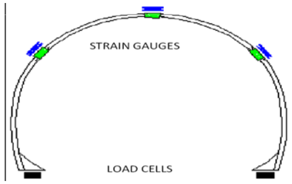
Other suggestions?

Scenarios 1-Tunnels

Preliminary lining

Sensor	SPI, normal	LAT, normal	SPI, critical	LAT, critical
Typical				
Strain gages (VW)	Hours	Minutes	Minutes	Seconds
Load cells	Hours	Minutes	Minutes	Seconds

Number of sensors	Depending on size of tunnel, many hundreds
Number of sensors per section	Around 5 to 20
Maximum distances between nodes/ instrumented sections	Around 100 m
Environmental conditions	Normally 0 to 30°C, in extreme -20°C to +50°C High humidity, splash water Dust



Final lining and long term monitoring

Sensor	SPI, normal	LAT, normal	SPI, critical	LAT, critical
Typical				
Strain gages (VW)	Hours	Hours/Minutes	Minutes	Seconds
Pressure	Hours	Hours/Minutes	Minutes	Seconds
Displacement meters	Hours	Hours/Minutes	Minutes	Seconds
Temperature	Hours	Hours/Minutes	Minutes	Seconds

Number of sensors	Depending on size of tunnel, many hundreds
Number of sensors per section	Around 5 to 20
Maximum distances between nodes/ instrumented sections	Around 100 m
Environmental conditions	Normally 0 to 30°C, in extreme -20°C to +50°C High humidity, splash water Dust

Scenario 2-Buildings

Sensor	SPI, normal	LAT, normal	SPI, critical	LAT, critical
Typical				
Inclination	Hours	Hours/Minutes	Minutes	Seconds
Displacements	Hours	Hours/Minutes	Minutes	Seconds
Piezometers	Hours	Hours/Minutes	Minutes	Seconds
Temperature	Hours	Hours/Minutes	Minutes	Seconds

Number of sensors	Often smaller systems of around 20, sometimes large systems with up to 100 sensors
Number of sensors per section	Around 2 to 5
Maximum distances between nodes/ instrumented sections	Around 30 m
Environmental conditions	Inside 0 to 30°C, Outside -30°C to +50°C High humidity, splash water Dust

Scenario 3-Damns

Sensor	SPI, normal	LAT, normal	SPI, critical	LAT, critical
Typical				
pressure	Hours	Hours/day	Minutes	Seconds
inclinometers	Hours	Hours/day	Minutes	Seconds
displacement meters / extensometers	Hours	Hours/day	Minutes	Seconds
Flowmeters	Minutes	Hours/day	Minutes	Seconds
Thermometers	Hours	Hours/day	Minutes	Seconds
Additional				
Wind meter	Minutes / Always			
GPS	Hours			
Precipitation	Minutes			
Webcam	Hours		Minutes	

Number of sensors	Many hundreds in build constructions, in older construction manual measurements are replaced time after time
Number of sensors per section	Around 1 to 10
Maximum distances between nodes/ instrumented sections	Within one construction part usually around 100m, over the whole construction up to 500 m or even more
Environmental conditions	-30°C to 40°C outside, in tunnels and caverns 0°C to 30°C High humidity, splash water, frost and fog

Scenario 4-Landslides and rock fall

Sensor	SPI, normal	LAT, normal	SPI, critical	LAT, critical
Typical				
pressure	Hours	Hours/day	Minutes	Seconds
inclinometers	Hours	Hours/day	Minutes	Seconds
displacement meters / extensometers	Hours	Hours/day	Minutes	Seconds
Thermometers	Hours	Hours/day	Minutes	Seconds
Additional				
GPS	Hours			
Precipitation	Hours			

Number of sensors	Often only small systems with only 5 to 10 sensors, sometimes larger
Number of sensors per section	Around 1 to 10
Maximum distances between nodes/ instrumented sections	Can be large to about 500 m
Environmental conditions	-30°C to 50°C High humidity, splash water, frost and fog Flooding and installation in manholes (under surface) would be preferable

Scenario 5: Heritage

Sensor	SPI, normal	LAT, normal	SPI, critical	LAT, critical
Typical				
inclinometers	Hours	Hours/day	Minutes	Seconds
displacement meters	Hours	Hours/day	Minutes	Seconds
Thermometers	Hours	Hours/day	Minutes	Seconds
Additional				
Wind meter	Minutes		Always	See processing
Accelerometers	Always or offline		always	See processing
Fire detection	Minutes		Always	Seconds
Webcam	Hours		Hour	

Number of sensors	small systems with only 10 to 20 sensors, larger systems with up to about 100 sensors
Number of sensors per section	Around 1 to 5
Maximum distances between nodes/ instrumented sections	Usually around 30 m
Environmental conditions	-30°C to 50°C outside, inside 0°C to 30°C splash water

Scenario 6: Landfill and Waste Management

Sensor	SPI, normal	LAT, normal	SPI, critical	LAT, critical
Typical				
Pressure meters (water / gas/ rock pressures)	Day	Day/week	Hours	minutes
Extensometers	Day	Day/week	Hours	minutes
Thermometers	Day	Day/week	Hours	minutes
Precipitation	Day	Day/week	Hours	minutes
Additional				
Soil moisture	Day	Day/week	Hours	minutes
pH meter	Day	Day/week	Hours	minutes
Flowmeters	Hour/minute	Hours/Day	Minutes	seconds

Number of sensors	Most systems around 30 to 80
Number of sensors per section	1 to 5
Maximum distances between nodes/ instrumented sections	Approx. 300 m
Environmental conditions	-30°C to 50°C High humidity, splash water, frost and fog

Scenario 7:Mining/Quarries

Sensor	SPI, normal	LAT, normal	SPI, critical	LAT, critical
Typical				
Pressure sensors	Day	Hours	Hours	minutes
Extensometers	Hours / Day	Hours	minutes	Seconds
Load cells	Hours /Day	Hours	minutes	Seconds
Additional				
temperature	Hours	Hours	Hours	minutes
precipitation	Day	Hours	Hours	minutes
wind	minutes		During blasting always	Seconds or below
acceleration	Always or offline		always	Seconds or below

Number of sensors	Most systems around 70
Number of sensors per section	2 to 10
Maximum distances between nodes/ instrumented sections	Approx. 400 m
Environmental conditions	-30°C to 50°C High humidity, splash water, frost and fog

QoS model

- Which are the different modes in which the system can operate over time;
- Which are the system requirement in each mode
  - Type of information which must be provided
    - with associated frequency of sampling, recording and reporting; latency requirements, accuracy requirements, percentage of packets which can be lost;
    - which are the different options to measure a given quantity and which subsets of options are fine/definition of different utilities associated to the different options;
      - Given the sets of sensors deployed is it possible to obtain the same information using different sets of nodes and sensors?
  - Additional information which maybe useful (e.g. increased sampling or extra measurements which may increase accuracy and understanding of events)
    - expressing how 'useful' additional 'tasks/measurements' which could performed by the system over the bare minimum are, based on end user perception (utility functions-which express [0…1] how important and how much added value that task would bring, based on end users expectations);
- Which are the events which should move the system from mode A to mode B and which are the associated actions to perform

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Objective of today: use end users presence to detail such QoS models for existing use cases and for new ones identified during the workshop.