Edge computing infrastructure for smart levee monitoring

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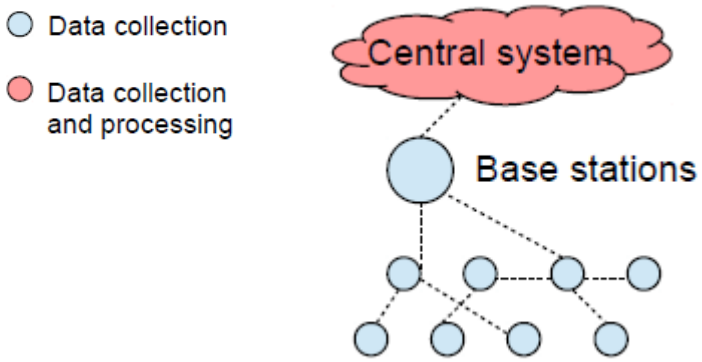
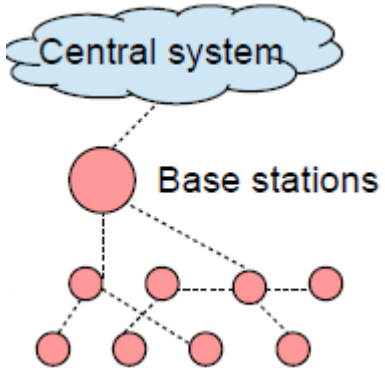
Motivation

- Flood warning systems utilize sensors to acquire data from monitored infrastructure
- Recent development in Internet of Things environments gives us the new perspective on the design of monitoring systems
  - The systems often have hierarchical architecture - sensors gather data and later transmit them to a central part where further processing take place
  - One of the ideas we decide to use is edge computing

Edge Computing Concept



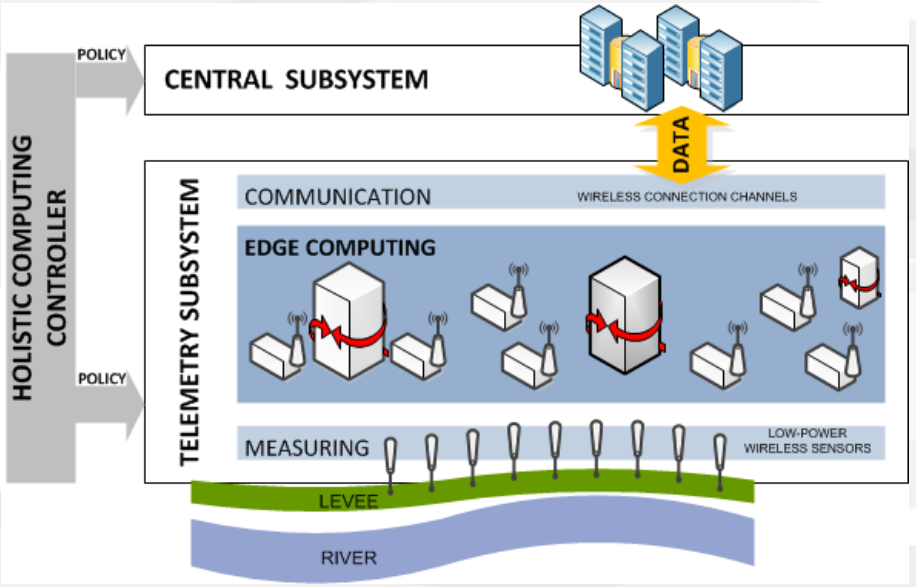


- In a classical approach to WSN, the **data gathered by sensors are transmitted** usually through the mesh or tree topology **to a central system for processing**

- In the Edge Computing concept the **data gathered by sensors can be processed close to the sensors and only selected preprocessed results can be transmitted to the central system**

System Layers

- The computerized monitoring and decision support system has a layered architecture that consists of the following layers:
  - **Measuring layer** - composed of the sensors or sensor networks deployed in the levee.
  - **Edge computing layer** - composed of the many distributed telemetry stations which collects data from the measuring layer, process it and transmits to the central part of the system for further processing.
  - **Communication layer** - provides bidirectional communication between Edge Computing layer and the central part of the system.



Edge Computing Layer

- The edge computing paradigm provides to the system following properties:
  - **local data processing** introduced in the edge computing layer gives the possibility to process data in place and transmitting only the computation results
  - **intelligent communication** allows smart rerouting of measuring data among other telemetry stations to the central part of the ISMOP IT system, in a case of problems with direct connection
  - **self-organization capabilities** of the edge computing system reorganize internal processing architecture to encompass the ever-changing runtime conditions

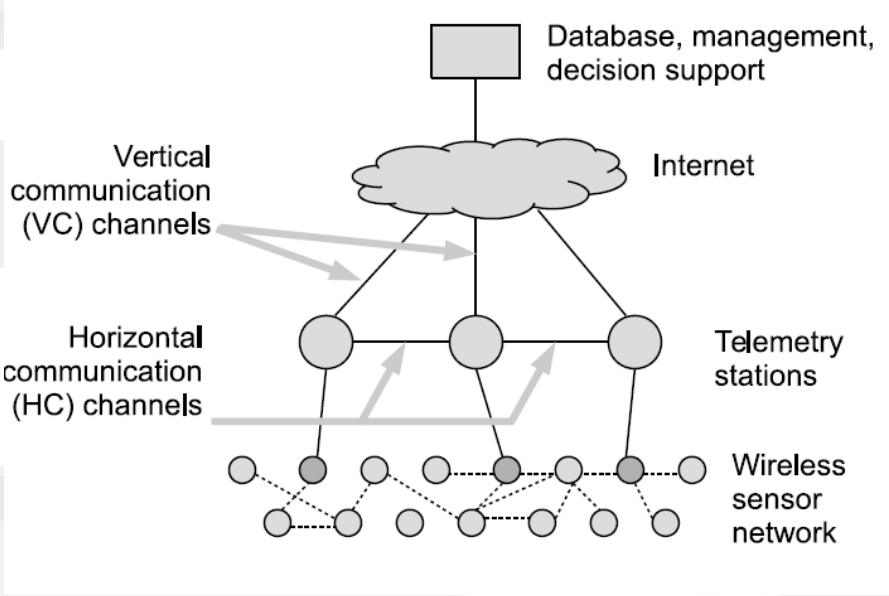
Local Data Processing

- The local threat level assessment may be performed in case the communication with Internet is lost
- The gathered data can be processed in-place and only results can then be transmitted to either reduce required bandwidth or to minimize the amount of redundant information submitted to a central data base
- Each station should be able to acquire data from more than a thousand of sensors, hence the information preprocessing, such as compression and encryption may be necessary

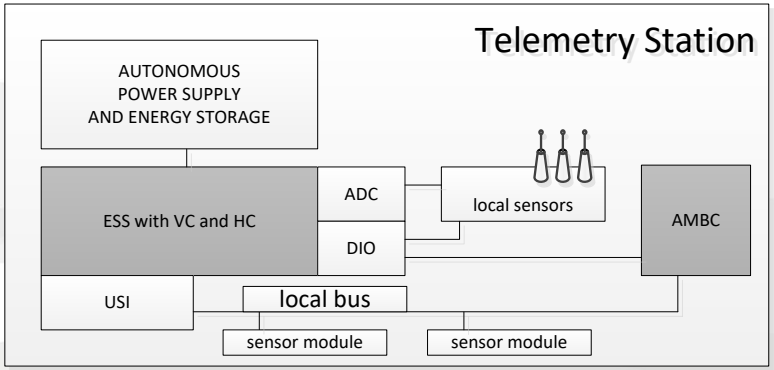
Communication Mechanisms

- **Vertical Communication** provides the communication path between a station and a central system (or the Internet)

- **Horizontal Communication** shall be utilized to:
  - locally distribute measurements, computing tasks and results between the stations;
  - provide a local low-latency communication path in case of an emergency situation – then a rescue team can connect directly to the local fog network and obtain the environmental condition information;
  - provide an alternate communication path during normal or emergency situation every time the VC channel is unavailable.



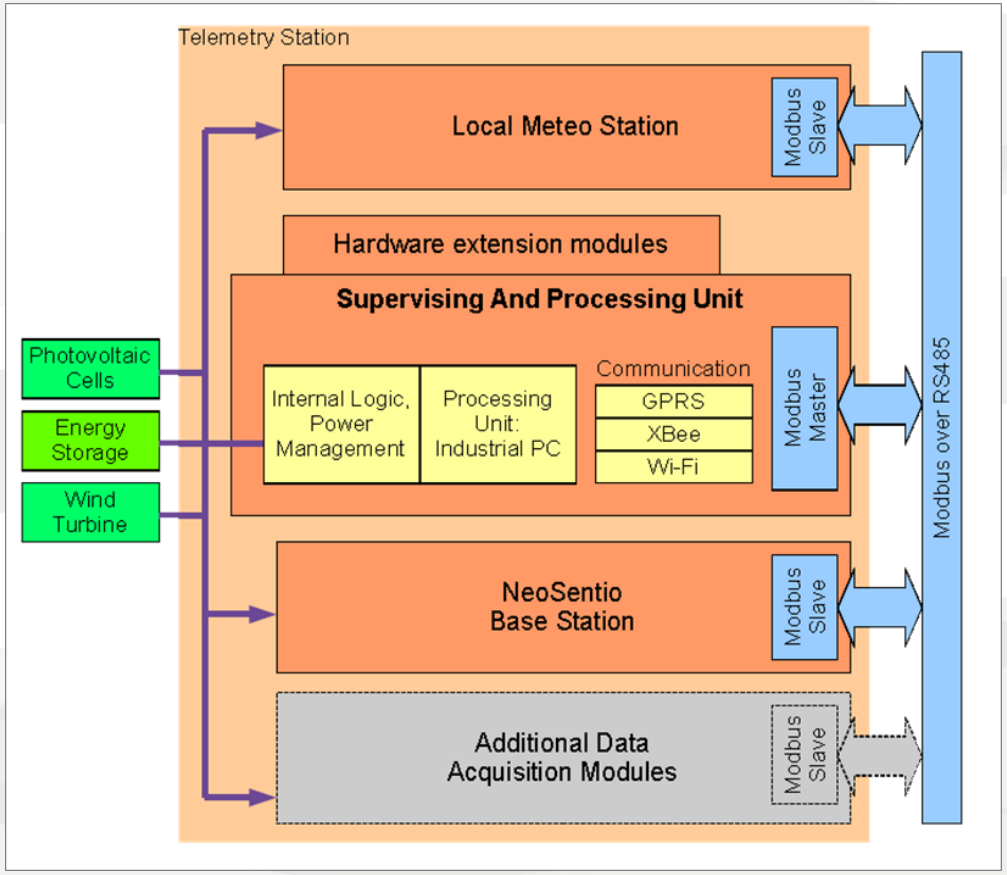
System Design



- **Autonomous Power Supply and Energy Storage** delivers the energy needed by the device from renewable sources
- Based on the complexity of computation the **Embedded Supervising System (ESS)** can schedule the task execution
  - The tasks can be executed directly on **ESS** or **Application Microprocessor-based Computer (AMBC)**
  - As the result of this approach less demanding tasks can be run without powering up main AMBC unit
- Various types of communication
  - **Horizontal Communication (HC)** for communication between telemetry nodes
  - **Vertical Communication (VC)** for sending information to the Central Subsystem
  - The interaction between the telemetry station and sensors is done via the Unified **Serial Interface (USI)**

Telemetry Station Prototype

Telemetry station (closed)



Summary

- The ISMOP project positively verified the proposed concept of edge computing infrastructure for Smart Levee Monitoring
  - Essential part of this infrastructure consists of the telemetry stations designed following edge computing concept
- Future work involves further research and development of their internal hardware and software

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