

# European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

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## MODELLING AND SIMULATION STUDIES ON INDOOR AIR QUALITY MONITORING



Ahmet Özmen

WG2: Sensors, Devices and Systems for IQC

Computer Engineering Department

Sakarya University / Turkey

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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY





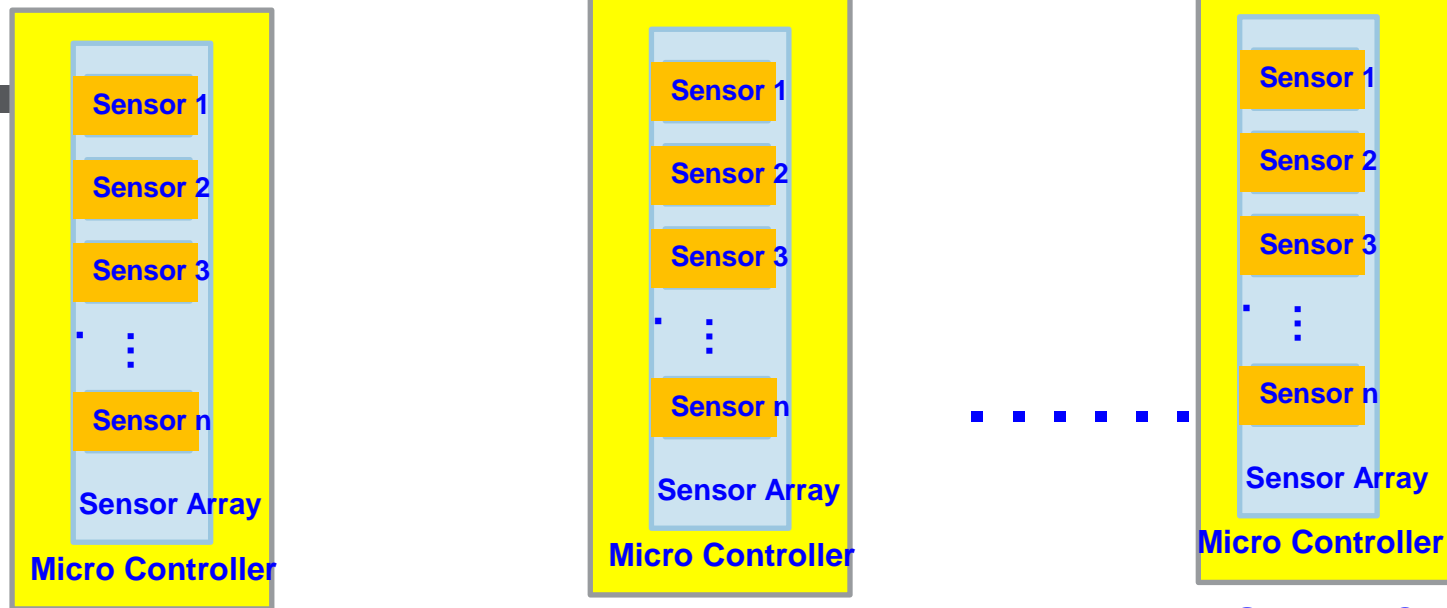
# Outline

- Motivation
- Problem statement
- Goal of the research
- Methodology
- Distributed simulator architecture
- Indoor air quality monitoring
- Current status
- Future work
- Conclusions



# Motivation

- Research on gas sensor characterization and information extraction
- Air quality measurement → gas concentration measurement
- Rapid progress on electronic gas sensors and instrumentation
- Development of distributed on-line gas sensor system for measurement → a challenging problem
- Air quality measurement in large scale turns out to be a distributed on-line sensor system



Sensor Cell

Sensor Cell  
Data

Sensor Cell  
Data

Data

Data

**Problem?**

**On-line!**

**Distributed!**

Central  
Server

Data/Control

Analysis and  
Control Tools

GUI - 1

GUI - 2

Database



# Goal of the Research

- Speed up distributed on-line gas sensor system development process
- Optimize parameters of not-exist distributed sensor systems
- Create a test bed for analysis of air-quality & energy efficiency of HVAC problem

**Develop a software simulator system to form distributed gas sensor measurement system virtually**



# Methodology

- **Sensor modelling → virtual sensor**
- **Environment modelling → virtual environment**
- **Sensor cell → virtual sensor cell**
- **Synthetic sensor responses**
- **The rest is same as real system**
- **Sample collection**
- **On-line analysis**
- **Data storage for later analysis**
- **Analysis tools**



# Sensor Modelling

- Modelling based on sensitive material is difficult
- Characterization data is used for modelling
- A library is created for well known gas sensors
- **PLAN:** Create a virtual sensor toolbox to choose from
  
- Simulated sensors generate synthetic sensor data similar to real sensors
- Multiple sensors can form an array
- Sampled sensor data is packed at every cell for forwarding



# Environment Modelling

- Virtual sensors are less useful without a virtual environment
- **PLAN:** 1) Mathematically model an environment based on gas material behavior
- 2) Find a way to describe an environment with a scenario file
- **RESULT:** Any environment can be created virtually.
- Expect to create real-like data for any coordinate in a 3-D space
- This is also a challenging problem!
- Have found some basic studies in the literature.
- We are still studying...

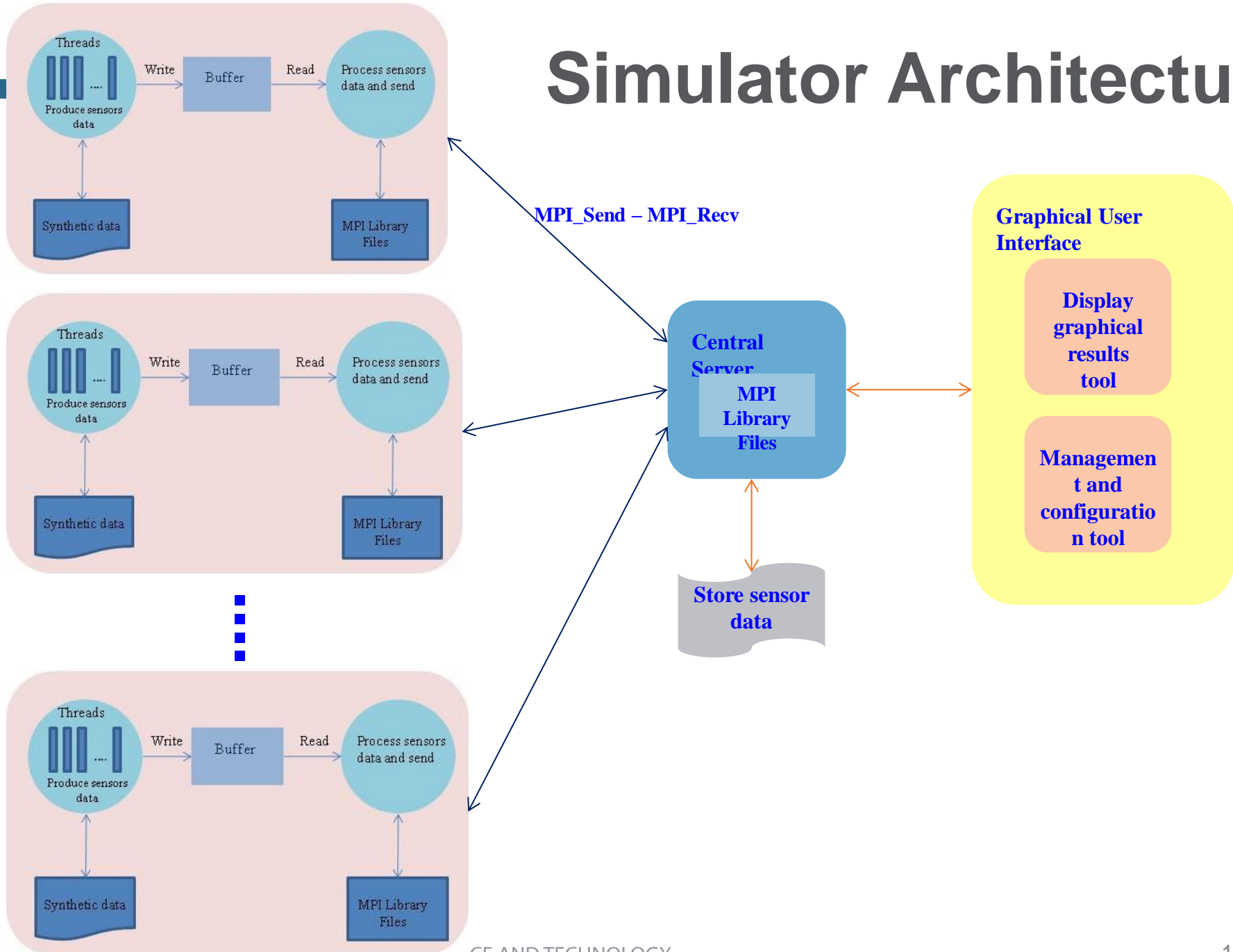




# The rest of the simulator system

- The rest of the system components can be used in a real measurement system:
- Data transfer infrastructure, central server and software analysis tools
- After a simulation study:
- Virtual sensor cells can be replaced with real sensor cells
- Distributed infrastructure and central server can be used for real measurements
- Software analysis tools can be used for real measurements

# Simulator Architecture





# Usage of the simulator?

- Distributed gas sensor systems can be experimented in a lab
- On-line distributed gas sensor system parameters can be optimized
  - Data protocol studies,
  - Data stress tests can be performed,
  - Data processing algorithms and location for the algorithms can be analyzed



# Indoor Air Quality Monitoring

- Simulator can be used to study cases about on-line indoor air quality monitoring issues
- Motivation for indoor air quality monitoring:
  - Health concerns
  - Productivity
  - Energy efficiency
  - Comfort



# Current status

- Able to model some sensors → need more real like
- Found some environment modelling approaches → need to adapt them to our purposes
- Good background about distributed systems due to parallel computing



# Future Work and Conclusion

- The simulator will create a platform where we can create and test various scenarios virtually
- For example, what happens at a crowded classroom during a winter day, and what can be done to make the air cleaner in the classroom?
- The simulator will guide us how to develop a distributed sensor system for air quality monitoring
- It can also help us to make smart decisions about air conditioning with respect to comfort and energy consumption
- It can also be used non-existed or toxic environment modelling and simulations